TS 03611:1.1

ESC 220

Standard

Rail and Rail Joints

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Document information

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Document history

Revision	Effective date	Summary of changes
1.0	15/03/2022	First issue as TS 03611 superseding ESC 220 *Rail and Rail Joints,* version 4.8. Version number recommenced in line with new designation.
1.1	08/03/2024	Second issue. Changes from the previous version include; amendment to section on placement and installation requirements for aluminothermic welding; correction of captions on figures 12 and 13; updating of designations of Transport standards.

Preface

This standard is a minor revision of TS 03611.

This standard details the design and performance criteria, allowable arrangements and acceptance standards for rail and rail joints.

Rail and rail joints are an integral part of the track structure and are key to the performance and safety of the rail network. The functions of rail and rail joints include guiding the passage of trains, transferring loads to the track substructure and serving as the interface between rolling stock and underlying track. Additionally, rail and rail joints are a critical component of signalling, electrical and civil systems.

The changes from the previous issue include:

- amendment to section on placement and installation requirements for aluminothermic welding
- correction of captions on figures 12 and 13
- updating of designations of Transport standards.

Table of contents

1 Scope

This standard establishes functional and design requirements, approved arrangements and acceptance standards for rail and rail joints.

TS 03510 contains the overarching requirements for track infrastructure, which is not covered by this standard. TS 03510 should be read in conjunction with this standard.

This standard details the minimum requirements for design and performance criteria, allowable arrangements and acceptance standards for rail and rail joints used in the MRA. However, the principles can be applied to any type of rail network (including light rail).

2 Application

This standard is intended for use by Technically Assured Organisations (TAOs) and is applicable to all of the MRA. This standard applies to the design of new track work, track renewal work and maintenance of existing track.

The requirements of this standard are applicable to rails and rail joints installed within plain line infrastructure and the non-machined elements of turnouts and special trackwork, unless alternative requirements are specifically stated.

This standard is intended to be used by competent personnel engaged in the provision of services relating to the railway infrastructure. Compliance with the standard will not in itself be sufficient to ensure that satisfactory outcomes are produced. Personnel providing services based on the requirements of this standard shall bring appropriate expertise to the matters under consideration. This standard is not specifically intended to cover light rail or metro systems; however, the principles of this standard may be applicable to the light rail and metro environment.

3 Referenced documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

Australian standards

AS 1085, Part 1-1981 *Railway Permanent Way Material – Part 1 Steel Rails*

AS 1085.1 *Railway track material – Part 1: Steel rails*

AS 1085.1–2002 Sup 1:2017 *AS 1085.1 Supplement 1:2017 – Railway track material – Part 1: Steel rails – History (Supplement 1 to AS 1085.1-2002)*

AS 1085.2 *Railway track material – Part 2: Fishplates*

AS 1085.4 *Railway track material – Part 4: Fishbolts and nuts*

AS 1085.7 *Railway track material – Part 7: Spring washers*

AS 1085.10 *Railway track material – Part 10: Rail anchors*

AS 1085.12 *Railway track material – Part 12: Insulated joint assemblies*

AS 1085.20:2020 *Railway track material – Part 20: Welding of steel rail*

Transport for NSW standards

TS 00021 *Track Type Approved Product Register*

TS 01506.1 *Development of Technical Maintenance Plans – Part 1: Development Process*

TS 02401 (T HR CI 12071 ST) *Guard Rails*

TS 03510 (ESC 200) *Track System*

TS 03608 (T HR TR 00111 ST) *Rail Lubrication*

TS 03610 *Buffer Stops*

4 Terms, definitions and abbreviations

The following terms, definitions and abbreviations apply in this document:

aluminothermic weld welding process used to join rails together. An aluminothermic reaction takes place within a crucible and the resultant metal flows into a mould enclosing the rail ends that are to be joined.

AMB Asset Management Branch

CWR continuous welded rail; track where the rail is joined by welding (and other non-moveable joints such as glued insulated joints) in continuous lengths between fixed points or in lengths greater than 220 m, and where adjustment controls are in place

down rail rail which, if one stands in the four foot and faces away from Sydney, is on the left

flashbutt weld fusion welding of rail ends by electric arc heating and contact under high pressure

four foot area between the two rails of a track

French rail Longwy and Micheville branded rail

gauge distance between the inside running (or gauge) faces of the two rails measured between points 16 mm below the top of the rail head

gauge corner the top corner of the rail above the gauge face

gauge corner region zone on top of the rail head between the running surface region and the gauge face

gauge face the zone of the rail head facing the inside of the track below the gauge corner region. In tighter curves the gauge face may be worn due to contact with the wheel flange

glued insulated joint pre-assembled rail joint consisting of rail sections connected by high strength, purpose designed fishplates and connecting bolts reinforced by a high-strength, insulating bonding material. The joint provides electrical insulation between the connected rail ends via the isolating resin.

HH head hardened

high rail generally the rail on the outside of a circular or transition curve

insulated plate joint field assembled joint consisting of bored rail ends, joined with purpose designed joint plates that are electrically insulated at all external surfaces and connected to the rail by high tensile bolts or swage fastenings

low rail generally the inside rail of a circular or transition curve

LWR long welded rail; track where the rail is welded into lengths between 27.4 m and 220 m, with the rail lengths joined by fishplated joints. Some thermal expansion is provided for at the joints

mechanical insulated joint mechanical field assembled joint incorporating insulating channels, ferrules and end posts designed to electrically insulate the joined rails

mechanical rail joint field assembled rail joint made by mechanical means (as opposed to welding), generally using bolted fishplated sliding joints that are designed within limits to allow the rail to expand and contract with temperature

MRA metropolitan rail area; this is the area bounded by Newcastle Interchange (in the north), Richmond (in the northwest), Bowenfels (in the west), Macarthur (in the southwest) and Bomaderry (in the south), and all connection lines and sidings within these areas, but excluding private sidings**.**

MGT million gross tonnes

rail defect internal rail discontinuities greater than the minimum size and for which there is a mandatory repair response

rail head region of the rail above the top of rail web

RIM rail infrastructure manager; in relation to rail infrastructure of a railway, means the person who has effective control and management of the rail infrastructure, whether or not the person-

(a) owns the rail infrastructure; or

(b) has a statutory or contractual right to use the rail infrastructure or to control, or provide, access to it

running surface region area on top of the rail head where contact between the wheel and rail occurs

TAL tonnes axle load

TfNSW Transport for NSW

up rail rail which, if one stands in the four foot and faces away from Sydney, is on the right

5 Design and performance criteria

Sections 5.1 to 5.5 set the requirements for the design and performance criteria for rail, rail joints, rail lubrication, rail adjustment and rail anchoring.

5.1 Design and performance criteria – rail

This standard has been developed taking into account the following criteria:

- rail size and type as follows:
  - rail cross-section properties
  - rail profile including gauge face angle, and wheel diameter and profile during service (for example, new, ground rail, rail incline and machined wheels)
  - service loads including effects of track alignment, maintenance standards and traffic task
  - rail wear during service
  - bending, contact and sub-surface rail stress limits for plastic deformation and fatigue
  - metallurgy (strength and impact resistance, hardness, cleanliness, chemical composition, microstructure and macroscopic properties)
  - rail joining methods, including strength and impact on temperature stresses
  - rail support
  - track deflection
  - noise and vibration
  - required track modulus.
- rail wear as follows:
  - rail cross-sectional area
  - rail second moment of area
  - metallurgy and stress limits
  - service loads including effects of track alignment, maintenance standards and traffic task
  - wheel rail interaction including rail profile and wheel condition
  - rail support (sleeper spacing, type and condition, and ballast condition)

  - rail condition including rail age, fracture history and rail surface
  - rail modulus.
- rail surface repair as follows:
  - metallurgy (strength and impact resistance, hardness, cleanliness, chemical composition, microstructure and macroscopic properties)
  - the ability to test the weld and rail section.
  - performance under rolling loads.

5.2 Design and performance criteria – rail joints

Rails are joined by either welding or mechanical connections.

Rail welds are a fusion joint for connecting rails, closures, glued insulated joints and other rail components in the track. These welds become an integral part of the running rail.

Non welded rail joints use mechanical connections to connect the two rails. They may be designed as either permanent or temporary rail joints.

This standard has been developed in consideration of the following criteria:

- sleeper type
- maximum lengths of welded rail to be used for different track structures and track alignments given the effects of temperature induced forces
- minimum lengths of rails including closure rails
- rail joint arrangement and position relative to sleepers.

The acceptance of welded rail joints shall take into account the following requirements:

- rail welds shall be formed either by flash butt or aluminothermic welding
- metallurgy (strength and impact resistance, hardness, cleanliness, chemical composition, microstructure and macroscopic properties)
- section strength and bending fatigue behaviour
- performance under rolling loads
- geometry achievable
- the ability to test the weld and rail section.

Non-welded rail joints shall be take into account the following:

- material specification
- dimensional tolerances

- joint strength
- joint arrangement and assembly requirements, for example, treatment of the rail (cutting, drilling, hardening), fastening tension, special locking devices
- design requirements for longitudinal movement of the rails (sliding or fixed)
- performance requirements (either test, or in-track)
- maintenance requirements, for example, lubrication to ensure free movement of sliding joints
- special conditions for use of the joint, for example, location, operational conditions
- special requirements for temporary joints, for example, speed restrictions or additional inspection requirements
- circuited track requirements, for example, electrical resistance.

5.3 Design and performance criteria – rail lubrication

Design and performance criteria for rail lubrication are in TS 03608, which shall be read in conjunction with this standard. Rail lubrication is used to control friction at the rail wheel interface and reduce consequential rail wheel wear, noise and train energy consumption.

5.4 Design and performance criteria – rail adjustment

Construction and maintenance requirements to control the build-up of longitudinal stresses in the rail shall be determined and specified in the RIM’s engineering manuals for all joining methods.

5.5 Design and performance criteria – rail anchoring

Rail anchoring systems are installed to resist longitudinal movement of rails that may be induced by expansion and contraction, or the effects of traffic. Resistance to longitudinal movement assists in the management of rail stresses and maintenance of track stress adjustment and stability.

Rail anchoring systems are mandatory equipment for the management of welded track and mechanical insulated joints. The management of rail stress using rail anchors shall be as specified in the RIM's engineering manual.

6 Allowable arrangements – rail

The requirements for new rail, rail section selection, use of HH rail, rail installation, recycled rail, transposed rails and rails in existing track are in Sections 6.1 to 6.7.

6.1 New rail

New rail shall comply with the following criteria:

- all new 50 kg/m and 60 kg/m rail shall be manufactured to AS 1085.1
- 47 kg/m and 53 kg/m rail cross section shall comply with AS 1085, Part 1-1981. All other properties shall comply with AS 1085.1
- rail ends in plain track shall be free of bolt holes at the completion of the installation
- new rail requirements shall conform to the minimum requirements as shown in TS 03510.

6.2 Rail size

Rail section shall be selected in accordance with the existing or proposed track structure class in TS 03510.

6.3 Use of head hardened rail

HH 60 kg/m rail shall be selected for use in accordance with the track structure class in TS 03510 and the following requirements:

- for tracks subject to more than 20 MGT per year of heavy axle load traffic (23 TAL or greater)
- for tracks where axle loads heavier than 25 TAL are to be used at levels greater than 1 MGT per year
- curves where the use of standard carbon rail would result in a predicted renewal cycle of six years or less
- no other locations are permitted to be installed with HH 60 kg/m rail unless a concession has been granted by the AMB.

In locations of rerailing or laying of new track situations may arise that require the installation of a combination of HH and standard carbon rail. In such instances if the nominal lengths of rail type do not exceed 50 m the predominant rail type required can be installed.

6.4 Installation requirements

The following requirements shall be considered when installing new or recycled rail:

- Rail installed on plain track shall be inclined at 1 in 20 towards the centreline of the track.
- Aluminothermic welds shall be minimised.
- The up and down rail of a track shall be the same nominal rail section.

- 60 kg/m rail shall be fastened only with resilient fastenings.
- When replacing 53 kg/m with 60 kg/m rail, allowance shall be made for the 13 mm increase in rail height. Tolerances shall be checked in relation to vertical structure clearance, overhead wiring clearances and electric train stop arm heights.

6.5 Recycled rail (serviceable rail)

Recycled or serviceable rail may be selected for use in existing main line tracks and new or existing sidings in accordance with the requirements detailed in Table 1 and Table 2. The recycled rail categories are described in Table 3. Operating classification is as defined in TS 03510.

Table 1 – Permitted recycled rail use in mainline

Operating classification	Category 1 (white rail)	Category 2 (blue rail)	Category 3 (red rail)
Heavy freight option	Not permitted	Not permitted	Not permitted
Passenger main line	53, 60	Not permitted	Not permitted
Mixed passenger freight main line	53, 60	50, 53, 60	Not permitted
Light passenger or mixed freight line	47, 50, 53, 60	50, 53, 60	Not permitted

Table 2 – Permitted recycled rail use in sidings

Operating classification	Category 1 (white rail)	Category 2 (blue rail)	Category 3 (red rail)
General yard	53, 60	53, 60	Not permitted
Passenger operations/ or maintenance	53, 60	53, 60	Not permitted
Freight Siding	41, 47, 50, 53, 60	41, 47, 50, 53, 60	41, 47, 50, 53, 60
Passenger siding	41, 47, 50, 53, 60	41, 47, 50, 53, 60	41, 47, 50, 53, 60
Engineering maintenance siding	41, 47, 50, 53, 60	41, 47, 50, 53, 60	41, 47, 50, 53, 60

Table 3 – Rail category by wear limit

Rail section kg/m	Nominal rail width mm	Nominal rail depth mm	Category 1 rail (white rail) width mm	Category 1 rail (white rail) depth mm	Category 2 rail (blue rail) width mm	Category 2 rail (blue rail) depth mm	Category 3 rail (red rail) width mm	Category 3 rail (red rail) depth mm	Category 4 rail (green rail) width mm	Category 4 rail (green rail) depth mm
60 kg/m	70	44	≥ 66.5	≥ 35	≥ 63.5	≥ 35	> 46	> 26	≤ 46	≤ 26
53 kg/m	70	40	≥ 66.5	≥ 35	≥ 63.5	≥ 35	> 46	> 22	≤ 46	≤ 22
50 kg/m	70	40	≥ 66.5	≥ 35	≥ 63.5	≥ 35	> 47	> 22	≤ 47	≤ 22
47 kg/m	70	37	≥ 66.5	≥ 33	≥ 63.5	≥ 33	> 46	> 24	≤ 46	≤ 24
41 kg/m	63	35	≥ 60	≥ 30	≥ 57	≥ 30	> 41	> 23	≤ 41	≤ 23
80 lb/ yard AS (1937) 'B' (new)	64	40	≥ 60	≥ 30	≥ 57	≥ 30	> 41	> 23	≤ 41	≤ 23
80 lb/ yard AS (1928) 'A' (old)	70	37	≥ 66.5	≥ 27	≥ 63.5	≥ 30	> 46	> 23	≤ 46	≤ 23
80 lb/ yard AS (1916) (old)	70	37	≥ 66.5	≥ 27	≥ 63.5	≥ 30	> 46	> 23	≤ 46	≤ 23
80 lb/ yard AA (1907)	64	40	≥ 60	≥ 30	≥ 57	≥ 35	> 41	> 23	≤ 41	≤ 23

Note: Rail sections indicated in this document are as detailed in AS 1085.1–2002 Sup 1:2017.

Recovered 53 kg/m rail may only be used for the operating classes listed above for the repair of rail defects and conversion to CWR to match worn rails on existing 53 kg/m track.

53 kg/m rail which is recycled for use on passenger main lines or mixed passenger freight main lines may be used only on lines operating with less than 5 MGT per year and which do not have more than one MGT per year of 25 tonne axle load freight traffic.

For equivalent rail class (see Table 4).

Where category 1 or 2 recycled 53 kg/m rail is used in passenger main line or mixed passenger freight main line tracks, it shall only be used for the repair of rail defects and conversion to CWR to match worn rails in existing 53 kg/m main line track. Moreover, it shall only be used on lines operating with less than 5 MGT per year and which do not have more than 1 MGT per year of 25 TAL freight traffic.

Equivalent rail sections, as detailed in Table 4 may be used interchangeably.

Table 4 – Equivalent rail sections

Rail section	Equivalent sections
60 kg/m	Not applicable
53 kg/m	107 lb/yard AS 1936, 103 lb/yard AS 1936 & 100 lb/yard AS 1928
47 kg/m	50 kg/m AS 1981, 94 lb/yard AS 1937, 90 lb/yard AS 1928 (90 new) & 90 lb/yard AS 1925 (90 new)
41 kg/m	80 lb/yard AS 1937 'B' (new), 80 lb/yard AS 1928 'A' (old), 80 lb/yard AS 1916 (old) & 80 lb/yard AA 1907

While recycled Longwy and Micheville brands of rail, previously known as French rail, are permitted in crossing loops and in sidings they shall not be used on main line tracks.

Category 4 rail is painted green and shall not be used in track.

Recycled rails used for rerailing shall meet the following requirements:

- rail wear shall meet the classification limits given in Table 3
- rail shall be ultrasonically tested and have any defects removed
- rail surface defects (such as wheelburns, corrosion and pitting) shall be removed or corrected
- all cripples or dipped welds shall be removed or corrected
- rails with more than 6 aluminothermic welds in a 100 m length shall be graded no better than red
- rail shall not have excessive rust, and shall be checked for underfoot corrosion and any mechanical damage
- joint bolt holes shall be cropped

- rail shall meet the limits for proximity of welds
- rail end straightness, twist and other rail distortions shall meet the requirements for installation of aluminothermic welds or mechanical joints
- gauge face shall be reprofiled to the correct rail profile by removing any lip that has developed
- gauge face angle shall not exceed 26° to the vertical (as shown in Figure 1) when the worn face is within 15 mm of the lower edge of the rail head
- concavity of the gauge face of the rail shall not exceed 1.5 mm.

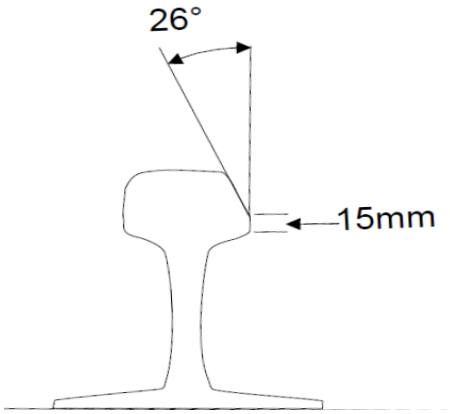

Figure 1 – Gauge face angle

Where it is necessary to grind one rail end to match the profile of an adjoining rail end, the maximum allowable rate of change in the rail head shall be 1 in 500. This is applicable in both the horizontal (as shown in Figure 2) and vertical plane (as shown in Figure 3) and any other plane where grinding is necessary.

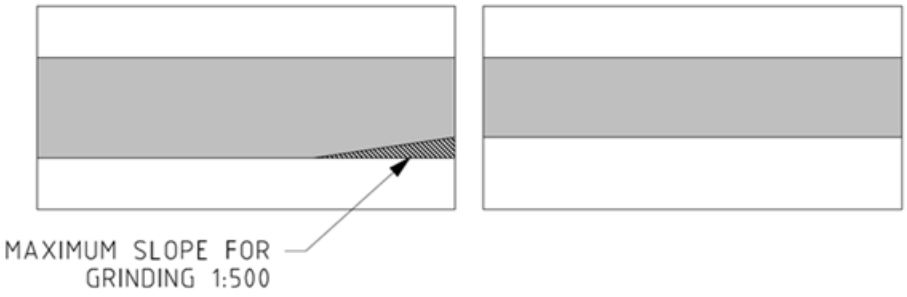

Figure 2 – Maximum slope for grinding – rail in plan

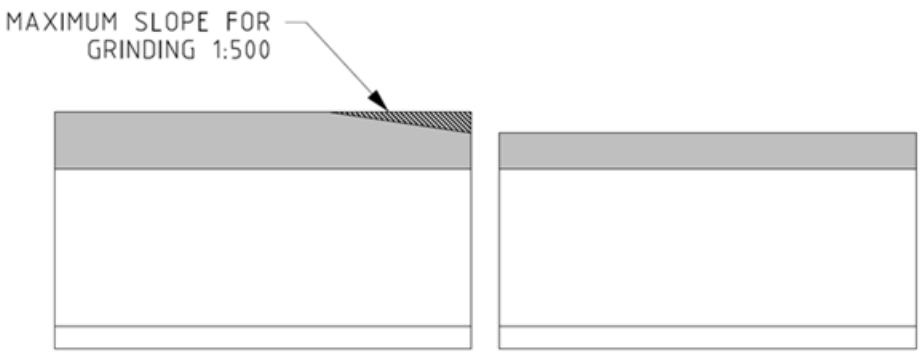

Figure 3 – Maximum slope for grinding – rail in elevation

6.6 Transposed rails

Rails subject to curve wear may be transposed and recycled in tangent track, subject to curve wear not exceeding the limits detailed in Table 5 prior to re-use.

Table 5 – Rail wear limits for transposing

Rail classification group	Rail section	Minimum head width 'B'
60	60 AS 1977 1981 2002	49
53	53 AS 1977 1981	49
53	107 AS 1936 1964	49
51	103 AS 1936	49
50	50 AS 1977 1981	50
50	100 AS 1928	52
50	100 AS 1916	58
50	100 C 1907	51
50	100 C 1901	52
47	94 AS 1937	49
45	90 AS 1928, 90 AS 1925	52
45	90 AS 1916	56
45	90 J 1913	52
41	80 ASB 1928	49
41	80 ASA 1928, 80 A 1916	56
41	80 AA 1906	48
41	80 A 1900	51
41	80 A (1) 1897	50
41	80 A (2) 1895	49
41	80 A (3) 1890	49
39	78 H 1903	55

Rail classification group	Rail section	Minimum head width 'B'
37	75 BHP 1917	48
36	71 2 D 1875	46
35	70 AS 1928, 70 AS 1925	52
35	70 AS 1916	48
35	70 lb 1910	48

Figure 4 shows rail wear measurement locations including the minimum permissible head width 'B' given in Table 5.

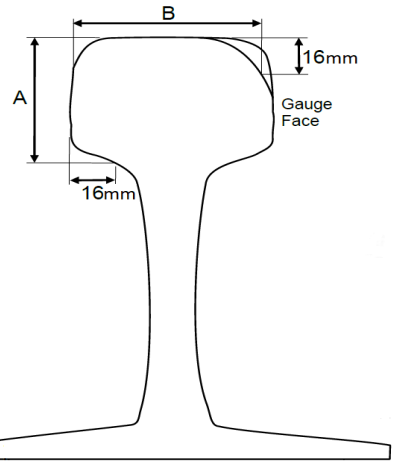

Figure 4 – Rail wear measurement locations

6.7 Rails in existing track

Requirements for worn rail shall be determined based on the RIM's current allowance for axle loads and speeds with consideration given to acceptable stress and fatigue cycles.

6.7.1 Rail wear

Worn rail in existing track shall comply with the following parameters:

- The RIM shall be responsible for determining the limits of rail head wear for the respective track classification.
- Rail head wear shall not exceed the limits shown in Table 6 unless approval has been obtained from the AMB.
- Rail head wear may be measured using a rail profile device or by taking top and side wear measurements (as shown in Figure 4).
- Top and side wear measurements shall be undertaken in accordance with Table 6.
- The measured head dimension shall be discounted for any metal flow outside the original rail profile.

- Considerations should be given to the combined effects of rail wear and track gauge widening in the determination of the rail head wear limits.
- The limits should apply to the worst location, and not the average rail wear, for the segment of track being considered (such as a curve).
- Individual limits should not apply to combinations of wear and defects as it may be necessary to adopt a lower limit.
- When approaching the rail wear limits, factors such as defect types, defect density and defect history should/shall be considered.
- Temporary speed restrictions can lead to an increase in rail stress in the low leg of curves.

Table 6 – Rail head wear limits

Axle load max	Sleeper type	Rail kg/m	Curve wear head width limit (B in Figure 4)	Tangent wear head depth limit (A in Figure 4)	Head loss % limit Curve radius 200 - 300	Head loss % limit Curve radius 300 - 400	Head loss % limit Curve radius 500 – 600	Head loss % limit Curve radius >600
23t	All	47	48	26	33%	33%	33%	33%
25t	All	53	48	26	33%	33%	33%	33%
Passenger	N/A	53	46	24	38%	38%	38%	38%
25t	Timber	60SC	46	26	40%	40%	43%	43%
25t	Timber	60HH	46	26	40%	44%	48%	52%
25t	Concrete	60SC	46	24	40%	47%	52%	55%
30t	Concrete	60HH	48	26	47%	51%	58%	60%
25t	Concrete	60HH	46	24	60%	60%	60%	60%

6.7.2 Rail defects

The RIM shall develop and document the following for the management of rail defects that is approved by the AMB:

- a technical maintenance plan (TMP) that includes a testing regime which outlines the frequency and identification of defects in rail in accordance with TS 01506.1
- processes and guidelines for testing of internal rail defects and for the acceptance testing of rail welds and weld repairs.
- response strategy to various rail defect sizes and limits based on track classification.

7 Allowable arrangements – rail welds

The requirements for flash butt and aluminothermic welds are included in Sections 7.1 and 7.2.

7.1 Flash butt welds

Flash butt welding processes shall meet the following requirements:

- LWR strings shall be supplied in accordance with the requirements of AS 1085.20. Type and proof testing shall be carried out using the method and frequency defined in AS 1085.20
- storage, transport and delivery of welded rail strings shall be in accordance with AS 1085.20.

Approved suppliers of LWR strings are available in TS 00021.

7.1.1 Rails approved for flash butt welding

Rails approved for flash butt welding into LWR strings are in Table 7.

Table 7 – Rails approved for flash butt welding

Rail section	Notes
60 kg AS 2002	As rolled
60 kg AS 2002	HH
53 kg AS 1981	As rolled
50 kg AS 2002	As rolled

For the rail sections nominated in Table 7, rail manufactured to the Australian standards published since the editions listed, are also approved for welding.

Only rails of the same weight and hardness may be welded by flash butt welding into welded rail strings unless approved by the AMB.

The minimum distance between flash butt welds shall be 5 m.

7.2 Aluminothermic welds

Aluminothermic welding processes and materials shall meet the following requirements:

- aluminothermic weld materials shall be supplied in accordance with the requirements of AS 1085.20. Type and proof testing shall be carried out using the method and frequency defined in AS 1085.20
- transport and storage of weld consumables shall be in accordance with AS 1085.20

- aluminothermic welding shall be undertaken by authorised competent personnel
- approved aluminothermic welds, including standard, wide gap and junction welds, and welding processes shall be in accordance with AS 1085.20.

7.2.1 Rails approved for aluminothermic welding

Rails approved for aluminothermic welding are in Table 8. For the rail sections nominated in Table 8, rail manufactured to the Australian standards published since the editions listed in Table 8 are also approved for welding.

Table 8 – Rails approved for aluminothermic welding

Rail section	Notes
60 kg AS 2002	Standard
60 kg AS 2002	HH
60 kg AS 1981	Standard
60 kg AS 1981	HH
53 kg AS 1981	Standard
53 kg AS 1981	HH
50 kg AS 1981	Standard
50 kg AS 2002	HH
107 lb AS 1936	Treated as 53 kg rail
103 lb AS 1936	Treated as 53 kg rail
100 lb AS 1928	Treated as 53 kg rail
47 kg AS 1981	Standard
94 lb AS 1937	Treated as 47 kg rail
90 lb AS 1928	Treated as 47 kg rail
90 lb AS 1925	Treated as 47 kg rail
90 lb AS 1916	Treated as 47 kg rail
90J 1913	Treated as 47 kg rail
41 kg AS 1977	Standard
80 lb AS 'B' 1928 (commonly called 80 NEW)	Treated as 41 kg rail
80 lb AS 'A' 1928	Treated as 41 kg rail
80 lb AS 1916 (both commonly called 80 OLD)	Treated as 41 kg rail

All other rail sections shall not be welded because of age, wear or suspect chemical composition.

Rails of dissimilar sections may be welded together using approved junction welds. The approved dissimilar sections that can be welded using aluminothermic welds are as follows:

- 60 kg/m to 53 kg/m
- 53 kg/m to 50 kg/m
- 53 kg/m to 47 kg/m
- 50 kg/m to 47 kg/m
- 47 kg/m to 41 kg/m.

7.2.2 Welding of Longwy and Micheville branded rail

Due to a high percentage of internal failures in Longwy and Micheville brands of rail (previously known as French rail) particularly vertical split webs, they shall not be welded into CWR lengths in main lines.

Field welding of Longwy and Micheville brand rails may be carried out in crossing loops and sidings, provided that ultrasonic testing is carried out and proves the rail satisfactory for welding.

Ultrasonic testing shall include a side scan on the web for a distance of no less than 1 m either side of the proposed weld.

7.2.3 Placement and installation requirements for aluminothermic welding

The following general placement and installation requirements apply:

- welds shall not be installed when directly exposed to moisture (for example rain or fog) unless protective methods approved by the AMB are used
- rail ends or aluminothermic welds shall not be located closer than 1.2 m from the centre of a glued insulated joint
- aluminothermic welds shall not be placed within 2.2 m of any weld or mechanical joint on plain track (main line or siding), except for when in turnouts
- when aluminothermic welds are installed opposite each other on adjacent rails, the gauge side of each weld shall be ground prior to the passage of trains
- welds shall not be installed on a sleeper or within 100 mm on either side of a sleeper (the preferred location of a weld is mid-sleeper bay)
- welds shall not sit directly on slab track
- welds shall not be located between sleepers of different types
- at least two sleeper bays shall separate a weld from a sleeper type transition

- aluminothermic welds shall not be located in the road surface of level crossings
- for new and major track works (including rerailing and track reconditioning), aluminothermic welds shall not be located within 10 m of the approach or departure to an underbridge or substructure, or within the stiffness transition zone between trackforms
- for track maintenance works (for example, removal of defects using rail closures), aluminothermic welds shall not be located within 6 m of the approach or departure to an underbridge or substructure, or within the stiffness transition zone between trackforms.

In turnouts and other special trackwork, the distance between a new aluminothermic weld may be reduced to a minimum of 1.2 m from an existing aluminothermic weld, flashbutt weld or joint, provided that:

- The existing weld or joint has no internal defects.
- The rail length shall be well secured by at least two sets of fastenings. Where ties are used, they shall be held by more than two rails such that they cannot skew if the rail breaks in two places.
- The new weld is ultrasonically tested within 6 hours of installation.

7.2.3.1 Closures

The minimum length of a closure to be welded into plain track is 2.2 m.

The closure length may be reduced to a minimum of 1.2 m in turnouts and other special trackwork provided that:

- The closure shall be well secured by at least two sets of fastenings. Where ties are used, they shall be held by more than two rails such that they cannot skew if the rail breaks in two places.
- The aluminothermic welds are ultrasonically tested within 6 hours of installation.

For all closures, the following shall apply:

- A flame cut rail end which has been left for more than twelve hours (four hours for HH rail) shall be re-cut immediately prior to welding, removing a minimum of 25 mm of rail.
- The closure shall conform to the existing rail with up to a maximum of 5 mm of gauge wear and 5 mm of mismatch in height (unless the rail is being welded using a junction weld in which case specified limits apply).
- For curves of up to 500 m radius, closures of less than 6 m in length shall have the last 600 mm of each end crowed to the correct curvature.

7.2.3.2 Welding near bolt holes

Where welding near bolt holes is required the following processes shall be followed:

- Bolt holes that have performed as a mechanical joint shall be closely examined for the presence of any damage. Such bolt holes shall be ultrasonically tested to confirm the absence of any rail defects. Any damaged bolt holes shall be removed.
- Bolt holes that are within 200 mm of a new weld shall be removed. However, the following exception applies.
- Where temporary mechanical joints have been used during rail installation in accordance with Section 9.2.1 welds shall be permitted to be installed to a minimum distance of 80 mm from a bolthole, this distance is to be maximised where possible and supplemented with the use of appropriate mitigating measures (such as deburring of the bolthole) to minimise rail related defects.

7.2.3.3 Welding near signal bonding holes

Aluminothermic welds shall not be placed within 80 mm of any holes drilled in the rail web for attachment of signalling bonds. This includes holes currently in use, those no longer in use and those that have been plugged.

8 Allowable arrangements – junction rails

Junction rails, that join rails with dissimilar sections, shall only be used as closures and shall be fully welded into the track.

Rails approved for use in junction rails are detailed in Table 9.

Table 9 – Rails approved for use as junction rails

Rail section	Notes
60 kg AS 1981, 2002	Standard
60 kg AS 1981, 2002	HH
53 kg AS 1981	Standard
53 kg AS 1981	HH
50 kg AS 1981	Treated as 53 kg rail
107 lb AS 1936	Treated as 53 kg rail
103 lb AS 1936	Treated as 53 kg rail
100 lb AS 1928	Treated as 53 kg rail
47 kg AS 1981	N/A
94 lb AS 1937	Treated as 47 kg rail
90 lb AS 1928	Treated as 47 kg rail
90 lb AS 1925	Treated as 47 kg rail
90 lb AS 1916	Treated as 47 kg rail
90J 1913	Treated as 47 kg rail

Rail section	Notes
41 kg AS 1977	N/A
80 lb AS 'B' 1928 (commonly called 80 NEW)	Treated as 41 kg rail
80 lb AS 'A' 1928	Treated as 41 kg rail
80 lb AS 1916 (both commonly called 80 OLD)	Treated as 41 kg rail

Approved arrangements are detailed in TS 00021.

9 Allowable arrangements – rail joints

Sections 9.1 to 9.5 set out the requirements for mechanical joints, temporary joints, insulated rail joints, fishbolts, washers, nuts and swage fasteners.

9.1 Mechanical joints

Rail joint design shall be in accordance with standard fishplated joints in AS 1085.2 or be equal to or exceed the performance of current proven designs.

Mechanical joints shall be constructed with a gap of 6 mm between rail ends at design neutral temperature of 35°C or as specified by the RIM's rail stressing strategy and defined neutral temperature.

9.1.1 Placement and installation requirements

The following placement and installation requirements shall apply:

- mechanical joints shall be installed suspended between adjacent sleepers
- permanent mechanical joints shall not be used on mainline track in the MRA
- mechanical joints in timber sleepered track with non-resilient fasteners shall be anchored as required in Section 5.5
- permanent mechanical joints shall be fastened through all six bolt holes, except for temporary mechanical joints as required in Section 9.2
- rail ends shall be saw cut to the following tolerances:
    - vertical –- ≤ 1 mm variation in the height of the rail
    - horizontal – ≤ 0.5 mm variation in the width of the rail
- bolt holes shall be drilled square to the web
- the size and location of bolt holes for the installation of mechanical joints shall be in accordance with the dimensions in AS 1085.2 and AS 1085.12

- mechanical joints shall be no closer than 6 m to each other, except in turnouts where shorter lengths are permitted, but shall not be less than 2.2 m apart
- mechanical joints shall not be used in continuously welded track, except within turnouts
- permanent mechanical joints shall not be used on bridges
- permanent mechanical joints shall not be located within 10 m of the approach or departure to an underbridge or substructure or within the stiffness transition zone between trackforms unless approved by the AMB
- mechanical joints shall not be installed within the following distance of bridge approaches:
    - 30 m of a transom top opening with spans less than 18 m
    - 60 m of a transom top opening with one or more spans ≥ 18 m long
    - 30 m of a ballast top opening ≥ 4.27 m long
- temporary mechanical joints on bridges shall be limited to no more than seven days

9.1.2 Prohibited arrangements

The following arrangements shall not be used:

- joints bored wide or tight giving a false reading of rail adjustment
- slotted plates (except as temporary or emergency rail joints)
- rail inserts
- rails with flame cut ends, except in temporary or emergency rail joints (see Section 9.2.2)
- rails with flame cut bolt holes, except in temporary or emergency rail joints (see Section 9.2.2).

9.2 Temporary joints

Temporary joints shall not remain in operational track any longer than detailed in Sections 9.2.1 to 9.2.3. Special conditions apply whilst they remain in track. Temporary joints may be used in the following circumstances:

- during rail laying, to allow train operations prior to welding into CWR
- during track restoration, to allow train operations prior to full repair of track.

9.2.1 Temporary bolted joints during construction

Where rail is required to be joined as a temporary measure during track construction or re railing and it is intended that the joint will be welded, the innermost bolt hole nearest the rail end shall not be drilled. The joint shall be fastened through the remaining 4 bolt holes. To limit damage to

the rail and to the track, these temporary joints shall not remain in track longer than 30 days if installed on concrete sleepers or 12 months if installed on timber sleepers.

9.2.1.1 Slotted fishplates

Slotted fishplates may be used as an interim measure during the laying of rail, or in emergencies, if a rail breakaway occurs and the track cannot be adjusted before use.

Slotted fishplates shall be removed as soon as the rail can be adjusted correctly. This shall occur prior to the commencement of train operations.

Slotted fishplates shall have properly prepared (machined) holes. Flame cut holes are not permitted.

9.2.2 Temporary bolted joints for emergency use

9.2.2.1 Use of flame cut rail ends

Running rails with flame cut ends shall only be used in extreme emergencies such as temporary track repairs following a derailment.

A speed restriction of 20 km/h shall be placed on the section until the flame cut rail end is removed.

If approved practices are followed, flame cut rail ends may be joined using aluminothermic welding processes.

9.2.2.2 Emergency use of flame cut bolt holes

Flame cut bolt holes may be used in an emergency to effect temporary repairs. A speed restriction of 10 km/h shall be placed on the section and the track continuously monitored until the flame cut bolt hole is removed.

9.2.3 Temporary non-bolted joints

Approved rail clamp assemblies may be used to create a temporary joint. Approved plates and clamps are detailed in TS 00021.Approved configurations and conditions of use are listed in Table 10.

Table 10 – Approved non-bolted joints

Clamp rail joints	Plate rail joints	Conditions of use
G-clamps (2 required)	Standard fishplates Bow plates	Maximum speed 30 km/h Remove within 12 hours
Robel clamps (1 or 2 required)	Standard fishplates Bow plates	Maximum speed 60 km/h Check and retighten within every 24 hours

Robel rail clamps may be used on 47 kg/m, 53 kg/m and 60 kg rail as an alternative to G-clamps provided the following conditions are met:

- they shall be installed in accordance with the manufacturer's instructions
- the clamp shall be mounted directly at the rail joint by using two fishplates
- bow plates may be clamped with 2 Robel rail clamps (one on each side of the bow).

9.3 Insulated rail joints

Insulated rail joint designs shall be equal to or exceed the standard insulated joints requirements in AS 1085.12.

Approved insulated joint arrangements, including proprietary designs are provided in Sections 9.3.1.1 to 9.3.1.6.

Insulated joint arrangements include the following:

- mechanical insulated joints
- insulated plate joints
- glued insulated joints.

The placement and installation requirements in Section 9.3.1 apply.

9.3.1 Placement and installation requirements

The installation of insulated joints shall meet the requirements in Sections 9.3.1.1 to 9.3.1.6. There may be instances where localised conditions affect the integrity of the insulated joint. Advice shall be sought from the RIM to determine what, if any remedial action is required.

9.3.1.1 General

The following requirements are applicable to all insulated joint installations:

- The locations of insulated joints shall be determined to meet the requirements of signal circuiting.
- Insulated joints shall be installed between adjacent sleepers of similar material with the insulating post placed centrally between the sleepers.
- Glued insulated joints shall be welded into the track.
- Insulated joints of any type shall not be installed on transom top bridges or within 30 m of bridge ends unless approved by the AMB.
- Insulated joints shall not be installed within the stiffness transition zone between trackforms or locations where additional track disturbance is likely.

- Mechanical insulated and insulated plate joints shall only be assembled with high tensile bolts.

  Where 53 kg/m and 60 kg/m insulated joints are to be installed with resilient fastenings, low profile clips shall be used to avoid fouling the bolts.

- When used with some baseplates in turnouts with timber bearers, low profile clips may still become foul of the joint bolts. Where this is the case, the offending clips shall be removed, subject to leaving at least one clip at each track plate set on opposite sides of the rail from one side of the joint to the other as shown in Figure 5.

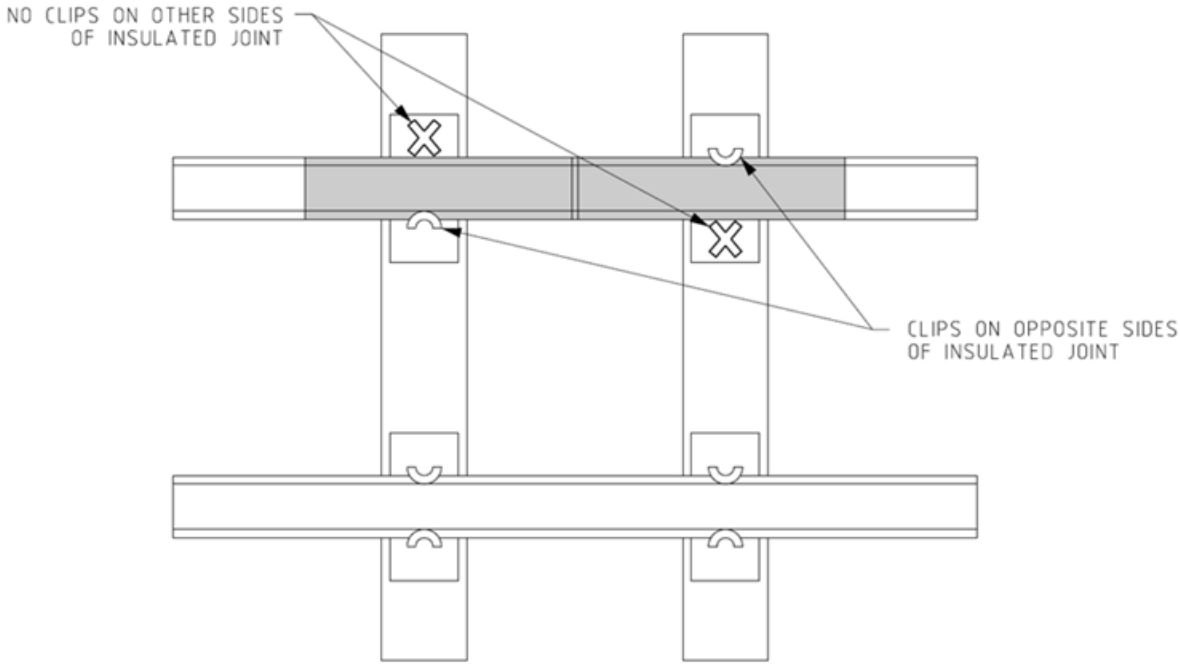

Figure 5 – Minimum clip arrangement at glued insulated joints

9.3.1.2 Mechanical insulated joints

A mechanical insulated joint is a field assembled rail joint using fishplates bolted together with insulating components.

The following requirements are applicable for the installation of mechanical insulated joints:

- they shall not be used in mainline track except in an emergency or as a temporary measure to suit short term construction staging
- they shall be anchored in accordance with Section 17 if installed on track with timber sleepers with non-resilient fastenings
- they shall be fastened through six bolt holes
- rail ends shall be square
- mechanical insulated joints shall not be used in CWR track.

9.3.1.3 Insulated plate joints

Insulated plate joints, such as Tenconi Benkler joints, comprise a pair of encapsulated fishplates that form a bolted assembly. The following are applicable for the installation of insulated plate joints:

- insulated plate joints shall not be used in mainline track except in an emergency or as a temporary measure to suit short term construction staging
- insulated plate joints may only be used in turnouts or diamond crossings on non-mainline legs; this excludes any direct connection with CWR plain track
- insulated plate joints shall be anchored in accordance with Section 17 if installed on track with timber sleepers with non-resilient fastenings
- insulated plate joints shall be fastened through six bolt holes
- curved track sections with insulated joints shall be formed in the field from straight fishplate pieces
- rail ends shall be square.

9.3.1.4 Glued insulated joints

Glued insulated joints (GIJ) are only approved for installation when preassembled in a workshop.

The following are applicable for the installation of glued insulated joints:

- Glued insulated joints are permitted on all tracks.
- All new glued insulated joints shall be grade A glued insulated joint assemblies manufactured in accordance with AS 1085.12 using six hole joint bars. Further acceptance testing may be required by the RIM (for example, Insulation testing) prior to installation in accordance with the RIM's procedures.
- Rail ends at the insulating post shall be cut at 15° to the perpendicular of the longitudinal axis as shown in Figure 6.
- HH rail shall be used to form glued insulated joints.
- Glued insulated joints manufactured with HH rail may be installed within non-HH rail sections.
- Glued insulated joints shall be pre-curved to suit the radius of the track in accordance with Table 11 and Table 12.
- In existing glued insulated joints, rail ends may be square or have a 15˚ cut to the perpendicular of the longitudinal axis as shown in Figure 6.

- For new turnouts, glued insulated joints shall be manufactured as part of the closure rails to avoid additional welds. This requires the location of the glued insulated joint to be determined in advance, in accordance with the signalling design.
- For existing turnout arrangements, a glued insulated joint unit may be welded into the turnout to form the closure rail.

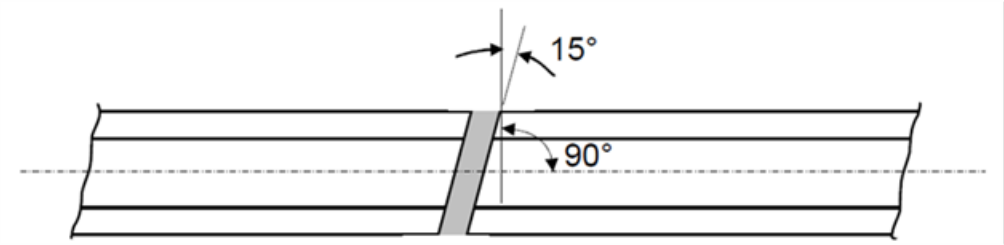

Figure 6 – Rail end angle

Table 11 – 3.43 m glued insulated joints

Curve radius	Measured full midordinate of track	Versine to be used
196 – 326 m	7.5 – 4.5 mm	6
326 – 980 m	4.5 – 1.5 mm	3
980 – straight	1.5 – 0 mm	0

Table 12 – 4.57 m glued insulated joints

Curve radius	Measured full midordinate of track	Versine to be used
217 – 326 m	12.0 – 8.0 mm	10
326 – 1305 m	8.0 – 2.0 mm	5
1305 – straight	2.0 – 0 mm	0

9.3.1.5 Insulated joints in turnouts and sidings

Glued insulated joints, insulated plate joints and mechanical insulated joints are approved for use in the turnout road of main line turnouts (that is, the route with lower speed and normally lower traffic) and in sidings.

Where practicable it is desirable that glued insulated joints be used in the turnout route of main lines, particularly if the turnout route is likely to see significant traffic. Otherwise, the use of insulated plate joints or mechanical insulated joints should be considered as the best option, balancing the location specific need for strength and electrical resistance.

9.3.1.6 Double glued insulated joints

Double glued insulated joint arrangements are not recommended for general use. They may only be used to maintain track circuit reliability at locations where rail head metal flow and bridging of insulation components is of concern.

The following are applicable for the installation of double glued insulated joints:

- They shall be the same as for single glued insulated joints as in Section 9.3.1.4.
- They may be used on straight track and curved track.
- They shall consist of 2 glued insulated joints 2.325 m apart as shown in Figure 7. The length of the double glued insulated joint is 5.765 m and is composed of three lengths of rail (1.720 m, 2.325 m and 1.720 m) rigidly joined by a pair of fishplates at each joint and adhesive insulating material.

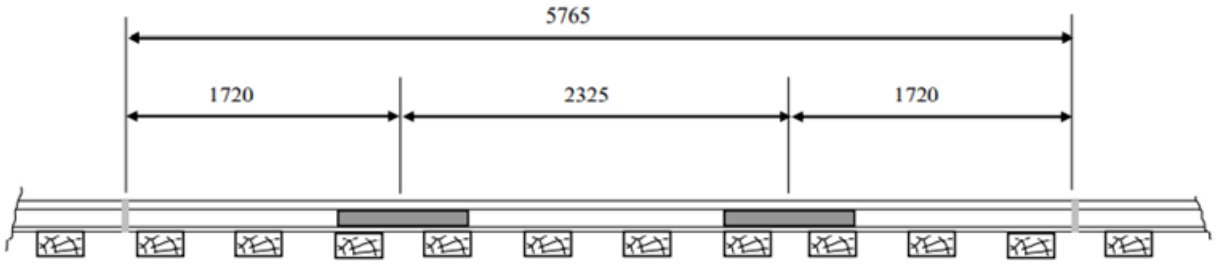

Figure 7 – General arrangement double GIJ

9.4 Fishbolts, washers and nuts

Fishbolts, washers and nuts used in conjunction with fishplates in mechanical joints shall be in accordance with AS 1085.4 and AS 1085.7. The length and diameter of standard fishbolts varies according to the rail sections in which they are being used as shown in Table 13.

Table 13 – Fishbolt sizes

Rail section – metric	Rail section – imperial coding	Fishbolt length	Fishbolt diameter
60		140	24
50 – 53	100 AS 28, 100 AS 25, 103 AS 36	140	24
53 AS 78	107 AS 36	140	24
45 – 40	90 AS 28, 90 AS 25, 80 AS ‘B’ 28	140	24
47 AS 78	80 AS 25, 94 AS 37	140	24
45 – 50	100 AS 21, 100 AS 16, 100CA 100C 90 AS 21, 90 AS 16, 90J	140	24
30 – 40	80 AS 21, 80AA 80A 78H 70 AS 28 60 AS ‘B’ 28	115	22
30 – 40	80 AS 16 80A 60 AS 25	115	22

Type 1 spring washers shall be in accordance with AS 1085.7. The nominal size shall be the associated bolt diameter.

9.5 Swage fasteners

Swage fasteners may be used in lieu of conventional fishbolts to provide a high strength fastening at fixed mechanical rail joints. Swage fasteners should not be used in open track in lieu of welding.

Swage fasteners are suitable for operating conditions with designed axle loads up to 30 tonnes at speeds of up to 120 km/h.

Only approved arrangements as detailed in TS 00021 shall be used.

Swage fasteners may only be used with fishplates meeting or exceeding the mechanical and chemical properties in AS 1085.2.

The following arrangements relate to the use of swage fasteners:

- Swage fasteners may only be applied to joints designed for no rail movement.
- Swage fastened mechanical joints may be used within turnouts and diamonds and between adjacent turnouts and diamonds, but they shall not be used directly adjacent to CWR plain track.
- The application of the swage fasteners is to be restricted to trackwork where the contacting surfaces and components of the joint can support the high clamping forces involved.
- Swage fastener heads and collars shall be fitted with washers made from cast or formed high strength steel to spread the clamping forces of the swage fasteners over a larger area. The hole diameter of the washer under collar shall not be larger than 1.5 mm in diameter more than the shaft size of the swage fastener.

10 Rail profiles (including rails in turnouts)

Rail profile management shall be determined to suit the RIM's rolling stock and provide an optimum wheel-rail interface which best manages ride and rail degradation issues.

10.1 Profiles and templates

New rails shall meet the rail profile requirements of AS 1085.1.

The RIM shall develop rail profiles and intervention frequencies that best suit their network through negotiation between the rolling stock and track maintainers to determine optimal wheel-rail interfaces for the network. The outcome of these negotiations shall be an operating procedure that requires the approval of the AMB before implementation. The system developed

shall maximise wheel and rail performance as well as effective train detection in track circuited areas

The operating procedure shall include the following:

- a table showing the profiles to be used for the various track geometry segments
- details of the minimum intervention periods for the various track geometry segments based on operational tonnage and track configuration
- a method of tracking grinding compliance against the approved intervention strategy.

The rail profiling management strategy shall include the following:

- All rail after installation requires an initial grind to an approved profile. All rail to be profile ground within 5 MGT (or 20% of the grinding cycle for preventive grinding (whichever is the larger) following the re-railing.
- Rail profiling can be achieved by either rail grinding, rail milling or other approved strategies as detailed in the operating procedure.
- Rail profiling shall be used for both preventive and defective rail management.

10.2 Tolerance to template

The rail shall be profiled so that the design template is achieved.

The maximum allowable gaps between the installed rail profile and the manual template shall be as follows:

- 0.20 mm (that is, a 0.25 mm feeler gauge shall not pass between the template and the ground rail head covered by the template) within the contact bands (minimum and maximum) on the contact band of any template. This includes the gauge corner area in the case of the high rail template.
- 0.40mm (that is, a 0.45 mm feeler gauge must not pass between the template and the ground rail head covered by the template) in the gauge corner and field side (up to 5 mm from the field side corner) regions outside the contact bands (minimum and maximum) where low and tangent rail templates have been used, and the field side region where the high rail templates have been used.
- If electronic measuring systems are used, the RIM shall determine the complying tolerances. These limits shall be at a tighter tolerance on the basis of ± values achieved through electronic measurements.

The application of these tolerances for manual measurement is illustrated schematically in Figure 8.

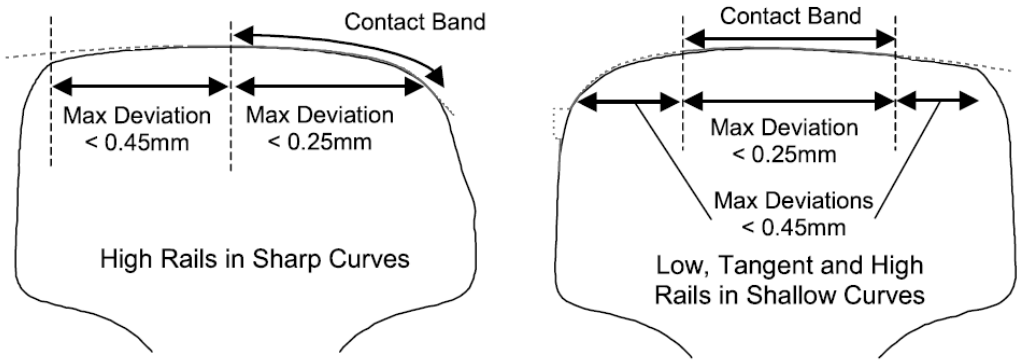

Figure 8 – Schematic illustration of rail tolerances and templates

The grinding process leaves visible facets on the head of the rail and gauge face. These facets shall be controlled if excessive contact stress points are to be avoided. The maximum facet width shall be as follows:

- 4 mm in the gauge corner region (refer to Figure 9).
- 10 mm elsewhere on the ground surface.

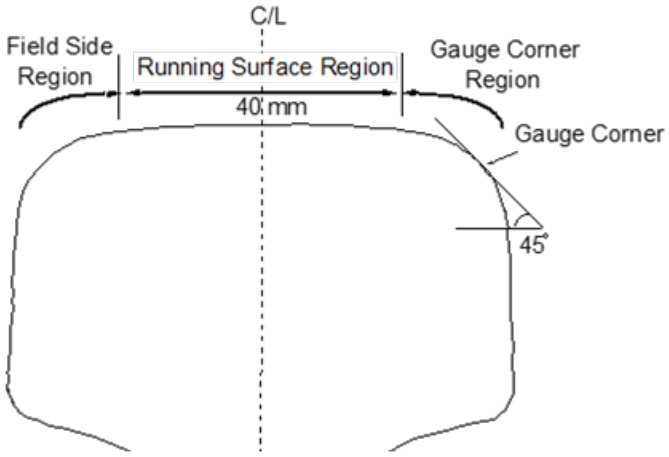

Figure 9 – Regions in 60 kg/m rail

In terms of rail profiling output, the operating procedure shall address the following requirements:

- there shall be no sharp ridges especially at the interface of facets
- there shall be no sharp "knife edge" on the outside edges of the rail that could cause a cutting injury
- there shall be no gouging on the rail surface and sharp scratches
- there shall be no indentations or longitudinal anomalies in the rail
- there shall be no cyclic grinding scratch marks
- there shall be no overheating (bluing) of the rail surface

- in noise sensitive regions the surface shall be no rougher than an average of 6 µm RA, while in other regions the surface shall be no rougher than an average of 10 µm RA.

10.3 Rail corrugations

When rail corrugations are measured at the centre of the running surface over any 1 m length, using a suitable measuring system the following criteria shall apply:

- short pitch corrugations (30-90 mm in wavelength) shall be removed, so that the remaining cyclic average longitudinal unevenness along the rail surface (peak to peak) shall be less than 0.015 mm, and the remaining longitudinal unevenness along the rail running surface shall be less than 0.05 mm
- longer pitch corrugations (about 200 – 450 mm in wavelength) shall also be removed, so that the remaining average longitudinal unevenness along the rail running surface (peak to peak) shall be less than 0.1 mm over any 1 m length.

11 Rail repair – permitted applications

Wire feed welding and aluminothermic rail head repair applications are detailed in Sections 11.1 and 11.2. Approved processes and materials are in TS 00021.

11.1 Wire feed welding

Wire feed welding processes may be used to perform the following repairs:

- repair or refurbish in-service fabricated and welded crossings manufactured from standard carbon and HH rail
- repair or refurbish in-service manganese cast crossings
- repair wheel burns, small transverse defect at engine burn, dipped aluminothermic and flashbutt welds in standard carbon rail, and in HH rail where axle loads do not exceed 27 tonnes and proposed welding depth is less than 12 mm.

Wire feed welding processes shall not be used on unconstrained rail (that is rail not fastened to the sleeper component of the track structure on both sides of the welding area) including parts of turnouts and other special trackwork.

11.2 Aluminothermic rail head repair

Aluminothermic rail head repair processes and materials for use on plain track shall meet the following requirements:

- aluminothermic rail head repair materials shall comply with the requirements of AS 1085.20
- type and proof testing shall comply with the requirements of AS 1085.20.

12 Rail lubrication

Rail lubrication systems shall be installed to reduce friction at the wheel rail interface to minimise consequential wheel and rail wear, excessive noise and unnecessary train energy consumption.

Rail lubrication should be optimised to achieve the required wheel-rail performance and minimise the likelihood of train detection failures.

Rail lubrication systems (number, location, spacing of lubricators and type of lubricant) shall be designed to meet the requirements in TS 03608.

12.1 Lubricator and lubricant types

Only type approved combinations of lubricators and lubricant greases shall be installed.

All type approved lubricator and lubricant combinations are listed in TS 00021.

12.2 Installation

Lubricators shall be installed and maintained in accordance with manufacturers' specifications.

New lubricator installations shall not be fixed by bolting through the rail.

Lubricator installations shall comply with all environmental aspects with respect to the application of the lubricant.

13 Rail adjustment

Rail in track, with the exception of rail lengths located more than 50 m inside tunnels, shall be adjusted to be stress free at a rail temperature (neutral temperature).of 35°C or as specified by the RIM's rail stressing strategy and defined neutral temperature.

For rail adjustment methodology refer to the relevant RIM's documents.

Rail in track located more than 50 m inside tunnels may be welded without further adjustment.

Rail shall be installed as standard welded track (CWR or LWR) in accordance with configuration requirements in TS 03510.

13.1 Long welded rail

The following requirements shall apply for the management of LWR:

- LWR shall be longer than 27.4 m
- the maximum LWR lengths shall be as follows:
    - 110 m for curved track < 600 m radius
    - 220 m for curved track ≥ 600 m radius
    - 220 m for tangent track.
- the fastening system shall be sufficient to prevent rail creep but not inhibit LWR's ability to accommodate thermal effects in the rails
- LWR shall be fastened to sleepers/sleeper plates with combinations of either non-resilient fastenings and anchors or non-resilient and resilient fastenings
- LWR shall not be fitted with more than 1 in 3 resilient fastenings
- mechanical joints in LWR shall be installed and maintained with a gap of 6 mm at rail temperature (neutral temperature) of 35°C or a gap distance as specified by the RIM at the defined neutral temperature
- an appropriate track structure arrangement as in TS 03510, shall provide the required resistance for the management of rail stresses, both lateral and longitudinal
- where non-resilient rail fastenings and Fair type rail anchors are specified in the design, the minimum anchoring requirements for LWR shall be as specified in Section 5.5.

13.2 Continuous welded rail

The following shall apply for the management of CWR:

- CWR shall be longer than 220 m
- CWR shall be adjusted to a stress free rail temperature (neutral temperature) of 35°C or as specified by the RIM’s rail stressing strategy and defined neutral temperature except in tunnels as in Section 13
- CWR shall be installed in accordance with the design alignment referenced to the track control marks as appropriate
- creep monitoring points shall be installed within 14 days of adjustment-creep monitoring facilities shall be located at every half kilometre at a minimum
- an appropriate track structure arrangement as in TS 03510, shall provide the required resistance for the management of rail stresses, both lateral and longitudinal
- CWR may be fitted with resilient fastenings or non-resilient fastenings and anchors

- CWR fitted with more than 1 in 4 resilient fastenings does not require supplementary anchoring, except where required by Section 14
- where non-resilient rail fastenings and Fair type rail anchors are specified in the design or where less than 1 in 4 resilient fastenings are installed, the minimum anchoring requirements for CWR are as in Section 14.

14 Rail anchoring

Rail anchoring requirements shall apply to all classes of track constructed with timber or equivalent sleepers and non-resilient fastenings.

Rail anchoring system configurations include the following:

- Fair type rail anchors
- resilient rail clips
- zero toe load resilient fastenings.

Only approved rail anchoring configurations shall be installed.

Rail anchors shall meet the requirements of AS 1085.10.

14.1 Anchoring of ballasted welded track

Welded track, both LWR and CWR, shall meet the following minimum anchoring requirements:

- double (or box) anchor every fourth sleeper except at mechanical joints
- double anchor every second sleeper for a distance of 32 sleepers either side of mechanical joints, starting at the second sleeper from the joint.

Basic anchoring of sleepers is where sleepers are anchored on both sides (double or box anchoring) of each rail. On track with a falling grade steeper than 1 in 80 in the direction of travel, or at other locations where considered necessary to control rail creep, the anchoring shall be increased by adding single anchoring each second sleeper (or on every sleeper, if necessary) throughout the welded rail length, to prevent rail creep.

14.2 Anchoring of insulated joints in welded track

At mechanical insulated joints every sleeper shall be double anchored for a distance of 32 sleepers on either side of the joint.

Glued insulated joints are considered as plain track and anchored in accordance with Section 13.1.

15 Management of welded track on bridges

The interaction between track and bridges results in forces in the rails and in bridge decks and their bearings, as well as displacements of the various bridge and track elements.

The requirements for management of welded track on bridges are detailed in Sections 15.1.1 to 15.1.3.

In the case of multi-span bridges with a continuous structure length supporting the track, the total length of the continuous bridge structure between the fixed and the moveable ends shall be considered, rather than the individual span lengths.

Guard rails and fastening systems shall be installed in accordance with TS 02401.

15.1.1 Transom top bridges

The following requirements shall be applied when welded rail is installed over bridge spans with expansion gaps:

- transom top bridges with spans < 18 m:
  - standard anchoring for welded rails on open track as detailed in Sections 14.1 shall be applied for welded rails over bridges of this length
  - on bridges where resilient fastening assemblies are in the majority or entirety, rail anchors shall be installed over the entire length of each span
- transom top bridges with spans ≥ 18 m long but < 80 m:
  - for track with non-resilient fastenings:
    - for a distance of 60m from a bridge end, the track shall be double anchored on every second sleeper
    - commencing at the fixed end of the bridge, the track shall be double anchored to every second transom for half the span length
  - for track with resilient fastenings:
    - commencing at the fixed end of the bridge, normal elastic fastenings shall be installed on one third of the span, and zero toe load resilient fastenings shall be installed on the remaining two thirds of the span
    - where bridge spans are located on curves < 400 m radius, zero toe load fastenings shall not be used
- transom top bridges with spans ≥ 80 m:
  - expansion switches shall be installed at the expansion end of the span or spans

- between expansion switches, the rails shall be double anchored to every fourth transom
- on bridges with non-resilient fastenings, normal elastic fastenings shall be installed over the entire length of each span.

15.1.2 Direct fixed bridges

For concrete and other track support structures, an assessment shall be made of the expansion requirements of the bridge structure as it affects the rails as follows:

- Direct fixed structures with spans < 25 m:
  - Where resilient fastenings are specified they shall be installed over the entire length of each span.
- Direct fixed structures with spans ≥ 25 m:
  - An assessment shall be made of all expansion requirements and appropriate zero toe-load fastenings specified. Prior to installation, completed assessments shall be submitted to the AMB for approval.

15.1.3 Ballast top bridges

The following requirements shall be applied for welded rail on ballast top structures:

- Ballast top structures with spans < 40 m:
  - Standard anchoring shall be provided as detailed in Section 14 for welded rails in open track that are installed on bridges of this length.
- Ballast top structures with spans ≥ 40 m:
  - The relative interaction of the track structure and the bridge structure shall be assessed. The assessment shall take into account all expansion requirements and the appropriate use of zero toe-load fastenings. Prior to installation, completed assessments shall be submitted to AMB for approval.

16 Rail at friction buffer stops

Friction buffer stops operate by sliding on the rail surface and applying progressive resistance to motion. They shall be compatible with the rail profile to permit for the sliding action. Refer to TS 03610 for specific requirements.

The condition of the rail surface shall not interfere with the free movement of the buffer stop. To achieve this, the following requirements shall apply:

- No joints or aluminothermic welds shall exist within the friction buffer stop activation length.

- No other attachments to the rail that would impede the operation of the buffer stop shall be present.
- Where flash butt welds are installed they shall be ground flush with the rail profile. There shall be no embossing on the rail in the activation length.
- Rail within the buffer stop total length (LT) shall be clear of any obstructions.

17 Connections to rail in open track

Temporary or permanent connections may be made to rails for the following purposes:

- signalling or electric traction currents
- the connection of other track components
- the attachment of wayside devices.

Examples of rail connection methods are:

- cad welding
- drilling
- clamping (this is the preferred methodology for attachment).

All connection methods shall be approved by the RIM.

The use of any other rail connection method shall require authorisation of the AMB.

The following restrictions shall apply:

- the centre of all drilled holes shall lie within 5 mm of the neutral axis of the rail for rail sizes of ≥ 41 kg/m and shall not be greater than 27 mm in diameter
- attachments to the lower rail web area shall not cause notching to remain in service
- no attachments shall be welded or drilled to the rail foot area.

18 Acceptance standards – rail

Any new rail installed in track circuited areas shall have its running surface region cleaned or ground to ensure there is sufficient unimpeded contact for signalling systems to function. This requirement shall apply to running rails and rails in special trackwork.

19 Acceptance standards – rail joints

The maximum permitted vertical deviation at a discontinuity such as a rail joint is 1 mm. New joints cut into the track shall have matching profiles at the gauge face and running surface. Where re-profiling is required to achieve the above requirement the re-profiling slopes should be as depicted in Figure 2 and Figure 3.

20 Acceptance standards – rail welding

Rail welding applied to rails within the MRA that shall meet the requirements of AS 1085.20 as a minimum.

All ultrasonic examination of rail welds shall be undertaken by the RIM's approved and prescribed ultrasonic rail examination procedures.

Only personnel holding formal competency for specific ultrasonic procedures shall undertake ultrasonic examination.

20.1 Flash butt welding

All welds shall be tested and meet the following requirements prior to the operation of any rail traffic, with the exception of slow speed track machines:

- Defects in welds:
  - For internal defects all ultrasonic indicators shall be below reportable limits as detailed in Table 14.
  - Visual defects will be in accordance with table 3-1 in AS 1085.20:2020.
- Weld collar tolerances – deviation from rail profile as follows:
  - At rail web, upperside and underside of the rail foot shall be in accordance with table 3-1 in AS 1085.20:2020.
- Surface alignment tolerances as follows:
  - Vertical alignment tolerance grade is AT3 in accordance with AS 1085.20. The top surface shall be checked with a 1 m straight edge as illustrated in Figure 10 and Figure 11. The permitted tolerances are for rail on concrete sleepers as shown in Table 15.
  - Horizontal alignment tolerance grade is AT3 in accordance with AS 1085.20. The rail alignment shall be checked with a 1m straight edge as illustrated in Figure 12 and Figure 13. The permitted tolerances are for rail on concrete sleepers as shown in Table 15

20.2 Aluminothermic welds

All new aluminothermic welds shall meet the acceptance requirements in Sections 20.2.1 to 20.2.3.

20.2.1 Internal condition

All new welds shall be ultrasonically tested in accordance with the RIM's inspection processes. All new aluminothermic welds shall be defect free in accordance with the RIM's requirements and shall not exceed the limits in Table 14.

Table 14 – Internal rail defect reporting limits

Defect type	Probe movement for size definition (mm)
Transverse defects (TD) head 70 ° probe	< 40
Defective wire feed weld (DWFW) head 70 ° and T/70 ° probe	< 25
Bolt hole cracked (BH) web 38 ° probe	< 20
Defective welds (DW) head 70 ° and 0 ° probe	< 40
Defective welds gassing defects DW gassing full weld 0 ° probe	Loss of weld base signal over < 35 or width of weld
Defective welds All horizontal web defects (HSW, HWS, FWS)	< 15
Defective welds (DW) web/centre foot 38 ° probe	< 25 When testing new flash butt welds remove all non-standard foot centre indications
Defective welds (DW) foot Twin 70 ° probe	< 15
Vertical split head (VSH) 0 ° and twin 70 ° probe	< 50 long or < 3 high
Vertical split web (VSW) 0 ° probe	Any registration in rail length
Transverse split web (TSW) 0 ° probe	< 20
Piped rail (PR)	< 25
Horizontal split web (HSW) 38 ° & 0 ° probe	< 20
Horizontal split head (HSH) 38 ° and 0 ° probe	< 25
Head and web separated (HWS) 38 ° and 0 ° probe	< 20
Foot and web separated (FWS) 38 ° and 0 ° probe	< 20

20.2.2 Surface condition of welding

All welds shall be profiled to match the entire section of the rail head each side of the weld with no visible deviations from a straightedge.

20.2.3 Geometry

Sections 20.2.3.1 to 20.2.3.2 detail the requirements for weld straightness and alignment.

20.2.3.1 Weld straightness

Weld faces shall be perpendicular to the top surface of the rail, with no more than 5 mm mismatch between the top of the head of each rail when the feet are matched.

20.2.3.2 Weld alignment

Sections 20.2.3.2.1 and 20.2.3.2.2 detail the requirements for weld alignment on straight and curve track.

20.2.3.2.1 For straight track

The top surface and rail alignment shall be checked with a 1 m straight edge as shown in Figure 10 and Figure 11 (top surface) and Figure 12 and Figure 13 (alignment). The permitted tolerances, indicated as A, B, C and D are in Table 15.

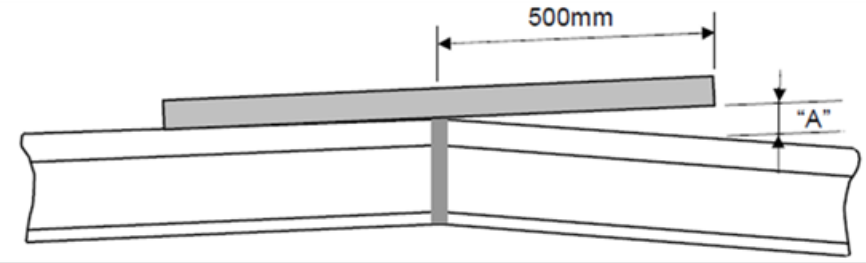

Figure 10 – Weld misalignment tolerance in vertical plane (peaking)

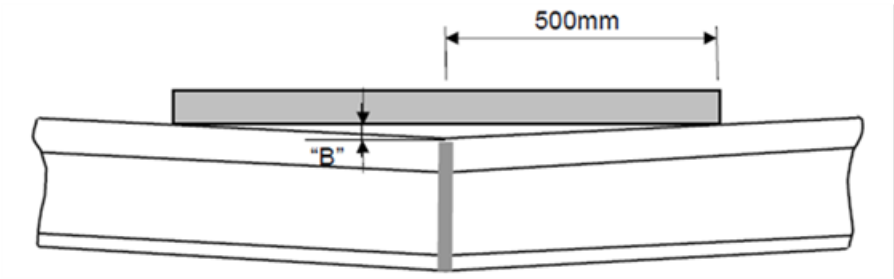

Figure 11 – Weld misalignment tolerance in vertical plane (hollow)

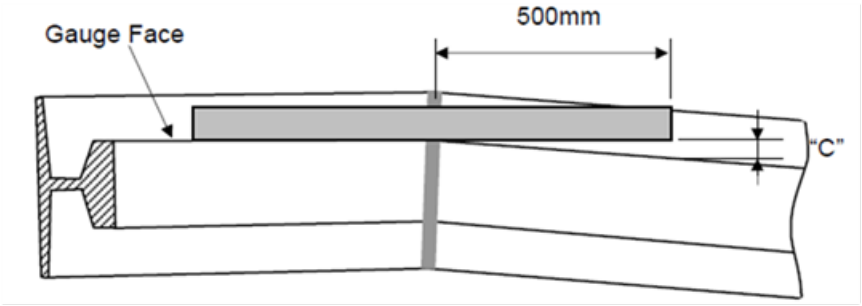

Figure 12 – Weld misalignment tolerance in horizontal plane (tightening)

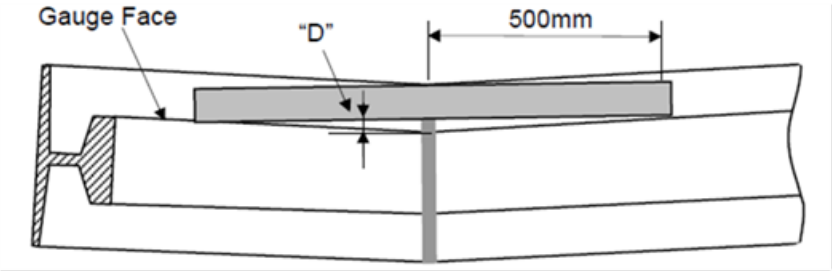

Figure 13 – Weld misalignment tolerance in horizontal plane (widening)

Table 15 – Weld surface/alignment limits

Weld surface/alignment limits	'A' mm	'B' mm	'C' mm	'D' mm	Vertical step mm	Horizontal step mm
For rail on concrete sleepers (new rail or rail in good condition)	0.6	0.3	0.6	0.3	± 0.3 over 100	± 0.3 over 100
Other situations	1.0	0.5	1.0	0.5	± 0.3 over 100	± 0.3 over 100

20.2.3.2.2 For curved track

Top surface requirements shall be the same as for straight track.

The horizontal alignment of the newly welded portion of rail shall have a curvature consistent with the curvature of the existing rail, and the gauge face at the weld shall be smooth and continuous. There shall be no visible elbow at the weld.

21 Acceptance standards – rail head repair welds

All new rail head repair welds shall meet the acceptance requirements in Sections 21.1 to 21.2.

21.1 Internal condition

All welds shall be ultrasonically tested. All ultrasonic indicators shall be below reportable limits as detailed in Table 14.

21.2 Surface geometry and condition

All welds shall be ground to the profile of the rail head each side of the weld with no visible deviations from a straightedge.

The top surface shall be checked with a 1 m straight edge as shown in Figure 14 and Figure 15. The permitted tolerances are shown in Table 16.

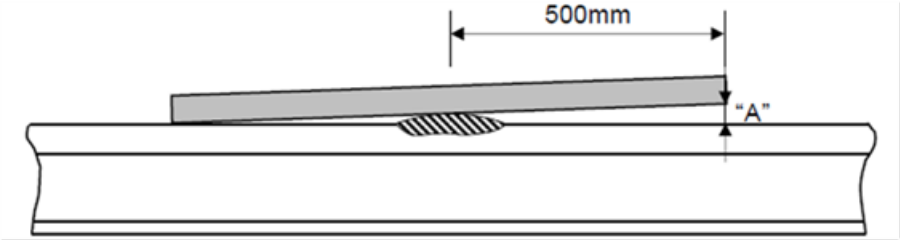

Figure 14 – Head repair misalignment tolerance in vertical plane (peaking)

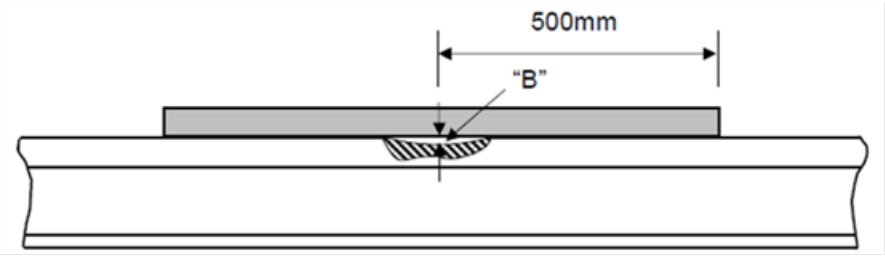

Figure 15 – Head repair misalignment tolerance in vertical plane (hollow)

Table 16 – Head repair weld surface limits

Weld surface limits	A mm	B mm
For rail head repair welds	0.6	0.3

The gauge face will normally be parent rail and shall be visibly smooth and consistent with the curvature of the existing rail.