

# Section 1: Rail

ETS-01-00

## Applicability

ARTC Network Wide

SMS

## Publication Requirement

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## Primary Source

Section 1: Rail

## Document Status

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**Amendment Record**

AMENDMENT VERSION #	DATE REVIEWED	CLAUSE	DESCRIPTION OF AMENDMENT
1.0	19 Mar 24		Document renumbered to ETS-01-00.  Internal Defect Assessment tables are amended.  Inspection and Assessment reformatted.  Rail lubrication maintenance and servicing removed.  "Risk Control" for rail wear removed.
1.1	02 Jul 24		Update aimed to address unclear responses to internal rail defects. Table 1-22 to 24 have been updated.
1.2	08 Aug 24		Table 1-22 table has been updated to correct typo
1.3	6 May 25		Addition of a Transverse defect (split web) in web/foot in Table 1-22 and Table 1-24.  Minor formatting adjustments to Table 1-22 to resolve interpretation issues.  Revised wording in Table 1-3 for matching profile to improve clarity.
1.4	07 Jul 25		References updated and patrol tasks updated for rail contamination.

**MANDATORY REQUIREMENTS ALSO EXIST IN OTHER DOCUMENTS.**

**WHERE A CONFLICT OF REQUIREMENTS OCCURS, THE MANAGER ENGINEERING SERVICES SHALL BE INFORMED SO THE AMBIGUITY CAN BE REMOVED. PENDING REMOVAL OF THE AMBIGUITY THE INTERPRETATION WITH THE SAFEST OUTCOME SHALL BE ADOPTED.**

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## 1 Section 1: Rail

### 1.1 General

#### 1.1.1 Reference Documents

The following documents support this standard:

- ETP-00-03 Civil Technical Maintenance Plan
- ETA-01-02 ARTC Straightedge Specification
- ETA-01-03 Supply of Field Assembled Mechanical Insulated Joint Components
- ETE-01-02 Ultrasonic Testing by Continuous Rail Flaw Detection Vehicle
- ETA-01-05 Non-Destructive Testing of Rail
- ETM-01-02 Rail Profiling
- ETM-06-10 Stressing Plain Line CWR
- ETM-06-11 Adjusting Plan Line Jointed Rail
- ETN-01-06 Weld Quality Management Manual

#### 1.1.2 Definitions

The following terms are used within this document:

TERM	DEFINITION
AMS	Asset Management System
CER	Civil Engineering Representative as per PEO-PR-008 Engineering, Design and Project Management Identification of Competence Procedure
COP	ARTC Track & Civil Code of Practice
Continuously Welded Rail (CWR)	Rail lengths welded end to end into strings greater than 400m without rail joints.
Design SFT (DSFT)	The SFT to which CWR is to be adjusted during stressing. On the ARTC network it is typically 38°C.
Dispensation	Short-term occasional failure to comply with the requirements of an ARTC Standard for short periods on discrete sites, where there is a reason, supported by – <ul style="list-style-type: none"> <li>• Assessment of risk</li> <li>• Risk control measures</li> <li>• Time bound action plan to return to compliance</li> </ul>
Equivalent Standard	A suitable alternative standard approved by the Manger Engineer Services
RIW	Rail Industry Worker – Competency Management System
Stress free	Rail which has no axial thermal forces, it is neither in compression nor in tension.
Stress free temperature (SFT)	The temperature at which the rail in CWR is stress free. If the rail were to be cut, the gap created would remain constant. It would neither close nor would it widen unless the rail temperature were to change.

## 1.2 Design

### 1.2.1 Rail Grades

The recommended minimum rail sizes are given below in Table 1-1.

Table 1-1: Rail Size Selection

TRACK CLASSIFICATION	RAIL SIZE (KG/M)	
	EXISTING TRACK	NEW CONSTRUCTION
Heavy Haul	60	60
Interstate Lines	47/53/60	60
Dual Gauge Standard/Broad	47/50/53	50
Dual Gauge Standard/Narrow	47/50/53/60	60
Main Intrastate Lines	47	50
Light Weight Intrastate Lines	40	41

### 1.2.2 Rail Specification

The following rail steels are approved for purchase for re-railing and component manufacture.

- Liberty OneSteel Standard Carbon
- Liberty OneSteel Head Hardened
- Voestalpine 350 HSH

The use of alternate steels is subject to type approval.

**Note:** *Components (such as switches and insulated joints) that have been manufactured using alternate rail steels and procured prior to 1st March 2022 may be used without type approval for the rail used.*

All new rail should be purchased undrilled and is to comply with the following Standards:

- 53 kg rail cross section shall comply with AS 1085.1 (1980) Railway Permanent Way Material Part 1: Steel Rails (superseded). All other properties shall comply with AS 1085.1 Railway Track Material Part 1: Steel Rails.
- 41 kg, 50 kg and 60 kg rail shall comply with AS 1085.1 Railway Track Material Part 1: Steel Rails or equivalent Standard.
  - Track with tighter curvature below R800m should use 60kg/m that complies with AS 1085.1 or equivalent standard. This profile suits the high leg of tight curves with most common wheel profiles and is acceptable for low legs until first grind occurs.
  - Track with curvature above R800m (particularly tangents) should use 60kg/m that complies with all aspects of AS 1085.1 or equivalent standard, except for the modified head profile shape as specified in Appendix A – Modified 60KG/M Tangent Profile.

Rail Purchased for use in CWR track should be obtained in lengths as long as possible to minimise the number of welds in track.

#### 1.2.2.1 Use of modified profile 60kg rail sections – Tangent tracks

60 kg/m rail can be sourced in two head profile forms to suit different track configurations. The purpose of differing head profiles is to eliminate the need for grinding the new rails immediately following installation. Where 60kg rail is to be installed in large scale tangent track sections, typically >10km length, consideration should be made to the rail section head profile being used.

Where deemed suitable for business cost and project timing goals, a modified version of the AS1085.1 Rail section with a different head profile shape in the wheel contact zone is allowed as per the specification dimensions shown in Appendix A – Modified 60KG/M Tangent Profile. This profile is specifically designed for tangent tracks above 800m radius curvature. All other specifications from AS1085.1 remain unchanged. Marking of this modified 60kg rail profile shall comply to AS1085.1, however with the removal of the rolled in “1085.1” portion of the branding (AS to remain) and the addition of brand modification letter “T”, to indicate Tangent.

The profile is primarily suited to Non- Heavy Haul – Interstate tracks as an alternative option for installation of new 60kg/m rail on curvature above radius 800m, particularly on high-speed tangents. Use of the new design profile is not desirable on tighter curvature and may also not meet the demands of heavy haul tracks above 25TAL without profile grinding at installation.

Noting that decisions around the use of Head Hardened rail are not affected by these head profile options, rail hardness and installation grinding practices shall still be assessed separately using the relevant sections of the Code of Practice.

#### 1.2.3 Track deflection limits

A design track deflection of 6.35 mm or less is desirable. Where the design track deflections under the vehicle design loads exceed 9 mm, to account for an expected increase in deterioration rates of the actual track structure condition, it is recommended that the specified inspection and assessment frequencies be reviewed.

#### 1.2.4 Rail Welding

Approved welding processes for joining rails include the following:

1. Aluminothermic
2. Flashbutt

Where possible, flashbutt welds should be used preferentially to aluminothermic welds.

Flashbutt welding processes shall be qualified as per 1.3.9.1.

Aluminothermic welding kits shall be type approved.

### 1.2.5 Mechanical Joints

Mechanical joints should not be used on concrete sleeper track with a speed >40km/h.

Mechanical joints are not permitted on bridges or within 30m of a bridge end.

The rail joint design shall be in accordance with standard fish plated joints covered in AS 1085 or be equal to or exceed the performance of current proven designs.

Expansion switches, junctions and other permanent joints not covered by AS 1085 shall be supplied in compliance with the specified design.

Fish plated rail joint components should be manufactured to conform to the appropriate Australian Standards. These standards generally define the materials, material tests, manufacture, design and specification of the component, and component testing and compliance:

1. Fishplates AS 1085.2
2. Fishbolts and nuts AS 1085.4
3. Spring washers AS 1085.7

In crossings, turnouts and other locations where fixed joints are used, the use of swage lock fastenings is an alternative method of fastening in lieu of bolts. Care should be taken however to ensure that the joint components can support the forces imposed by this type of fastening due to the tensile loading across the fastening.

### 1.2.6 Insulated Joints

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*Note: This section refers to factory assembled insulated joints. For field assembled insulated joints refer to ETA-01-03.*

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Insulated joints shall conform to AS1085.12 or comply with an equivalent standard. Where insulated joints supplied in according with AS1085.12 shall meet the following requirements.

1. Insulated joints used in main lines (as per CoP: Section 0) containing rails heavier than 47 kg/m rail shall be manufactured from head hardened rail as per AS1085.12 and meet the requirements of Grade A1
2. Insulated joints used in main lines (as per CoP: Section 0) containing 47kg/m rails shall be flame hardened as per A1085.12 and meet the requirements of Grade B
3. Insulated joints used in sidings (as per CoP: Section 0) shall be standard carbon as per A1085.12 and meet the requirements of Grade B if not of the same standard as main line.
4. Fishplates shall be of the six-hole bar type and conform to AS1085.2
5. Insulated joints shall incorporate C50L, M24mm high grade swage lock fastenings.
6. Rail ends shall be angle cut as provided for in AS1085.12. Angle cutting shall be at 15 degrees to a line square across the rail head.
7. The profile of the end post shall be as per AS1085.12. The thickness shall be 6.0mm  $\pm$ 1mm.
8. Insulated joints placed in curves should be pre-curved to suit the radius of the track.

## 1.2.7 Rail lubrication

### 1.2.7.1 General

Lubrication may be required wherever there is potential for significant wear. The wear can arise from wheels or rails, evidenced by the condition of the gauge face of the rail or from the presence of metal flakes on the foot of the rail. The benefits of good lubrication practise include:

- reducing high rail gauge face wear
- reducing wheel flange wear
- reducing the risk of wheel climb on high rails
- reducing Rolling Contact Fatigue (RCF) initiation on the high rail gauge corner
- reducing rail grinding maintenance on the high rail
- reducing wheel / rail noise
- reducing energy (fuel / electrical power) requirements of trains.

Gauge face lubrication should be considered:

- On curves of 800 m radius or sharper depending on track design, wheel and rail profiles, and train operations
- On other curves exhibiting, or with a history of, gauge face wear on the high rail.
- Where flanging noise is a problem.

Rail lubrication equipment and assembly details shall be type approved and shall be installed, adjusted, cleaned, maintained and used in accordance with the manufacturer's instructions. Any new installations of equipment including lubricant and friction modifier etc. shall be approved by the asset management authority.

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*Note: Gauge face lubrication is not normally fully effective in reducing wheel squeal. Other friction modification techniques may be required to further control squeal.*

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### 1.2.7.2 Lubricator Types

Electronic Dual-Long Bar Tangent lubricators are the preferred type for new installations where multiple curves are being treated.

Single pump, single blade lubricators are the preferred type for new installations where single curves and/or tangent locations are not feasible.

The decision for either system will be driven by economics and business needs unique to the locations e.g. MGT levels, trains speeds and types, remote access.

### 1.2.7.3 Strategies to Improve Performance

There are two principal strategies for improving the performance of trackside lubrication:

1. Improvements in grease transfer,
  - by placing trackside lubricators on moderate curves in advance of the sharp curves which are the main target
  - by use of electronic long bar tangent lubricators with distributed pressure pumping systems
2. Improvements in the lubricant used, by choosing (at higher cost) a high-performance product.



Both strategies will result in an increase in lubricant travel and a reduced friction coefficient on the gauge face of the rail. The outcome is:

- A reduction in the number of lubricators needed.
- A reduction in the amount of lubricant required.
- A reduction in rail wear and a reduction in wheel wear.

There is also less lubricant contamination of the rail surface and less lubricant wasted. This means better locomotive adhesion and braking, and less rail damage from wheel burns and lubricant induced crack propagation.

The application of the first strategy involves a review of the existing lubricator location and the repositioning of lubricators to suit. A 'before and after' inspection needs to be carried out which includes the taking of friction measurements.

#### 1.2.7.4 Performance Targets

The lubrication system objective should be to meet the following performance targets.

- The friction coefficient on the gauge face of outer rails on curves should be  $< 0.25$ .
- The friction coefficient on the top of rail contact surfaces of both rails should be  $> 0.3$  ( $> 0.40$  preferred) and  $> 0.40$  on grades steeper than 1 in 50.
- A lower friction level may be acceptable on the contact surface in the immediate area of the lubricator (within 50 m)
- It is also desirable that the difference in the running surface friction coefficients between the high and low rails should be  $< 0.15$ .

Sufficient rail lubricant shall be applied to the gauge face of the outer rail of curves, so that rail wear and flanging noise are minimised.

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*Note: The requirements and measurement in this section should be referred to when undertaking lubrication performance study.*

*The friction testing can be carried out with a tribometer and cover at least 100 m in each track section to be assessed.*

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#### 1.2.7.5 Rail Lubricants

Lubricants used for gauge face lubrication shall meet the following basic minimum performance requirements.

- Four Ball Weld Load  $> 315\text{kg}$  minimum,  $> 500\text{kg}$  preferred.
- Oil Separation (40deg C, 168hrs)  $< 7\%$  mass maximum, less than 5%w preferred.
- Ambient Temp range (storage): -10 deg C to 45 deg C
- Operating temp range (under normal load on rail): -10 deg C to 85 deg C
- Flash Point  $> 200$  deg C
- Drop Point temperature: Shall be higher than operating range in use.

Desirable performance criteria should meet the following.

- Water washout loss < 5%
- Pumpability (low temp flow pressure): prefer less than 500mbar at -20°C
- Good resistance to drooping (of beads)
- High adhesion to rail steel in normal track use

Any deviations below these values shall be shown as fit for purpose through the normal Type Approval procedures, with trials and field testing to validate.

The application of higher performing lubricant should be considered on a case-by-case basis. The decision to adopt the use of high-performance lubricant will depend on the cost benefit trade-off where the cost of using a better lubricant is weighed against the benefits. However, savings in rail wear can take a long time to realise.

The standard lubricants may not be adequate under severe grade braking locations (more than about 1:50). For individual cases this can be verified by measuring wheel temperatures (by non-contact thermometer) to ensure that maximum wheel temperatures are well within the temperature range of the lubricant. Alternatively, a higher level of lubricant supply may improve rail protection under extreme temperatures. This would be achieved by placing more units in the affected area, with dedicated supply per each curve an option.

#### **1.2.7.6 Alternative Systems**

Alternative methods for rail lubrication and for the application of friction modifiers shall be subject to the assessment and specification of the:

- Type of lubricant and/or friction modifier to be used.
- Method of application
- Controls to be used.
- Extent of application.

Changes to the use of lubricants or friction modifiers shall only occur following analytical or empirical analysis or investigation and authorised by type approval or engineering waiver.

#### **1.2.7.7 Preferable Requirements**

The lubricating system shall comply with relevant environmental preferable requirements, for the control of excess lubricant and friction modifiers. Grease that meets acceptable standards for biodegradability is preferred over mineral based greases.

In terms of biodegradability the desired outcome of the grease is decomposition by biological agent and/or natural biological processes into simpler (natural) molecular forms. Preference will be given to greases that have:

- high biodegradability (able to be broken down (decomposed) by micro-organisms rapidly), and
- limited effect on disposal of ballast due to contamination, and
- non-toxic in aquatic systems (it will not harm or kill organisms within aquatic systems); and
- will not bio-accumulate (it is not accumulated into living tissue within an organism, which can be magnified in concentration up the food chain)

Mineral oil-based lubricants generally have:

- high-cost remedial works due to contamination of ballast on track after years of use
- low biodegradability.
- a high potential for bioaccumulation.
- measurable toxicity towards marine and aquatic organisms; and
- a tendency to stick to and stain clothing and be difficult to remove during washing.

### 1.2.8 Guard rails

Guard rails are not mandatory but where specified in new designs shall be as follows:

1. Guard rail size of AS80lb/yd, CR80lb/yd, AS40kg/m, or AS41kg/m or greater with rail head wear not exceeding 40%, or other equivalent sections. Asymmetrical rail sections may be used with the approval of ARTC.
2. Both sides of the track shall be protected, unless the identified hazard is only on one side of the track where a single guard rail may be installed for protection from that hazard.
3. The top of the guard rail shall be at the level of the adjacent running rail surface, or below it by no more than 50 mm.
4. The working face of the guard rail that comes into contact with derailed wheels shall be a minimum of 200mm and a maximum of 380mm from the gauge face of the running rail and be located to keep derailed wheels on sleeper ends and avoid rolling stock impacts with structures. The maximum clearance is preferable and if a smaller clearance is adopted an effective maintenance regime shall be in place for replacing the guard rails, when tamping ballast top bridges, and the rails at the bridge ends.
5. The working face of the splay rail which comes into contact with the derailed wheels should start approximately 600mm from the gauge face of the running rail and be angled towards the running rails to ensure derailed wheels pass the correct side of the guard rail end or vee.
6. Splay rail bends shall be formed without cutting the rail.
7. Splay rail sleepers should be fully supported for their entire length.
8. Guard rails may extend past the end of structure, or another hazard being protected if required.
9. Guard rails and guard rail ends shall be fastened to every sleeper. They may be connected directly to timber sleepers with no plates.
10. Guard rail lengths shall be joined using four-hole fish plated joints as a minimum or their equivalent with at least two bolts on each side. No joints are permitted in the vee.
11. The guard rail end design is to:
  - a. be flared away from the running rails.
  - b. be vee shaped where there are pairs of guard rails between the running rails and extend a minimum 3.6m beyond the end of structure or hazard being protected.
  - c. extend parallel for a minimum of 3m beyond the structure end.
12. Installed at both ends of the bridge where traffic is bi-directional.

13. Where transoms are bolted to girders the spikes are to be adjacent to the rail flange.
14. When transoms are clipped to girders the spikes are to be installed through holes drilled in the guard rail flange.
15. Block out holes for guard rail fastenings in concrete sleepers shall be grouted with an approved high strength grout.
16. Suitable isolation arrangements are to be made where required in track circuit areas.
17. For fixing details, dimensional setouts and componentry detail and sizes, Standard Guard Rail drawings are available.
18. For special installations, such as where noise and vibration limiting track fixings are used or where expansion joints exist, specific design details of guard rail installations to suit will be required. Approved track fixings are to be used. The design is to be certified by a person with appropriate competencies for approving track design.

### 1.2.9 Junction Rails

The following junction rails have been approved for use in ARTC tracks:

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

#### 1.2.9.1 47kg/m to 60kg/m Junction Rails

47kg/m to 60kg/m Junction Rails may be used on the following conditions.

1. The 47kg/m end of the junction rail shall not be shortened.
2. The forged section and the adjacent 47kg/m weld shall not be used as a stressing point.
3. 60 kg/m to 47 kg/m junction rails should not be used in the following circumstances.
  - a. on bridges or within 8m of a fixed point (e.g. level crossings, turnouts or bridge abutments)
  - b. transition zones where track modulus changes (e.g. sleeper transitions)
  - c. in tracks rated for >25 TAL
  - d. Where a 60 kg/m to 47 kg/m junction rail is used the local maintenance team should be advised of what their repair options are in the event of a failure of a 60 kg/m to 47 kg/m junction rail.
4. The forged section of the 60 kg/m to 47 kg/m junction cannot be protected by plating.
5. Any failures of or adjacent to 60 kg/m to 47 kg/m junction rail should be reported to the local engineering authority and [standards@artc.com.au](mailto:standards@artc.com.au)

## 1.3 Construction and Maintenance

### 1.3.1 Rail materials

Rail should be stored in such a way that does not contact the ground (e.g. use of dunnage). Rail may be stored on free draining surfaces (such as ballast).

*Note: Rail stored in contact with the ground will often develop underside corrosion, this has the potential to create an initiation point for defects which are not likely to be detected prior to failure.*

#### 1.3.1.1 New rail

New rail shall comply with 1.2.1 and 1.2.2.

Where 60kg/m rail is used for rail renewal on tangent track both rails should be changed over.

For dual gauge (Standard/Broad) 50kg/m rail shall be used, as required by the concrete sleeper design.

#### 1.3.1.2 Cascaded Rail

Prior to its reuse in track cascaded rail shall be assessed for conformance with Table 1-3.

Rail which has exceeded the maximum allowable wear limits for either absolute or minimum remaining height or width as detailed in Table 1-26 and Appendix C shall not be reused.

Worn rails being cascaded from curves to straights shall not be reused if the maximum allowable wear limits for remaining height or width as detailed in Table 1-2 below has been exceeded.

Rail should not be transposed on mainlines.

**Table 1-2: Maximum Allowable Rail Wear For All Curve Worn Rail Sections To Be Re-Used In Tangent Track**

APPROX. KG/M	RAIL SECTION	WIDTH OF NEW RAIL HEAD (MM)	MINIMUM REMAINING WIDTH (MM)	TOP REMAINING HEIGHT (MM)
60	60 AS 1977 1981 HH	70	49	27
60	60 AS 1977 1981	70	49	29
53	53 AS 1977 1981	70	49	26
53	107 AS 1936 1964	70	49	26
51	103 AS 1936	70	49	26
50	50 AS 1977 1981	70	50	25
50	100 AS 1928	70	52	29
50	100 AS 1916	76	58	26
50	100 C 1907	70	51	26
50	100 C 1901	70	52	27
47	94 AS 1937	70	49	25
45	90 AS 1928, 90 AS 1925	70	52	26
45	90 AS 1916	73	56	24
45	90 J 1913	70	52	27

APPROX. KG/M	RAIL SECTION	WIDTH OF NEW RAIL HEAD (MM)	MINIMUM REMAINING WIDTH (MM)	TOP REMAINING HEIGHT (MM)
41	80 ASB 1928	64	49	26
41	80 ASA 1928, 80 A 1916	70	56	25
41	80 AA 1906	64	48	26
41	80 A 1900	64	51	27
41	80 A (1) 1897	64	50	29
41	80 A (2) 1895	64	49	29
41	80 A (3) 1890	64	49	33
39	78 H 1903	70	55	23
37	75 BHP 1917	62	48	29
36	71 2 D 1875	57	46	30
35	70 AS 1928, 70 AS 1925	64	52	25
35	70 AS 1916	60	48	28
35	70lb 1910	60	48	28

*Note: Dimensions indicate rail head remaining not actual wear*

#### 1.3.1.3 Closure rails

Closure rails should conform with the criteria in Table 1-3. Rails that are unsuitable for re-use should be cut into lengths no longer than 2m and marked as such.

In addition to the requirements of Table 1-3 closure rails should conform to the following criteria:

1. Longer lengths are often used to improve the track geometric quality and reduce track maintenance.
2. Rails that are satisfactory for re-use should be marked with a white stripe.

Table 1-3: Assessment of Cascaded Rail

FACTOR	SPECIFICATION	METHOD OF TEST	FREQUENCY / TIMING OF TEST	METHOD OF ASSESSMENT	COMMENTS
Defects in rails and welds	Defects shall be identified and classified as detailed in 1.4.2, 1.4.4.2 and 1.4.8	Refer to 1.4	Ultrasonic testing as required by	Refer to 1.4.2.2, 1.4.4.2, 1.4.8.4	Rail to be free of internal and surface defects including squats and wheel burns
Wear limits	Refer to Table 1-26	Gauge or measurement of wear	Once only prior to unrestricted service	Refer to 1.4.9.2.1	
Metallurgical properties	<p>No testing is necessary if the rail conforms to AS 1085.1 or the relevant superseded Australian Standard or has extensive proven service under the relevant operating conditions.</p> <p>Otherwise for each rail type determine suitability in terms of:</p> <p>Ultimate yield strength</p> <p>Chemical composition</p> <p>Inclusions</p> <p>Impact resistance</p> <p>Hardness</p> <p>Microstructure</p>	<p>N/A</p> <p>Applicable Australian and International Standards</p>	<p>N/A</p> <p>Once only prior to use of rail type</p>	<p>N/A</p> <p>Review by metallurgist competent in rail examination/ testing/ evaluation</p>	
Location of bolt holes in rail to be welded	The distance from the edge of the bolt hole to the rail end shall be no less than 65 mm	Direct measurement	Once only prior to welding	Compare with the Specification	Distances less than 65 mm may cause masking of weld defects during ultrasonic testing and poor heat distribution during welding

FACTOR	SPECIFICATION	METHOD OF TEST	FREQUENCY / TIMING OF TEST	METHOD OF ASSESSMENT	COMMENTS
Adjacent welds	<p>Welds shall be no closer than 4 m from the next weld or the end of a rail.</p> <p>Welds or rail ends shall not be located closer than 1.5 m from the centre of a insulated joint</p>	Direct measurement	Once only prior to welding	Compare with the Specification	<p>Longer lengths of closure rails and insulated joints are often used to improve the geometric quality of the final weld/rail surface and reduce track maintenance.</p> <p>In turnouts aluminothermic welds may be placed closer than 4 m to a minimum of 1.2 m to a flashbutt weld, aluminothermic weld or rail joint (mechanical or glued) provided that:</p> <p>The flashbutt weld or joint is ultrasonically tested and no defects are found.</p> <p>The rail length is well secured by two ties with the ties held by more than two rails such that they will not skew if the rail breaks in two places.</p>
Adjacent non welded joints	Joints shall be no closer than 6 m. Not to be applied retrospectively, in points and crossings and in tracks with loose rail.	Direct measurement	Once only prior to installation	Compare with the Specification	Special consideration should be given in turnouts where shorter lengths may be necessary.
Rail end straightness	The rail end straightness shall be limited to that which permits the final weld or mechanical joint to comply with Clause 1.3.9.5 on rail discontinuities.	Direct measurement		Compare with the Specification	Care should be taken with rail end straightness due to excess loading on the fastenings, sleepers and rail in service
Rail Twist					Care should be taken with twist and other rail distortions that may induce excess loading on the fastenings and sleepers, gauge variation and eccentric loading of the rail in service.
Discontinuities	Refer to 1.3.9.5	Refer to 1.3.9.5	Once only prior to unrestricted service	Compare with the Specification	Where the specification is not met at any location along the rail corrective action should be taken, for example blending or transition grinding of the rails.



FACTOR	SPECIFICATION	METHOD OF TEST	FREQUENCY / TIMING OF TEST	METHOD OF ASSESSMENT	COMMENTS
Rail cross section	Rail conforms to AS 1085.1 or the relevant superseded Australian Standard	Check branding	Once only prior to use	Compare with the Specification	Some other rail cross sectional shapes have unacceptable properties (e.g. due to sharp head/web fillet radius, unacceptable rail head profile)
Gauge face angle	Refer to 1.4.9.2.3	Gauge or profile measurement	Once only prior to use	Compare with the Specification	
Closure rail length	Closure rails shall be a minimum length of 4 metres	Direct measurement	Once only prior to use	Compare with the specification	
Matching profiles	Rail vertical wear should be within 5mm of parent. Side wear should be within 1mm of parent rail.  A closure rail should be no taller than the parent rail. <sup>1</sup>	Direct measurement	Once only prior to use	Compare with the specification	Prevention of rail misalignments into the track.
Corrosion	No corrosion causing loss of section of discontinues	Direct measurement	Once only prior to use		Check underside of foot. Rail stored on natural ground often contains foot corrosion, leading to undetectable rail defects and ultimately rail break.
Rail Head Condition	No end batter present  No crushed or laminated head	Visual	Once only prior to use		End batter shall be cut off

<sup>1</sup> This requirement avoids the needs to lift adjoining track.

Ultrasonic Test Flow Diagram

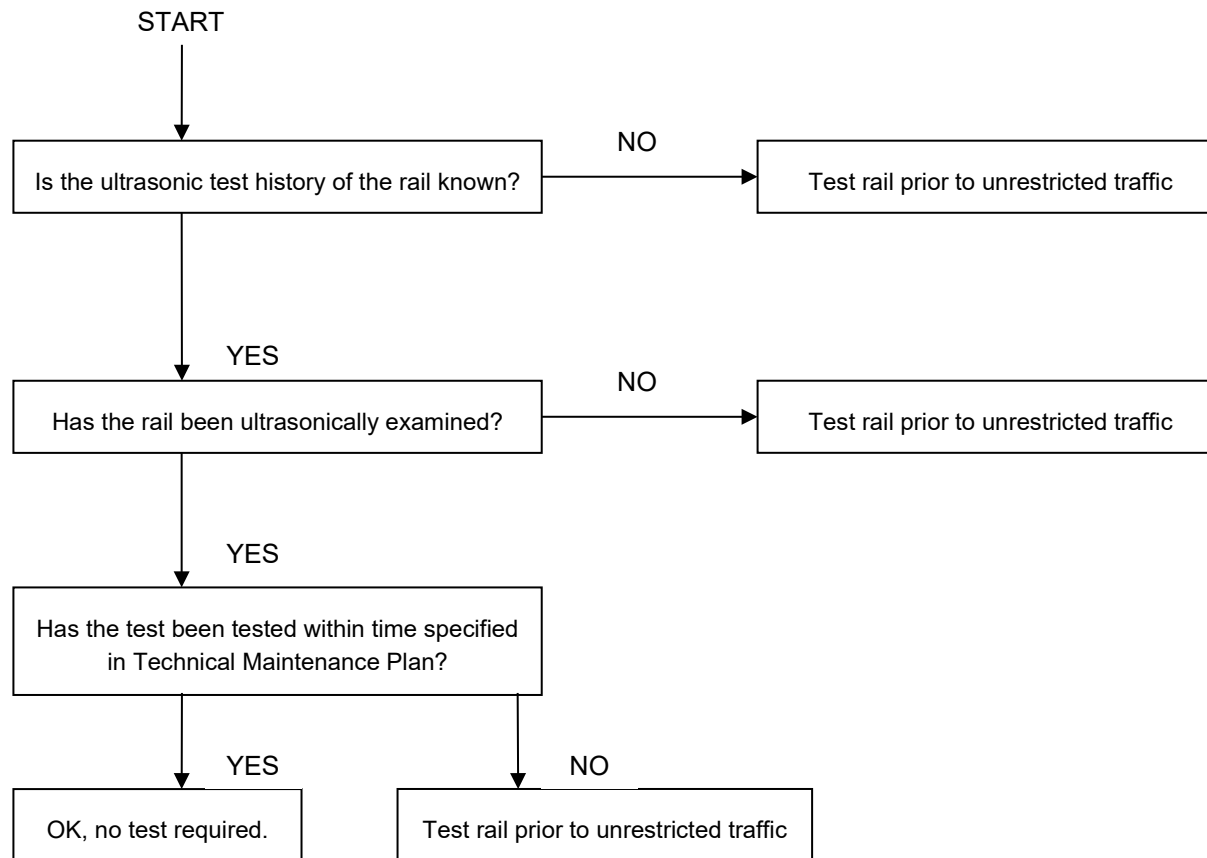


Figure 1-1: Rail Acceptance - Ultrasonic Test Flow Diagram

## 1.3.2 Rail welds

### 1.3.2.1 Mandatory Requirements

Rail welding may only be undertaken using processes listed in 1.3.9.

A welded rail joint shall not be located within 65 mm of any bolt hole.

No weld may be located within 1.2 meters of any other weld or joint.

On plain track (main line or siding), aluminothermic welds shall not be placed within 4.0 metres of any weld (flashbutt or aluminothermic) or mechanical joint. This restriction does not apply to the distance of welds each end of a new glued insulated joint to the central joint.

### 1.3.2.2 Recommendations

Rail welds should be centrally located between the sleepers.

Opposing aluminothermic welds may be staggered by at least one sleeper bay to reduce impact loading, care should be taken to ensure a twist is not created.

Rails of dissimilar section (either by weight, design or wear) can usually be welded together using the approved welding processes or appropriate junction rails. Current approved junction rails are detailed in 1.2.9.

Junction rails should be used over junction welds where possible.

#### 1.3.2.2.1 Fixed points

Where practical all rail joints and welds should be as far away as possible away from the edges of any fixed point, some examples of fixed points are:

- Bridge abutments
- Edge of the level crossing
- Transitions zones where track modulus changes abruptly, for example sleeper transitions.

When planning welding work near or at fixed points,

- Avoid new welds within fixed points if possible.
- As far as is practicable.
  - All welds, including Junction welds, and stepped welds of same sized rail (using approved step kits) which have steps >5mm at the foot of the rail due to head wear, shall be placed a minimum of 4m away from the edge of the fixed point.
    - Emergency closure welds may be used temporarily below these minimum distances described above; however, they shall be recorded as Known Condition defects and removed as soon as is practical based on risk review in each case.
  - In rail replacement projects, new aluminothermic welds should be carefully planned and placed a minimum distance (into the track) of 8m away from the edge of the fixed point.

Where possible Insulated Joints should be placed a minimum 6m away from the edge of the fixed point.

#### **1.3.2.2.2 Turnouts:**

In turnouts, new welds may have to be placed closer than 4m to a minimum distance of 1.2 metres to other welds due to fixed constraints. This is acceptable provided that:

- The existing weld has been ultrasonically tested during the last cycle and no significant defects found.
- The rail is well secured, so that in the unlikely event of a rail break, the rail will not skew.
- The rail length has been maximised.

#### **1.3.2.2.3 Installation of Step and Junction Welds on Transom Top Bridges**

The best practice is to avoid installing step and junction welds on all transom top bridges and to have all welds located as far as possible from the start / end of the bridge, at a minimum of 4.0 metres. When planning for the installation of rail on a transom top bridge, the aim should be to use the longest length of rail available of uniform size and to minimise the number of welds spanning these higher risk areas. Where welds are needed to be installed flashbutt welds are preferable to aluminothermic welds.

Transition rails are preferable to install then step welds on transom top bridges. If step welds are to be installed on transom top bridges. A gap will exist under the most worn welded rail, between the foot of this worn rail and the adjacent transoms. When the fastenings are reinstalled, the rail will be pulled back down onto the top of the sleeper plate. However, this location where the gap existed between the rail and the transoms will make the rail deflect under load and create a stress riser location, also an upward force is placed on the fastening systems, both rail to transom and transom to girder.

Therefore, if a step weld is performed the hold down bolts of the adjacent transoms should have loosened and packing should be installed between the transom and girder until the top of the plate and bottom of rail are firmly in contact, then retighten the hold down bolts. Packing between the transoms and girder can be utilised up to 35mm.

### **1.3.3 Rail Joints**

#### **1.3.3.1 Mechanical Joints**

Joints should be centrally suspended between sleepers.

Joints on opposite rail legs may be adjacent to each other (i.e. square). Where staggered joints are used the effect on vehicle resonances should be taken into consideration. Ideally a mechanical joint, which is not an insulated joint, should not be closer than 9 metres from any other non-welded rail join in either rail.

Where a closure rail is required to remain permanently jointed in track using mechanical joints at either end this closure shall not be shorter than 10m, however,

1. In an emergency a shorter rail may be used as a temporary measure, but the mechanical joints shall be welded out as soon as possible.
2. In this emergency/temporary situation 6 hole/4 bolts joints may be installed with the two centre bolts not used, nor the rail bored, for the bolts either side of, or closest interface of the two rails, as it is intended to weld the track.

Where fish plated joints are being installed permanently a minimum of 6 hole/6 bolts should be utilised.

Where mechanical joints, other than insulated joints, are in electrified or signalling track circuited areas appropriate electrical bonding should be installed across the joint.

Where a mechanical joint has been repaired all bolts should be fully tightened and have a maximum dip of 1mm over 1 metre.

#### 1.3.3.2 Insulated Rail Joints

Insulated joints shall be installed in all new welded tracks and used as replacement for all existing insulated joints on these lines when renewal is required.

Field assembled insulated joints are not approved for use in CWR and shall not be used to replace existing insulated joints of any kind. Components such as bolts, insulation and plates of an existing field assembled joint may be replaced until the joint can be fully replaced by factory assembled insulated joint.

Insulated joints should be installed to a minimum length of 4.0 metres, however some locations such as near turnouts may require shorter lengths. The centre of an insulated joint shall not be located closer than 1.5 m from welds or rail ends.

The insulated joint is to be centrally suspended between sleepers and located within 700 mm of its design location.

#### 1.3.3.3 Temporary Rail Joints

Temporary joints are intended for the temporary joining of rails to permit the short-term passage of trains at reduced speed and requiring special inspections when in use. They can be construction joints, joints over broken rails or temporary joints during maintenance. They shall only be used in the following circumstances.

1. To permit the passage of trains during work possessions.
2. To plate broken rails or welds where,
  - a. the break is vertical.
  - b. Multiple defects are not present.

Temporary joints shall only be used under the following conditions:

1. They shall have a speed restriction of 30km/h.
2. Their components shall be supplied in compliance with the specified design and shall be installed using the supplier's instructions (potential injury of the person installing the clamp and/or subsequent failure of the joint and train derailment risk).
  - a. Where specified in the supplier manuals, a torque wrench shall be used for safety reasons.
  - b. Risk of joint failure and clamp failure demands accurate setting of torque as per supplier's installation methods.
3. In Heavy Haul, plates around broken welds shall be bolted in place.
4. They shall be inspected and re-tightened every 24 hours

#### CER AUTHORITY

The CER may authorise an alternate frequency for re-inspection and re-tightening of temporary joints based on operational factors.

Where electrical bonding is provided for temporary joints in electrically circuited areas it shall be installed to meet signalling requirements.

### 1.3.4 Rerailing

Rail that is placed in preparation for re-railing shall be located so that it is secure and there is no risk of it fouling the maximum rollingstock outline as defined in ARTC standards for clearances. If the rails are left in the four-foot they shall be well clear of the running rails and stood upright on their feet.

When replacing rail:

1. Ineffective pads shall be replaced.
2. The rail seat shall be cleared of all ballast.
3. Ineffective insulators shall be replaced.
4. Ineffective clips or fastenings shall be replaced.

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**Note:** Any loss of thickness in pads and insulators will reduce their effectiveness

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All rail inserted into track shall have a clean surface condition to ensure electrical contact between the rollingstock wheels and the rail. Where the surface condition inhibits the electrical connecting it shall be cleaned or ground until it allows for acceptable electrical contact. This applies to any rail installed to track, including rail in turnouts, catch points and insulated joints.

If any lubricators are present in section where re-rail has occurred these shall be checked to ensure they are correctly installed, adjusted and functioning as per the manufacturer's instructions.

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**Note:** The good practice is to replace all pads during rerailing. To provide better in track support and minimise maintenance work, it is also suggested that fastening system (pads, insulators and clips etc.) to be replaced.

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### 1.3.5 Rail Defect Rectification

Repair of defective rails and welds shall be carried out in accordance with Table 1-4. Defective rails removed from track shall be immediately rendered unsuitable for reuse. When a defect is to be removed consideration should be given to removal of any other identified rail and weld defects in the vicinity.

**Table 1-4: Rail and Weld Repair Guidelines**

CODE	DEFECT	COMMENT ON ACTIONS
BHC	Bolt hole (crack, elongation or non-conforming)	Defects shall be cut out and replaced by a closure rail. The closure rail may be welded at both ends provided specified rail lengths are not exceeded.
BR	Broken rail	Defects should be cut out and the rail welded (subject to compliance with guidelines for distances to bolt holes) or replaced by a closure rail.
CR	Corroded rail	The defective portion of rail should be replaced.
EB	Wheel burn	Defects shall be repaired by repair welding or replaced by a closure rail. Small wheel burns may be ground out.
FW / HW	Foot/web separation and head/web separation	Repairs shall be carried out by replacing the complete rail between welds unless the rail has been examined in detail by manual ultrasonic examination.

HSH / HSW	Horizontal split (head or web)	Repairs shall be carried out by replacing the complete rail between welds unless the rail has been examined in detail by manual ultrasonic examination.
MJ	Mechanical joint	The necessary repair shall be determined by a competent worker.
PR	Piped Rail	Repairs shall be carried out by replacing the complete rail between welds unless the rail has been examined in detail by manual ultrasonic examination. The rail removed should be immediately rendered unsuitable for reuse.
RD	Damaged Rail (e.g., notches, broken foot))	Defects shall be cut out and the rail welded or replaced by a closure rail.
SC	Shatter Crack	Repairs shall be carried out by replacing the complete rail between welds unless the rail has been inspected in detail by manual ultrasonic examination. The rail removed should be immediately rendered unsuitable for reuse.
TD	Transverse Defect (including those from shells or wheel burns)	The defect shall be removed, and the rail restored by welding.
TDX	Multiple transverse defects	Repairs shall be carried out by replacing the complete rail between welds, unless the rail has been inspected in detail by manual ultrasonic examination. The rail removed should be immediately rendered unsuitable for reuse.
VSH / VSW	Vertical Split (head or web)	Repairs shall be carried out by replacing the complete rail between welds, unless the rail has been examined in detail by manual ultrasonic examination. The rail removed should be immediately rendered unsuitable for reuse.
WT	Weld defect (head, web or foot)	Repairs shall be carried out by removing the weld and replaced by a closure rail or using wide gap welds if no bolt holes exist.
WT	Weld defect: repairs of surface defects	Ultrasonic defects that occur are to be found in other defect classifications. Alignment defects may be corrected by grinding, surface repair or replacement with a closure rail.
WT	Weld defect: surface (e.g. gas hole, hot tear, shrinkage, porosity)	Repairs shall be carried out by removing the weld and replacement with a closure rail. A wide gap weld may be used if no bolt holes exist.

### 1.3.6 Cutting of rail

Rail cutting shall only be carried out using the processes specified below.

When cutting rail in track

1. Do not use a saw for the initial cut – the rail may close up if it is in compression, causing the cutting disc to shatter.
2. Do not remove fastenings before cutting the rail – the rail may release stored energy and move in rapidly causing significant injury

Rail ends shall be cut square to defined tolerances and finish depending on the purpose of the cut.

Rail saw cutting is the preferred method of cutting rail and it is the only method permissible for preparation of closures to be used for a later welding operation.

Flame cutting of rails is only permitted:

- In emergencies
- Where allowed for aluminothermic welding (but not for junction welds) by the relevant business unit Asset Manager. When aluminothermic welding is to be carried out:
  - For head hardened rail, welding shall be carried out within 30 minutes – if this is not possible, 30 mm is to be cut off the cooled rail ends immediately prior to welding.
  - For as-rolled rails, flame cut rails should be welded in the same work shift – if this is not possible, 30 mm is to be cut off the cooled rail ends prior to welding.
  - Both ends of the rail to be welded shall be of the same type, i.e. either both flame-cut or both sawn.
  - Flame cut rails should be protected from impact for example rail traffic or during transportation until welding occurs.

Any flame cut rail ends discovered at joints in running lines shall be replaced as soon as possible by welding in a new section, or by replacing the affected rail with a saw cut rail.

### 1.3.7 Drilling of Rail

The drilling of holes in rails should be minimised, e.g. by using rail mounted equipment that does not require drilling of the rail.

Marking the centre of the hole to be drilled should be carried out using an appropriate template or equivalent. Holes shall be drilled square to the web via use of an appropriate guidance mechanism. Drilling requires appropriate cooling of the drilling tool and holes shall be deburred.

The location of the centre of bolt holes relative to the neutral axis of the rail should be in accordance with the dimensions detailed for the rail size being drilled in AS 1085.1 and the hole centre spacings along the web, as well as the diameter, in accordance with those for the appropriate fishplate to be installed as detailed in AS 1085.2

Flame cut holes are not permitted in running rails or other track components except in an emergency such as a derailment. If flame cut bolt hole are used to effect temporary repairs a speed restriction of 10km/h is to be placed on the section. The affected rail and/or rails shall be removed prior to increasing the speed restriction.



In the case of emergency repairs all site drilled holes should be de-burred or the rail section with holes be cut out and replaced with welded closures.

### 1.3.8 Rail Stress Control

#### 1.3.8.1 Maintenance of the existing rail stress condition

The method specified in this clause may be used where the length of rail to be adjusted does not warrant the disturbance of the track which would be necessary in a full stress adjustment. It is used primarily for the replacement of short sections of rail such as the replacement of insulated joints or defective rails and welds. The length of rail to be inserted should not exceed 15 m.

During execution of this procedure, measurements shall be taken to ensure that the process has been carried out correctly. Reference points shall be established on the rail outside the insert length prior to cutting. The distance between the reference points shall remain the same (i.e. within tolerance prescribed below) following the stressing procedure. This may be achieved either by direct measurement of the distance or using independent datum points.

Measurement of the length between the two reference points shall be made,

- prior to cutting the rail; and
- after the rail has been welded into track.

Comparison of these two measurements shall be within 3 mm.

If the results of the measurements indicate that the rail adjustment is out of tolerance, then either:

- rail stresses should be readjusted, or
- the guidelines in Section 6, Track lateral stability, should be implemented.

#### 1.3.8.2 Stress adjustment of continuously welded rail (CWR)

Rail stress assessment and, if necessary, adjustment should be carried out whenever the following events occur:

- New or recycled rail is being laid into track.
- A stress check is being carried out.
- The rail stress is suspect, for example due to the presence of:
  - buckle.
  - break-away / pull-apart.
  - mechanical joint failure.
  - significant rail creep; or
  - Significant changes in track alignment.
- The rail was cut, and practices described in 1.3.8 were not used.

Rail stressing processes shall be executed in accordance with ETM-06-10 or ETM-06-11 as appropriate.

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*Note: Rail stress assessment and adjustment is not required for dead-ended sidings where an effective anchor does not exist and one end free to move provided the track is clipped up within the maintenance tolerance of DSFT and the track alignment is not changed after clip-up*

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### 1.3.9 Rail welding processes

Welding of rails should be carried out to meet the requirements detailed in the following clauses.

Only approved aluminothermic, flashbutt or rail surface repair welding processes are to be used.

#### 1.3.9.1 Flashbutt welding

Flashbutt welding is the preferred method of welding, its use should be maximised where possible.

##### 1.3.9.1.1 Mandatory Requirements

Following commencement of production welding, in addition to the inspection and testing of finished welds in AS 1085.20, a sample weld shall be produced or selected after every 2000 welds and subjected to bend testing.

Only rails with the same section size, weight and hardness may be welded by flashbutt welding into welded rails.

Flashbutt welding shall only be used on new rails (sections with 3mm or less wear).

Welding rail ends together using flashbutt welding shall be carried out using a specified process as set out in Table 1-5 and AS 1085.20. Type and proof testing shall be carried out using the method and frequency defined in AS 1085.20.

##### 1.3.9.1.2 Qualification Requirements

In addition to requalification requirements in AS 1085.20, the following occurrences will require requalification of the process.

1. Welding machine variations.
  - Following rectification of a welding machine malfunction (any item that affects the electrical, hydraulic or mechanical setup. (including alignment))
  - Following machine overhaul or work other than routine maintenance.
  - If the machine has not been used for more than three months.
  - Any change in the welding parameters or operational performance of the welding machine software program.
2. When there is a change from rail: supplier, grade or section size.
  - Grade refers to the chemical composition (including alloying) or significant changes in the mechanical properties during the steel manufacture process.
  - Changeovers in production to/from Standard Carbon rail grades to/from rail grades with post-casting heat treatments, such as Head hardening, are excluded from requalification requirements where the steel is from the same supplier and does not vary in chemistry for either rail type SC or HH.

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*Note: A welding machine does not require requalification to change between two rail types already it is already qualified for.*

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3. Any change to another approved procedure relating to the welding.

Sample welds for slow bend test shall be in the as welded condition. No straightening is permitted to correct the geometry of these welds. The sample weld shall either be selected from produced welds or prepared by welding together two equal lengths of short piece rails to suit clamping head, usually two 600mm lengths.

Pulse flashing has some advantages over continuous flashing for the following reasons.

- Improved control of flashing process.
- Shorter weld cycle.
- Reduced rail usage.
- Narrower weld and heat affected zone.
- Improved bond strength.

Both methods are acceptable providing they meet all quality requirements specified for the finished welds.

#### **1.3.9.1.3      *Mobile flashbutt welding machine***

Procedure approval shall be carried out for each individual machine (no Type Approval) by testing weld samples produced in accordance to AS 1085.20.

#### **1.3.9.1.4      *Quality***

The contractor shall have in place a quality system accepted by ARTC. A system conforming to ISO 9001 shall be deemed to satisfy the requirements. The contractor shall also provide a quality plan to be reviewed and accepted by ARTC. The plan is to include weld reporting which should be in the format of a chart and report.

The contractor shall provide the performance specification to monitor the quality of the weld. The minimum specification shall include the following.

- Welding current.
- Upset force or pressure.
- Upset displacement.
- Welding time.

Other aspects such as weld geometry and ultrasonic testing shall be in accordance with ARTC Track and Civil Code of Practice and related engineering procedures, standards and work instructions. In addition, foot alignment should not exceed the dimensional tolerances of the joined rails as specified in AS 1085.1 or applicable standard.

Rails shall be secured in the Flashbutt Welding Machine by clamps with such a surface shape or contour, that when a clamping force is exerted on the rails, it shall not damage the rail in such a way that subsequent cracking in the rail in operation will occur from this damaged area.

#### **1.3.9.2      *Aluminothermic welding***

Aluminothermic weld materials shall be supplied in accordance with AS 1085.20. Type and proof testing shall be carried out using the method and frequency defined in AS 1085.20.

Welding rail ends together using aluminothermic welding shall be carried out using a specified process as set out in Table 1-6.

Transport and storage of weld consumables shall be in accordance with AS1085.20.

Consumables affected in any way which will impact on the integrity of the final weld shall not be used.

Aluminothermic welding processes used for various gap and rail size combinations shall be as per the supplier recommendation.

### 1.3.9.3 Electric arc welding

Electric arc welding may be used to repair rail head surface defects and switch and crossing components (except switch blades). Electric arc welding may consist of:

- Manual metal arc welding (MMA)
- Flux-cored arc welding (FCAW)
- Gas Metal arc welding (GMAW)

Type and proof testing of these methods shall be carried out using the method and frequency defined in AS 1085.20.

Repairing the rail running surface shall be carried out using a specified process as set out in Table 1-7.

Where wire feed or head repair welding is to be used for wheel burns, squats, etc, prior ultrasonic testing should usually be completed as specified in approved procedures. In general, if damaged rail is left untreated for more than 24 hours, ultrasonic testing should be carried out.

These welding processes shall not be used for joining rail.

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*Note: Welding repair on switch blades may be conducted under emergency based on the specific location and advice from the relevant Engineering Manager.*

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### 1.3.9.4 Other weld processes

Welding process types other than the above (e.g. gas pressure, induction etc) shall only be used with the approval of the Manager Track and Civil Standards who may require a Type Approval.

Table 1-5: Flashbutt Welding - Process

FACTOR	SPECIFICATION	METHOD OF TEST	FREQUENCY / TIMING OF TEST	METHOD OF ASSESSMENT	ACTIONS
Welding practices	Use equipment manufacturer's method or other method approved by ARTC	Weld completion report by welder certifying conformance with specification.	Every weld immediately after completion	Against specification	<p>When a process non-conformance is identified possible corrective actions include:</p> <ul style="list-style-type: none"> <li>• Stop welding.</li> <li>• Reassess process.</li> <li>• Readjust settings.</li> <li>• Rework</li> </ul>
	<p>Performance specification shall include at least:</p> <ul style="list-style-type: none"> <li>• Welding current</li> <li>• Upset force or pressure.</li> <li>• Upset displacement.</li> <li>• Welding time</li> </ul>	<p>Visual observation of welding process.</p> <p>Check graph or meter</p>			
Worker competency and training	Welder to be competent and hold current certification of Rail Welder – Flashbutt competency in RIW	Audit of welder competency.	Welders shall be recertified at least every two years. More frequent assessment may be necessary where evidence of non-conformance is identified.	Competency assessment against specification	Retraining of welder or withdraw certification.
Post weld testing <sup>[1]</sup>	External visual inspection. Refer to 1.4.2 (Rail and welded joints) and 1.3.9.5 (Weld Quality)	Visual: Weld certification that the weld has been visually inspected, and no recordable defects have been found	Every weld immediately after welding	As specified in 1.4.2.2 and 1.3.9.5	As specified in 1.4.2.2 and 1.3.9.5
	Internal inspection	Ultrasonic testing: Weld certification that correct practices and equipment have been used and that no recordable defects have been found	Every weld at production or within 90 days of installation into track	Any sizable defect in the weld <sup>[2]</sup>	Remove

**Note:** 1. ARTC may specify strength testing and macroscopic testing of welds following welding machine malfunction, overhaul, change of rail section or work shift.

2. Sizable defects includes any defect indication that is able to be sized, the defect does not need to meet the minimum sizes specified in Table 1-22 or Table 1-24

Table 1-6: Aluminothermic Welding - Process

FACTOR	SPECIFICATION	METHOD OF TEST	FREQUENCY / TIMING OF TEST	METHOD OF ASSESSMENT	CORRECTIVE ACTIONS
Welding practices	Manufacturer's method or other method approved by ARTC	Weld completion report by welder certifying conformance with specification.  Visual observation of welding process.	Every weld immediately after welding	Against specification	When a process non-conformance is identified possible corrective actions include: <ul style="list-style-type: none"> <li>• Stop welding.</li> <li>• Reassess process.</li> <li>• Rework</li> </ul>
Worker competency and training	Welder to be competent and hold current certification of Rail Welder – Aluminothermic competency in RIW	Audit of welder competency	Welders shall be recertified at least every two years.  More frequent assessment may be necessary where evidence of non-conformance is identified.	Competency assessment against specification	Retraining of welder or withdraw certification
Post weld testing	External visual inspection. Refer to 1.4.2 (Rail and welded joints) and 1.3.9.5 (Weld Quality)	Visual: Weld certification that the weld has been cleaned of mould material then visually inspected and no recordable defects have been found	Every weld prior to unrestricted traffic immediately after welding	As specified in 1.4.2.2 and 1.3.9.5	As specified in 1.4.2.2 and 1.3.9.5
	Internal Inspection	Ultrasonic Testing: Weld certification that correct practices and equipment have been used and that no recordable defects have been found	Welds to be tested ultrasonically within the timeframe specified in ARTC standard ETA-01-05	Any sizable defect in the weld <sup>[1]</sup>	Remove

**Note:** 1. Sizable defects includes any defect indication that is able to be sized, the defect does not need to meet the minimum sizes specified in Table 1-22 or Table 1-24

Table 1-7: Manual Metal Arc and MIG Repair Welds - Process

FACTOR	SPECIFICATION	METHOD OF TEST	FREQUENCY / TIMING OF TEST	METHOD OF ASSESSMENT	ACTIONS
Materials	All materials shall be supplied to Australian Standard or equivalent to owner's specification	As per owner's standard	Prior to use	Against the specification	As necessary
Welding practices	Owner's weld procedure specification (WPS) and weld procedure qualification report (PQR)	Weld completion report by welder certifying conformance with specification	Every weld immediately after welding	Against specification	Stop the use of the welding procedure. Reassess Process.
Worker competency and training	Welders shall be assessed as competent. Dependant on the risk this may necessitate certification similar to that under AS 1554 for special purpose welding.  ARTC welders or welders working under ARTC processes to hold current certification of Rail Welder – Electric competency in RIW	Audit of welder competency. Weld procedure qualification report (PQR)	Welders shall be recertified at least every two years.  More frequent assessment may be necessary where evidence of non-conformance is identified	Competency assessment against specification	Retraining of welder or withdraw certification.
Post weld testing	External visual inspection. Refer to Clauses 1.4.2 (Rail and welded joints).	Visual: Weld certification that the weld has been visually inspected, and no recordable defects have been found	Immediately after all welds	As specified in 1.4.2.2 and 1.3.9.5	As specified in 1.4.2.2 and 1.3.9.5
	Internal inspection  Particular attention should be given to problems that may occur due to internal defects created by welding process.	Ultrasonic testing: Weld certification that correct practices and equipment have been used and that no recordable defects have been found. No testing available for manganese steel products.	Welds to be tested ultrasonically within the timeframe specified in ARTC standard ETA-01-05	Any sizable defect in the weld <sup>[1]</sup>	Remove

**Note** 1. Sizable defects includes any defect indication that is able to be sized, the defect does not need to meet the minimum sizes specified in Table 1-22 or Table 1-24

### 1.3.9.5 Weld Quality

This section covers:

1. Minimum geometry tolerances
2. Inspection requirements
3. Corrective actions

Welding of rails should be carried out to meet these standards. Only approved aluminothermic, flashbutt, wire feed or head repair welding processes are to be used.

1. The weld quality standards detailed in this section apply to welds formed during laying rail in track,
2. Production of rail lengths for installation, and
3. Insertion of rail welds into track, including those for closure rails.

The measurements and requirements of this section are explained in more detail in ETN-01-06.

#### 1.3.9.5.1 Visual Inspection

Each weld shall be visually inspected closely by a qualified welder after the completion of the weld and prior to leaving the worksite, following ETN-01-06 Weld Quality Management Manual. Table 1-8 details the minimum actions and response time for visual weld defects.

**Table 1-8: Minimum Actions And Response Time For Visual Weld Defects**

FACTOR	RESPONSE TIME	ACTION
Visual Weld Defect (Includes, porosity, hot tears, shrinkage, lack of fusion, inclusions, black holes, cracks and lack of collar formation)	7 Days	Speed restriction, plate or remove.  <i>(Note: if speed restrict or plate is the chosen action, this action shall only stand for 90 days, then the weld will need to be removed)</i>
Flashing / Finning	90 Days	Grind or remove

#### 1.3.9.5.2 Ultrasonic testing of new welds

Ultrasonic testing of new welds is to be completed within the timeframe specified in ETA-01-05 Non-Destructive Testing of Rail (for Internal & Surface Defect).

Any indication of an Internal rail flaw detected ultrasonically shall require replacement of the new weld.



**1.3.9.5.3 Semi-Finished Welds**

Where there is insufficient time for a new weld to fully cool to the same temperature as the adjoining rail, thus preventing final grinding to be completed, the weld can be left in a “semi-finished” state (as defined in Table 1-9) for a period not exceeding 14 days. It is important that in this state the weld is peaked, to allow enough metal to be left for the final grind.

Under normal circumstances, during this period, trains can run over the weld at normal speeds.

**Table 1-9: Standards for Semi-Finished Welds**

FACTOR	STANDARD FOR SEMI-FINISHED STATE
Vertical Alignment (Peak in running surface)	+0.8 to +1.2mm over 1 metre (about 1mm preferred)
Vertical Alignment (Dip in running surface)	Strictly no dip allowed
Horizontal Alignment (gauge face)	0.5mm over 1metre
Vertical alignment (Weld Collar)	Vertical $\pm 2$ mm preferred, absolute maximum $\pm 4$ mm

**1.3.9.5.4 Finished Welds**

Minimum standards for rail running surface of new finished welds are given in Table 1-10.

The welded rail is to be checked for correct surface straightness and proper alignment, using a 1 metre straightedge (see ETA-01-02 for details), or an electronic straightedge, or an alternative straightedge or measuring device. Where an electron straightedge is not used the top surface shall also be checked with a (P1) (dipped weld) gauge or a measuring system capable of detecting changes in weld ramp angle.

On curved track the newly welded portion of the gauge face shall have a curvature consistent with the curvature of the existing rails and the gauge face of the weld shall be smooth and continuous.

The vertical alignment of the weld is to be checked to confirm it has been installed perpendicular to the rail by performing a visual check that the edges of the weld collar at the rail foot and head are in alignment on both sides of the weld. If any deviation is detected then the alignment is to be checked utilising a square rule or similar device and the measured misalignment values compared to the limits in Table 1-10. Deviations up to 2mm are acceptable, from 2mm to 4mm are to be recorded as defects in AMS with no action required and >4mm are to be recorded as defects in AMS and actioned in accordance with Table 1-11.

Table 1-10: Tolerances of Finished Rail Welds

FACTOR	LIMITS	METHOD OF TEST	CORRECTIVE ACTION TO ACHIEVE TOLERANCES
Vertical Alignment (Peak in running surface)	+0.0mm to +0.3mm over 1m, absolute max peak 0.5mm	1m reference and height difference measure	Remove or grind
Vertical Alignment (Dip in running surface)	Nil	1m reference and height difference measure	Remove or lift
Horizontal Alignment (Peak or Dip in gauge face)	0.5mm over 1m	1m reference and alignment difference measure	Remove or bend
Vertical deviation in rail running surface (ramp angle)	7 milliradians or $\pm 0.35$ mm over 50mm	Measured with dipped weld ((P1)) gauge or electronic straightedge over 1m	Remove or grind
Collar alignment (Vertical)	Vertical $\pm 2$ mm preferred, absolute maximum $\pm 4$ mm	A square gauge and steel rule or weld collar alignment gauge	Remove

**Notes:** A peak in running surface is preferred to be +0.3mm

Limit exceedances are to be records in the asset management system.

Where surface repair welds have been undertaken the surface geometry shall meet that of the existing parent rail and should comply with the ramp angle requirements.

Where alignment is taken using a digital straight edge the value recorded may be rounded to the nearest 0.1mm

**1.3.9.5.5 Remediation of finished welds**

Remedial actions in accordance with Table 1-11 are required for all new geometry defects.

**Table 1-11: Remedial Actions for Rail Weld Geometry Tolerance Exceedances**

DEFECT TYPE	DEFECT SIZE	RECTIFY WITHIN	
		HEAVY HAUL & INTERSTATE	INTRASTATE & LIGHT WEIGHT
DIP WELDS (WTD = Weld Thermit Dip)			
Small (WTDS)	Dip is greater than zero but less than 0.5 mm	90 days	180 days
Medium (WTDM)	Dip is equal to or greater than 0.5 mm but less than 1.0 mm	30 days	60 days
Large (WTDL)	Dip is equal to greater than 1.0 mm	14 days	28 days
PEAK WELDS (WTP = Weld Thermit Peak)			
Small (WTPS)	Peak is greater than 0.5 mm but less than 1 mm	90 days	180 days
Medium (WTPM)	Peak is equal to or greater than 1 mm but less than 2 mm	30 days	60 days
Large (WTPL)	Peak is equal to or greater than 2 mm	14 days	14 days
VERTICAL DEVIATION IN RUNNING SURFACE			
Small	7 to 12 milliradians over 50 mm base	90 days	180 days
Medium	13 to 18 milliradians over 50 mm base	30 days	60 days
Large	19 milliradians or greater over 50 mm base	14 days	28 days
VERTICAL ALIGNMENT OF WELD COLLARS			
	> 2mm misalignment from head to foot	Record in AMS (no action)	
	> 4mm misalignment from head to foot	28 days (Heavy Haul)	90 days (Non-heavy Haul)
HORIZONTAL ALIGNMENT			
GAUGE NARROW (WTGN = Weld Thermit Gauge Narrow) OR GAUGE WIDE (WTGW = Weld Thermit Gauge Wide)			
Small (WTGNS) or (WTGWS)	Narrowing or widening is greater than 0.5 mm but less than 1 mm	90 days	180 days
Medium (WTGNM) or (WTGWM)	Narrowing or widening is equal to or greater than 1 mm but less than 2 mm	30 days	60 days
Large (WTGNL) or (WTGWL)	Narrowing or widening is equal to or greater than 2 mm	14 days	28 days

## 1.4 Inspection and Assessment

### 1.4.1 Patrol Inspection

Patrol Inspections are intended to find obvious defects that affect the safe running of trains or material integrity of the track structure.

Track patrol inspections should keep a lookout for rail defects and conditions (i.e., indicators of a defect) that may affect the integrity of the track structure.

PATROL INSPECTION	
Applicability	As per ETP-00-03. All running lines, sidings and yards.
Frequency	7 days if not specified by ETP-00-03 Technical Maintenance Plan
Reference Procedure	ETE-00-02 Track Patrol, Front of Train, and General and Detailed Inspections
Competency Required	Track Examiner & Certifier

A patrol inspection should look for the following defects:

- Broken rails and rail welds
- Rail and rail weld deformations and discontinuities
- High levels of rail wear or obvious unusual wear patterns
- Broken, battered or pumping joints.
- Wheel burns, Squats or Rolling Contact Fatigue (RCF)
- Obvious over or under lubrication, including surface contamination.
- Contamination of rail with foreign matter, including leaves.
- Unusual vehicle tracking patterns.
- Rail corrugation or crippling
- Other obvious indications of defects.

**Note:** *The inspection should be carried out at a speed consistent with the local conditions and the full scope of the inspection being carried out (e.g. the type and number of other infrastructure elements being inspected).*

*Rail head contamination can cause issues with detection, tractioning and braking. Where rail head contamination has been identified the risk of runaway and SPAD should be considered. If a risk of SPAD or runaway has been created by rail contamination appropriate controls shall be established and corrective actions planned.*

## 1.4.2 General Inspection – Rail, Rail Welds and Surface Conditions

### 1.4.2.1 Inspection Requirements

GENERAL INSPECTION OF RAIL, WELDS AND SURFACE CONDITIONS	
Applicability	As per ETP-00-03. All mainlines, crossovers and crossing loops
Frequency	Mainlines: 365 days where not specified by ETP-00-03 Crossing Loops, Crossovers: 730 days where not specified by ETP-00-03
Competency Required	Track Examiner & Certifier

Inspections of rail and welded rail joints are undertaken to identify conditions which if left unattended have the potential to result in rail breaks. These inspections shall be undertaken on rails and welded rail joints on tracks with both CWR and jointed rail configurations.

A general visual inspection shall include the elements from the patrol inspection as well as Table 1-12.

**Table 1-12: Rail Running Surface Defect Inspection**

COMPONENT	TASK
Rail Welds	Visual check for indicators of poor alignment.
	Measurement of alignment only where concerned about weld condition
	Visual check of general weld surface condition
	Measurement of distance to adjacent welds, joints or bolt holes where suspected defect is identified
Rail Surface	Visual check of rail surface where defects identified or known history
Rail Condition	Visual check of rail condition where defects identified or known history

### 1.4.2.2 Assessment

The detection of rail running surface defects during inspection will generally be through identification of these secondary effects. In some modes of track deterioration timber sleeper track has a better inherent ability to tolerate impacts resulting in a lower rate of deterioration than for concrete sleeper track.

Assessment of the track condition by a competent worker should include consideration of the track alignment, sleepers, fastenings, track geometry and support either side of the gap (or break). The need for reinforcement on a defect rail (temporary plating) should be determined as an act to prevent rail breaking, before the defect can be remediated.

Minor RCF can be managed through corrective grinding and is covered by ETM-01-02. Where severe RCF is present it may be managed through increased metal removal or localised removal of the rail, this should be based on a local assessment.

**Table 1-13: Rail Running Surface Defect Assessment**

CRITERIA	ELEMENT	CONDITION	ACTION
Weld alignment and condition <sup>[1]</sup>	Peak in running surface	1mm over 1m	Routine Inspection
		2mm over 1m	Record defect
	Dip in running surface	0.5mm over 1m	Routine Inspection
		2mm over 1m	Record defect
		0.5mm over 1m	Routine Inspection

CRITERIA	ELEMENT	CONDITION	ACTION
	Peak or Dip in Gauge face	2mm over 1m	Record defect
	Ramp angle <sup>[2]</sup>	8 milliradians	Routine Inspection
		10 milliradians	Record defect
	Weld surface condition	Battering present	Increase Monitoring
		Breakout of surface or gauge face	Record Defect
		Track pumping occurring	Record Defect
			Apply TSR as required
Weld placement	Non-conforming to bolt hole distance	Any bolt hole within 65mm of weld	Record Defect
	Weld	Any weld plain track within 4m of another weld or mechanical joint	Record Defect
		Any weld at turnout within 1.2m of another weld or mechanical joint	Record Defect
Rail Surface	Rolling Contact Fatigue	RCF resulting in shielding (LBWE)	Manage as per ETA-01-05
		RCF Cracking >10mm in length or formation of minor defects	Review grind profiles and metal removal (Refer to ETM-01-02)
		RCF breaking out / spalling	Record defect and escalate to local engineering authority
	Squats	Visually observed	Record defect
		Breaking out	Increase Monitoring. Record Defect
		Track Pumping	Record defect. Repair or remove based on local engineering advice
	Unusual wear or wheel contact patterns	Visually observed	Monitor and raise to local engineering where further advice is required
	Corrugations	Visually observed	Record Defect and raise to local engineering where further advice is required
Rail Condition	Broken Rail or Joint	Visually observed	Follow requirements for Broken Rail in 1.4.3
	Damaged Rail	Visually observed	Assessed by a competent worker based on extent, location and geometry of defect. Any sharp notches should be recorded for removal.

CRITERIA	ELEMENT	CONDITION	ACTION
	Rail Crippling	Visually observed	Record Defect and raise to local engineering where further advice is required
	Corrosion	Inspect as per 1.4.5	As per 1.4.5

**Notes:**

1. *The limits given are recommended limits only for existing rail welded joints and are not recommended for normal track construction and upgrading work (refer to 1.3.9.5). Imperfections that may have damaged rollingstock should be advised to the train operator.*
2. *May be measured with a digital straight edge*

### 1.4.3 Management of Broken Rails

Where the defect has broken completely through the full rail section or has lost a segment of the head or foot one of the following actions shall be taken, in order of preference (as operations and time permit).

1. Remove the broken rail and install a closure rail in accordance with all CWR standards.
2. Install an approved temporary joint plate across the break as per 1.3.3.3, speed restrict according to conditions and reassess the joint as conditions require. Temporary joints have no defined maximum allowed time in track, however,
  - a. risks shall be considered when using them for longer than several days,
  - b. they shall be protected by speed restrictions according to ARTC Rail standards,
  - c. they shall be monitored daily
3. Pilot trains across the gap, the following applies to the movement of traffic over a break in a running rail,
  - a. Assessment of the track condition by a competent worker should include consideration of the track alignment, sleepers, fastenings, track geometry and support each side of the break.
  - b. The following conditions are not suitable for pilot of trains.
    - i. Any break with remaining large cracks at angles away from the break into the rail section.
    - ii. A break that is not clean and vertical
    - iii. A break that occurs on the high leg of a curve with less than 800m radius
    - iv. A break on an unrestrained rail i.e. a switch/blade
    - v. Any break within 1m of a Thermic weld or joint.
    - vi. A gap greater than 50mm

**1.4.3.1.1 Reporting and Investigation of Broken Rails, Welds and Insulated Joints**

The purpose of reporting broken rails, welds and insulated joints is to determine the cause of failure and why the defect, if present, was not previously detected, or if any trends in failures are becoming evident.

All rail break inspection details may be recorded either electronically utilising the electronic forms on the Asset Management System or manually on the appropriate ARTC standard forms available on the ARTC Extranet site as follows:

- Form ETE0101F-01 Rail Break Report (Non-Heavy Haul)
- Form ETE0101F-02 Rail Break Report (Heavy Haul)

**1.4.3.1.2 Reporting and Investigation Process**

For all broken rails, the pieces shall be initially inspected and assessed by competent persons nominated by the relevant Manager and the on-site part of ETE0101F-01 or ETE0101F-02 Rail Break Report form completed in the field. Photographs of the break are to be attached. As a minimum, this should include one from the top of rail, and one from each side of the rail (field side and gauge side).

**1.4.3.1.3 Standard Investigation Process**

If there is no doubt about the cause of the break, ETE0101F-01 or ETE0101F-02 Rail Break Report form is to be forwarded, with photographs of the break and submitted to the nominated competent person in the relevant Area Managers office, who shall complete the office part of the form. After review in the office, the data shall be entered into the database.

**1.4.3.1.4 Additional Investigation Steps**

For breaks such as those:

- Of an unusual or complex nature.
- Where defects appear to have been present in the broken rail for a considerable period of time and not detected by ultrasonic inspections.
- Where the cause of the break is not immediately apparent from visual inspection.
- Where a pattern of breaks is becoming apparent.

Both sides of each break, (about 150mm long) including all pieces, together with the completed on-site part of ETE0101F-01 or ETE0101F-02 Rail Break Report form, are to be forwarded to the appropriate area office concerned as soon as possible after removal from track, for visual examination by competent person(s) nominated by the relevant Manager.

The pieces of broken rail are to be packaged securely, with line, track rail (Up / Down), and kilometrage clearly marked on rail and with paperwork clearly identifying the incident (Rail Break Report form).

After inspection by the competent person, the office part of ETE0101F-01 or ETE0101F-02 Rail Break Report form is to be completed.

If after this inspection, doubt exists about the cause of the break or the break requires more detailed examination, the broken rail pieces are to be forwarded to an accredited laboratory for metallurgical examination and report.



## 1.4.4 General Inspection – Rail Joints

### 1.4.4.1 Inspection Requirements

GENERAL INSPECTION OF MECHANICAL JOINTS	
Applicability	All jointed tracks including tracks with long welded rail (LWR)
Frequency	730 days where not specified by ETP-00-03 Technical Maintenance Plan
Competency Required	Track Examiner & Certifier

GENERAL INSPECTION OF INSULATED JOINTS	
Applicability	All tracks with associated equipment items 'Insulated Joint'.
Frequency	365 days where not specified by ETP-00-03 Technical Maintenance Plan
Competency Required	Track Examiner & Certifier

Inspections of insulated rail joints and mechanical joints are undertaken to identify conditions which if left unattended have the potential to result in failure of rail joint components.

A general visual inspection shall be carried out at intervals not exceeding twelve (12) months or as specified by ARTC e.g., in an approved Technical Maintenance Plan or at lesser intervals if specified in the joint design (including temporary joint installations).

**Table 1-14: Rail joints defect inspection**

COMPONENT	TASK
Overall	Visual check for evidence of pumping
Fishplates	Visual check for cracks through plate
Fishbolts	Check if bolts are tight and effective
Rail Ends	Visual check joint ends for batter. Measure as required.
	Measure rail end gap.
Insulated Joints	Visual examination of insulation material
	Measure gap between rail ends, including metal flow
	Insulation general condition
Mechanical Joints	Check for frozen joints

**Note:** Asset management authority should conduct review on the inspection frequency based on the Network's tonnage and track condition to determine if more frequent inspections should be carried out.

### 1.4.4.2 Assessment

Free movement of sliding joints shall be maintained. Where joints are frozen or poor joint regulation exists, the track should be assessed in accordance with the recommendations in CoP Section 6.

Rectification work should be programmed on a priority basis. Where the assessment responses include increased monitoring, knowledge of local factors that may affect the tracks deterioration

rate and performance history is required. The increased monitoring frequency should be determined by these factors. This increased monitoring should be continued until rectification work is carried out. Ideally increased monitoring should be conducted in alignment with track patrols.

#### CER AUTHORITY

If the cause of a defect is known and it is known that it will not deteriorate into an unsafe condition an alternate response what is provided in this section is permitted with appropriate documentation and approval by the CER.

**Table 1-15: Rail Joints Defect Assessment**

COMPONENT	PARAMATER	CONDITION	RESPONSE
Overall	Pumping	Any	Increase monitoring until repaired Apply TSR as required
Fishplates <sup>[1]</sup>	Visual cracks	1 or both plates	Increase monitoring until repaired
	Loose	1 or both plates	Increase monitoring until repaired
	Complete failure	1 fishplate	40km/h TSR until repaired
		Both fishplates	10km/h TSR until repaired
Fishbolts / Huck Bolt <sup>[2]</sup>	Effective	≥ 2 on both rail ends	Routine Inspection
		1 only on either rail end	Increase monitoring until repaired
		Nil on one rail end <sup>[3]</sup>	20km/h TSR until repaired
		Nil on both rail ends <sup>[3]</sup>	10km/h TSR until repaired
Rail Ends	Batter	> 2mm for over 100mm	Increase monitoring until repaired
	Rail end gap	≤ 20mm	Routine Inspection
		21mm to 30mm	Increase monitoring until repaired
		> 30mm <sup>[5]</sup>	40km/h TSR until repaired
	Rail end mismatch misalignment	> 3mm <sup>[5]</sup>	20km/h TSR until repaired
Insulated Joints <sup>[4]</sup>	Insulation material	Defective	Increase monitoring until repaired
		Delamination observed	Increase monitoring until repaired
		Batter or metal flow across joint	Repair
	Fastening components	Worn pads and parts	Replace
	Gap between rail ends	≥ 4mm	Routine Inspection
		< 4mm	Increase monitoring until repaired
Mechanical Joints	Frozen		Assess as per COP: Section 6

#### Notes

1. *Failure means broken through whole cross-section between inner fishbolts.*
2. *Effective means able to maintain satisfactory vertical and horizontal alignment of rail ends under traffic. Ineffective bolts may be missing, broken, or loose (depending on condition of other bolts and operating environment). Effective bolts may be tight, or loose (depending on condition of other bolts and operating environment).*
3. *Default speed restriction may be increased after risk assessment of rail end pull-apart potential, and potential for the unacceptable alignment of rail ends.*
4. *It is an assumption that electrical failure of an insulated joint causes the signalling to "fail safe". i.e. it is a track reliability issue and not a track safety issue.*
5. *Default speed restriction may be increased after risk assessment of rail end gap growth potential, and wheel climb potential.*

#### 1.4.5 General Inspection – Rail Corrosion

##### GENERAL INSPECTION OF CORROSION

Applicability	All known wet locations such as tunnels; Saline areas with known corrosion
Frequency	365 days where not specified by ETP-00-03 Technical Maintenance Plan
Competency Required	Track Examiner & Certifier

In addition to other inspections, rails in tunnels and wet locations shall be examined for corrosion. The examination should be carried out on a wet day to confirm the location of water ingress into the tunnel.

The examination requires the removal of any debris and ballast from the rail sections and particularly from the foot and web area to determine where:

- the rail is being corroded.
- the rail is wet.
- there is major wear on the foot at sleepers and plates.

Where there is a reduction in rail size in the foot or web measurements should be taken at a maximum spacing of 20 metres with the results reported on the appropriate form. Care should be taken to ensure the worst dimensions in the area are recorded.

Once reduction in size is noted it should be recorded in the AMS for reference at the next examination.

The maximum allowable loss of web and foot size is 3mm at which stage the rail should be replaced.

Details where the web width, foot depth and foot width corrosion measurements should be taken for 53 and 60 kg/m rail are show in Figure 1-2.

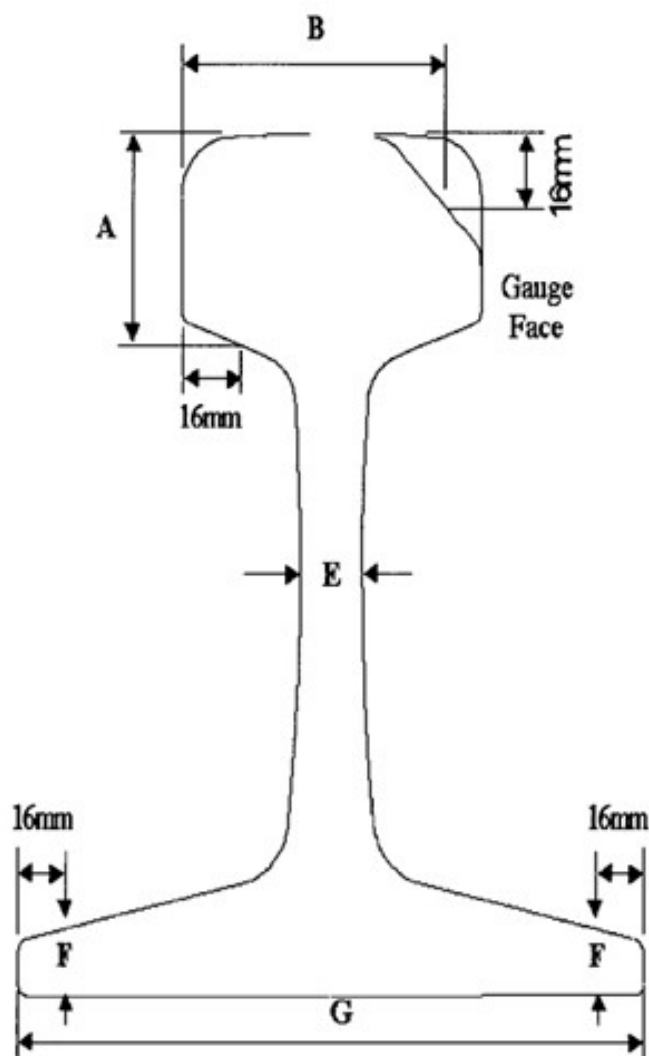


Figure 1-2: Rail cross-section locations of where to take corrosion measurements for 53 and 60 kg/m rail

The corrosion limits for 53 and 60 kg/m rail can be seen in Table 1-16.

Table 1-16: Original and Allowable Rail Limits Due to Corrosion

Rail Section	Web Width (mm)		Foot Depth (mm)		Foot Width (mm)	
	'E'		'F'		'G'	
	Original	Limit	Original	Limit	Original	Limit
53kg/m	15	12	13	10	146	143
60kg/m	17	14	13	10	146	143

#### 1.4.6 General Inspection – Guard Rails

GENERAL INSPECTION OF GUARD RAIL CONDITION	
Applicability	Running Lines where Guard Rails are installed on Bridges.
Frequency	365 days where not specified by ETP-00-03 Technical Maintenance Plan
Competency Required	Track Examiner & Certifier

The inspection of guard rails is undertaken to identify conditions which may inhibit these assemblies from performing their primary function.

A general visual inspection should be looking for the following defects:

- Missing or ineffective rail/sleeper fastenings.
- Lack of guard rail continuity.
- Obvious damage to components.

Guard rails are not required on bridges.

All existing guard rails shall be safely maintained in accordance with Table 1-17 until they are removed.

Table 1-17: Responses for Guard Rail Condition

DEFECT NAME (TYPE CODE, POSITION CODE)		
DEFECT SIZE	RESPONSE TIME	ACTION
<b>SLEEPER FASTENINGS MISSING OR INEFFECTIVE</b> <sup>[Note]</sup>		
Isolated (non-effective) fasteners missing or ineffective on either side of the guard rail	—	No action
2 or more consecutive fasteners missing or ineffective on either side of the guard rail	13 Weeks	Replace or restore to specification
For splay rails or the ends of guard rails 1 or more fasteners missing or ineffective	13 Weeks	Replace or restore to specification
<b>COMPONENT DAMAGE</b>		
Any damaged components which may render the guard rail ineffective in the event of a derailment	13 Weeks	Damaged guard rail components should be replaced or restored as necessary.
<b>RAIL JOINT CONDITION</b>		
Ineffective rail joint	13 Weeks	Ineffective joint components should be replaced or restored as necessary.
<i>Note: These defect sizes and responses apply to all configurations of guard rail fasteners.</i>		

## 1.4.7 General Inspection – Rail Lubrication Equipment

### 1.4.7.1 Inspection

GENERAL INSPECTION OF RAIL LUBRICATION	
Applicability	All Running Lines where rail lubricators have been installed.
Frequency	182 days where not specified by ETP-00-03 Technical Maintenance Plan
Competency Required	Track Examiner & Certifier

General inspections of rail lubrication device shall be carried out at the prescribed intervals to identify defects that may impact the functionality of a lubricator. Lubricant refilling rates may be more frequent and should be made to suit variations in climatic conditions.

An unscheduled general inspection shall be carried out to investigate reported train traction and braking anomalies from operators.

A general visual inspection shall include the elements from the patrol inspection as well as Table 1-18. Plunger and blade settings are in Table 1-19.

**Table 1-18: Rail Lubricator Inspection**

COMPONENT	TASK
Main reservoir	Check the grease level
	Check container condition (signs of damage, cracks, leaks etc.)
	Check filter valve condition (cleanness, fitted with cover etc.)
Pump assembly (Mechanical lubricators)	Check plunger condition
	Check plunger height above rail
	Check plunger function
Wheel sensor (Electric lubricators)	Check wheel sensor condition
	Check wheel sensor height below rail top
Greasing plate assembly	Check blade / wiper bar for signs of wear
	Check blade / wiper bar height below rail top
	Check for grease delivery
Others	Check for visual leaks around hoses, blade ends or pumps
	Check for even spread of the grease along the gauge face of the rail – around curves
	Check for signs of excessive side wear, shiny wear marks on the gauge face and / or steel flakes along the rail foot – around curves
	Check for excess lubricant on the gauge side or lubricant being transferred to the top of the rail head (where it is not intended to be applied).

**Note:** *There are various types of lubrication equipment in the field. Available manuals should be carried when conducting inspections and checked against if special equipment components are identified on site.*

Table 1-19: Plunger and Blade Settings

SETTING	Plunger height (above top of rail head) *	Blade / Wiper bar height	Wheel sensor (distance below rail top)
Mechanical lubricators	1 – 3 mm	19 mm below rail top	N/A
Electric lubricators	N/A	As per product manual	40 mm (or as specified by product manual)

**Notes:** *\*Generally, the required plunger heights above the running surface of the rails for correct supply of lubricant are 3 mm in summer when the lubricant is less viscous, and up to 5 mm in winter when the lubricant is more viscous.*

*However, it is essential to observe if any lubricant is migrating to the running surface of the rails. If this occurs, the height of the plungers shall be reduced.*

*The plunger height may be lowered on higher train speed lines as the lubricant could be pumped excessively.*

#### 1.4.7.2 Assessment

The following actions can be undertaken to rectify conditions found during inspection following Table 1-20. More details refer to the specific user manual for different types of lubricators.

Table 1-20: Rail Lubricator Inspection Actions

CRITERIA	ELEMENT	Condition	ACTION
<b>Main Reservoir</b>	Grease level	Half or less than half of the capacity	Fill main reservoir.
	Damages and leakage	Loose hose fittings or damaged hoses.	Tighten any hose clips or nuts / bolts / screws or replace the hose.
		Loose bolts on the container or cracks around bolt holes	Tighten all bolts or replace faulty parts
	Filler valve	Dirty and clogged	Clean
<b>Pump assembly (Mechanical lubricator)</b>	Plunger	Worn plunger	Replace plungers if necessary; if pump not operating replace assembly with exchange service unit.
	Plunger height	Lower or higher than Table 1-19 - passing wheels do not actuate pumps	Adjust as required in Table 1-19.
	Plunger testing	Activated plunger not delivering grease to blade	This may require the pump to be primed to remove air locks.
<b>Wheel Sensor</b>	The unit	Visual damage	Replace the sensor if necessary

CRITERIA	ELEMENT	Condition	ACTION
(Electric lubricator)		Sensor height from the rail top is different to the user manual – passing wheels do not activate the pump	Adjust as required in the user manual
Greasing plate assembly	Blade / Bar	Worn blade / Bar or visual damage	Repair or replace damaged parts.
	Blade / Bar height	Outside the range in Table 1-19	Adjust blade height and tighten bolts.
	Blade / Bar surrounding	Excessive grease delivery to the rail head and adjacent track structure	Remove excessive grease and prime greasing plate.
		Insufficient grease delivery	Adjust greasing plate height as required.
	Blade / Bar fitting	Loose fittings, faulty gaskets or visual displacement	Adjust and tighten fittings and replace gaskets if necessary.
Others	Leakage	Visual leaks around hoses, blade ends or pumps	Tighten all rail clamps, hose clamps and bolts.
			Clean waste material from rail and rail lubricator. Wash the Greasing Plate, Anchor Block and Pumps and Main Container.
	Dry rail around curves	The gauge face of the rail isn't smooth in texture or display good coverage of the lubricant.	Record the observation and service the unit as per user manual
		Excessive curve wear, such as shiny wear marks on the gauge face.	Record the observation and service the unit as per user manual
		Steel shavings along the rail foot.	Record the observation and service the unit as per user manual

#### 1.4.7.2.1 Maintenance Procedures

Maintenance servicing and repair, the removal and re-installation of lubricator shall follow the specific user manual.

Maintenance servicing should be carried out at regular intervals, generally related to the density of rail traffic and the size of the lubricant reservoir. Lubricators will typically require basic servicing at intervals of 2 – 4 MGT.



### 1.4.8 Detailed Inspection – Internal Rail Defects

DETAILED ULTRASONIC INSPECTION	
Applicability	All running lines
Frequency	Every 15MGT where not specified by ETP-00-03 Technical Maintenance Plan
Competency Required	Continuous Testing: Managed by contractor. ISO9712 Level 2 preferred Manual Testing: Ultrasonic Tester

Detailed inspection internal rail defects should be carried out as in the sections below.

#### 1.4.8.1 Continuous ultrasonic testing

- Identification of defects shall be carried out via continuous ultrasonic testing at a frequency of 15MGT during the service life of the rail or as specified otherwise by ARTC e.g., in an approved Technical Maintenance Plan. All main lines, crossing and refuge loops and sidings where the authorised operating speed exceeds 25 kph shall be tested.
- After appropriate analysis the frequency may be varied for the lighter axle load operating regimes and for newer rail.
- The ultrasonic rail inspection reporting system shall supply reports to ARTC or nominated representative indicating whether rail testing has been inhibited by “shielding” from gauge corner fatigue damage, other rail surface defects or any other cause. Any loss of testing shall be investigated using the ARTC standards for Non-Destructive Testing of rail. This data should be used for the determination of rail repair, rail grinding and rail replacement programs.
- Technical aspects of this testing should be based on the Railways of Australia (Australasian Railway Association) report 'WZ/89/A/92 Ultrasonic Testing of Rail in Railway Applications'.
- When doing ultrasonic inspection of rails by rail flaw detection vehicles the rail surface in the vicinity of rail lubricators shall be checked. Where there is a build-up of grease on the head of the rail the lubricator should be turned off 24 hours prior to the scheduled inspection. If this is not practical the lubricator may be turned off more than 24 hrs ahead of the rail flaw inspection, but this time should be kept to a minimum since additional rail wear may occur. The lubricators should be turned back on as soon as practicable after the rail flaw inspection.

#### 1.4.8.2 Manual ultrasonic testing

Identification of defects should be carried out in accordance with ARTC training procedures via manual ultrasonic testing in the following situations:

- At new aluminothermic and flashbutt welds (including wire feed welds).
- To confirm suspected defects indicated by the continuous ultrasonic inspection.
- Where there are suspected defects as found by visual inspection.
- When known defects are due to be reinspected and reassessed.

Probe configurations shall be carefully selected for the defect being examined. As a basis the following standards shall be used to derive the work instructions:

- AS 2083 for calibration of equipment.

- AS 1085.20 for weld test procedure

Common internal defects and their descriptions are summarized in Table 1-21.

#### **1.4.8.3 Other detailed inspections**

Other detailed inspections may be used in conjunction with ultrasonic detection, for example magnetic particle, dye penetrant, X-ray, eddy current and magnetic induction.

A manual inspection shall be carried out when a joint has been reported as 'Mechanical Joint Suspect' (MD) by the ultrasonic test car. Detailed inspection may require removal of fish plates to observe the defect.

New welds shall be checked for alignment and meet the requirements of Table 1-10.

#### **1.4.8.4 Assessment**

##### **1.4.8.4.1 Minimum Action**

Upon detection of any actionable defect planning should commence to remove the defect.

The method and response times for the rectification of rail defects as provided for in this Standard are minimum requirements only.

- Local instructions can be issued for requirements above these minimum actions.
- Response times commence from the date and time of discovery.
- If the track conditions in the area of the defect are poor and create an increased risk of failure, consider shortening action response times and/or applying appropriate additional mitigations.

##### **1.4.8.4.2 Dispensation for exceedance of maximum allowable response times**

###### **CER AUTHORITY**

The CER may provide a dispensation to the maximum allowable response times and actions defined in this procedure for the removal of discrete rail defects where there is a justifiable reason for the inability to achieve the mandated response times, subject to the conditions in this section.

The CER shall not increase the maximum allowable speed over of a defect by more than 20km/h from the speed restrictions defined in this procedure.

This dispensation can only be granted by the CER.

Dispensations for rail defects removal response times shall be entered into the EAMS.

The following are examples where a dispensation may be justified subject to assessment of risk and appropriate risk control measures:

- The lead time for replacement components exceeds the mandated response times for defect removal. The dispensation timescale shall be minimum practical subject to a risk assessment.
- The short notice diversion of the required maintenance resource would require the deferment of other planned work with equal or higher risk/consequences.
- Third party permits are required in order to carry out the defect removal for example temporary road closure.

This dispensation shall not be used to manage systematic non- compliance with ARTC Standards.

The following risk factors should be considered when considering dispensation.

- Frequency of rail traffic
- Type of rail traffic
- Condition of track including fastening system
- Track alignment (curve or tangent, high leg or low leg)
- Multiple main lines

#### **1.4.8.4.3      *Marking of rail defects***

All rail defects that require action shall be durably marked with paint.

The marking shall show the full extent of the defect. The overall length and centre line of the defect shall be clearly marked.

The marking will eliminate the need for additional ultrasonic inspection prior to repair to confirm location and size and provides a visual indication that the defect has been removed from track.

#### **1.4.8.4.4      *Untestable rail***

Where full ultrasonic testing cannot be completed, the rail shall be reported as “untestable”.

#### **1.4.8.4.5      *Defects within Points and Crossing***

In Points and Crossing layouts where it is not possible to adhere to the maximum response times due to the complexities of the unit's design or the supply of replacements, then the removal response time and mitigations to be applied shall be in accordance with the dispensation clause in this procedure.

#### **1.4.8.4.6      *Repeated or continuous defects***

If the defect type is repeated or continuous in a rail length between welds the whole length of rail affected shall be replaced (for example hydrogen shatter cracking or longitudinal vertical splits)

After assessment, the data from the Rail Break Report forms and any metallurgical reports are to be entered into the AMS and other databases as required local instruction.

#### **1.4.8.4.7      *Classification of rail defects and minimum remedial action***

All rail defects e.g. inclusions, micro cracks etc., are classified by type and size as defined in Table 1-22, Table 1-23 and Table 1-24 below, with corresponding minimum actions and response time for rail defects;

- Where a defect is greater than the defined minimum size, it is to be classified as a rail defect with type and size as per the applicable table.
- Where a defect is less than the minimum size shown in the applicable table, it is to be classified and reported as a “non-sizeable defect” and no remedial action or defect recording is required unless local instructions exist. This doesn't apply to new welds, refer to 1.3.9 for welding processes.
- Defects that are actioned through re-assessment (where allowed) without being plated shall be ultrasonically re-assessed at the frequency of the response time.
- Defects that are actioned through plating (where plating is a specified option) may be re-assessed at the frequency that ultrasonic testing occurs on that line by ARTC e.g. in an approved Technical Maintenance Plan.

- Defects that are re-assessed and change in size shall be actioned in accordance with the applicable table based on their new size.
- Where the minimum response is “plate and remove” the appropriate TSR shall remain in place until the defect is removed.

#### **1.4.8.4.8      *Non-heavy haul rail defects classification and minimum actions***

The Rail defects classification and minimum actions and response time for rail defects are provided in Table 1-22.

An exception to Table 1-22 is shown further below in Table 1-23. These exceptions are to allow for the high counts of smaller defects found in existing 47kg/m rail in non-heavy haul tracks for SA/WA/VIC, which shall remain under the previous defect management regime until the rails are replaced.

#### **1.4.8.4.9      *Heavy haul rail defects classification and minimum actions***

The minimum actions and response time for rail defects are provided in Table 1-24.

Table 1-21: Internal Defect Description and Ellipse Defect Attribute

CODE	ELLIPSE DEFECT ATTRIBUTE	DESCRIPTION	TYPICAL FAILURE MODE
BHC	Rail Web Bolt Hole Crack	A progressive fracture that originates at a bolt hole and progresses radially away from the hole.	Upon failure, the rail may break into several pieces.
EB	Rail Head Transverse Crack from Wheel Burn	A scar on the running surface of the rail caused by intense friction heating from slipping driving wheels.	May develop into Transverse defect
FW	Rail Foot Web Separation	A progressive crack along the foot/web fillet area	May lead to collapse of rail or complete break
HSB	Rail Head Horizontal Split	A progressive longitudinal fracture in the head of a rail, where separation along a seam spread horizontally through the head, parallel to the running surface	Upwards or downwards curve, resulting in loss of rail head.
HSW	Rail Web Horizontal Split	A progressive longitudinal fracture in the web of rail, oriented horizontally along the length of the rail.	Upwards or downwards curve, resulting in S break. May develop into head/web separation.
HW	Rail Head Web Separation	A crack that generally occurs in the rail end and separates the head from the web.	May lead to collapse of rail head or complete break
MJ	Suspect Internal Rail Flaw	Damage to mechanical or insulated joint, including surface batter, flow, broken or damaged fish plates or missing bolts.	Loss of track circuits. Can fail similar to rail break.
PR	Rail Web Piped Rail	A vertically orientated defect resulting in opening of a cavity and a bulge in the web (i.e. a pipe).	May lead to collapse of rail or complete break
TD	Rail Head Transverse Crack	A single, isolated defect growing in the transverse and vertical planes. May be in the head web or foot.	"Head: Will often result in a straight break. Web or foot: Often result in 'S' break."
SW	Rail Web/Foot Transverse Crack		
TDX	Rail Head Multiple Transverse Cracks	When 2 or more transverse defects are closer than 2m apart.	
VSH	Rail Head Vertical Split	A progressive vertical fracture in the rail, where separation along a seam spread vertically through the head, along the length of the rail.	Failure of rail head, resulting in loss of section
VSW	Rail Web Longitudinal Vertical Split	A progressive vertical fracture in the rail, where separation along a seam spread vertically through the web, along the length of the rail.	May develop into piped rail or HSW
WF	Rail Head / Web / Foot Transverse Weld Defect	Defects originating from imperfections within flashbutt weld zones (e.g. inclusions, fusion defects). If internal flaw shows signs of growth, should be re-classified at TD	Often develop into transverse defects
WFW	Rail Head Repair Weld Defect	May be inclusions introduced during the arc welding process, and/or excessive or insufficient hardness in the weld or heat affected zone of the underlying rail	Can lead to internal defects, eventual near surface cracking and loss of welded region, or transverse defect
WT	Rail Head / Web / Foot Transverse Weld Defect	Defects originating from imperfections within aluminothermic weld zones (e.g. inclusions, fusion defects). If internal flaw shows signs of growth, should be re-classified at TD	Often develop into transverse defects

Table 1-22: Rail Defect Management for Non-Heavy Haul

TYPE OF DEFECT	CODE	SIZE DEFINITION		IMMEDIATE SPEED RESTRICTION (KM/H) UNTIL ACTION TAKEN	MINIMUM ACTION BY TRACK CONFIGURATION				OTHER ACTIONS / NOTES		
		SIZE	MEASUREMENT		CURVE ≤600M RADIUS		CURVE >600M RADIUS and TANGENT				
					ACTION	RESPONSE TIME	ACTION	RESPONSE TIME			
1	Transverse Defect	Head (Fissures or Shelling)	TD	S	10 to 20 mm	-	Plate until Removed	7 days (P1)	Reassess or Plate until Removed	90 days (PR)	Refer to Table 1-23 for exceptions to defect responses on Transverse defects.  If TD is reported in shatter cracked rail, the full length shall be replaced weld to weld. *TSR shall remain in place until the defect is removed.
				M	21 to 30 mm	20	Plate until Removed	1 day (E)	Plate until Removed	28 days (P2)	
				L	over 30 mm	20	Plate* and Remove	2 hours (E) 1 day (E)	Plate until Removed	1 day (E)	
		Web/Foot	SW	S	20 to 40mm	-	Remove	7 days (P1)	Remove	7 days (P1)	*Multiple refers any TD found within 2m of any other TD - <b>Replace the full defect length.</b> TDX size is determined by the largest TD in the group.  For 47/53kg rail, suggest replacing full rail length – weld to weld.
				M	41 to 75mm	20	Remove	1 day (E)	Remove	1 day (E)	
				L	over 75mm	20	Remove within 1 day (E). Stop trains if necessary.				
		Multiple Transverse Defects	TDX*	S	10 to 20 mm	40	Remove	7 days (P1)	Remove	28 days (P2)	
				M	21 to 30 mm	20	Remove	1 day (E)	Remove	7 days (P1)	
				L	over 30 mm	20	Remove within 1 day (E). Stop trains if necessary.				
2	Defective Welds	Head	WT or WF	Size as for TD, noting exceptions in Table 1-23 in SA/WA/VIC							
		Web		S	25 to 50mm	-	Plate until Removed	28 days (P2)	Reassess or Plate until Removed	90 days (PR)	
				M	51 to 75mm	20	Plate until Removed	7 days (P1)	Reassess or Plate until Removed	28 days (P2)	
				L	over 75mm	20	Remove	1 day (E)	Plate until Removed	1 day (E)	
		Foot		M	15 to 35mm (If at edge: 10 to 35mm)	20	Plate until Removed	7 days (P1)	Plate until Removed	7 days (P1)	
L	over 35mm		20	Remove	1 day (E)	Plate until Removed	1 day (E)				
3	Wheel burn	EB	Same as TD – If complete reading not possible treat as TDX.							Where several engine burns exist in the same rail length, consideration should be given to replace full rail length, weld to weld.	
4	Wire Feed Weld	WFW	Sized and actioned as per TD.							As for TD if in switch or crossing, speed restriction and retest until removed.	
5	Horizontal Split Head	HSH	S	25 to 100mm	-	Remove	28 days (P2)	Remove	90 days (PR)	Refer to Table 1-23 for SA/WA/Vic exceptions to defect responses.	
			M	101 to 200mm	-	Remove	7 days (P1)	Remove	28 days (P2)		
			L	over 200mm	40	Remove within 1 day (E). Stop trains if necessary.					
6	Vertical Split Head	VSH	S	25 to 200mm	-	Remove	28 days (P2)	Reassess	90 days (PR)	If any of the following exist, then upgrade to the next size and actions. • visible discolouration (Under Head Stressing), • and/or cracked out, • and/or if the defect runs into any other defect, • and/or if the defect comes within 100mm of a weld, bolthole or joint gap, • and/or if there is rail vertical top wear more than 10mm.	
			M	201 to 400mm	-	Remove	7 days (P1)	Remove	7 days (P1)		
			L	over 400mm	40	Remove	7 days (P1)	Remove	7 days (P1)		
			E	Visible cracking or rail head collapse (dip of VSH greater than 0.5mm measured with a 1m straightedge).	20	Remove within 1 day (E). Stop trains if necessary.					
7	Head and Web separation	HW	S	20 to 75mm	-	Remove	7 days (P1)	Remove	7 days (P1)	If at weld or rail end – use HSW sizing	
			M	76 to 200mm	20	Remove	1 day (E)	Remove	1 day (E)		
			L	over 200mm	20	Remove within 1 day (E). Stop trains if necessary.					
8	Foot and Web separation	FW	S	20 to 40mm	-	Remove	7 days (P1)	Remove	7 days (P1)		
			M	41 to 75mm	20	Remove	1 day (E)	Remove	1 day (E)		
			L	over 75mm	20	Remove within 1 day (E). Stop trains if necessary.					
9	Horizontal Split Web	HSW	S	20 to 40mm	-	Remove	7 days (P1)	Remove	7 days (P1)		
			M	41 to 75mm	20	Remove	1 day (E)	Remove	1 day (E)		
			L	over 75mm	20	Remove within 1 day (E). Stop trains if necessary.					
10	Vertical Split Web	VSW	S	Any registration in one rail length	-	Remove	6 months (P3)	Remove	6 months (P3)	If any visible cracking action as large defect.	
		PR (If piped)	S	25 to 150mm	-	Remove	28 days (P2)	Remove	28 days (P2)		
			M	151 to 300mm	-	Remove	7 days (P1)	Remove	7 days (P1)	If piped rail, then replace full rail length weld to weld.	
			L	over 300mm	20	Remove within 1 day (E). Stop trains if necessary.					
11	Bolted Hole Crack (all angle)	BHC	S	0 to 10mm	-	Reassess until Removed	28 days (P2)	Remove	90 days (PR)	A speed restriction of 40 km/h shall be applied if the defect is not actioned within the response time (noting the restriction may be removed again once the overdue action is completed). *When TSRs are different for curved and tangent tracks.	
			M	11 to 20mm	-	Reassess until Removed	7 days (P1)	Remove	28 days (P2)		
			L	21-40mm	60 / -*	Reassess daily until Removed	1 day (E)	Reassess until Removed	7 days (P1)		
			E	Over 40mm	40 / 60	Assess daily until Removed	Prior to the passage of the next train	Assess daily until Removed.	Prior to the passage of the next train		
12	Mechanical Joint Suspect	MJ	Remove plates and inspect within 7 days (P1). Refer to bolt hole cracks for actions.								

Table 1-23: Exceptions to Non-Heavy Haul Defect Responses In Rail ≤ 47kg In SA/WA/VIC Only.

TYPE OF DEFECT			CODE	SIZE DEFINITION		IMMEDIATE SPEED RESTRICTION (KM/H) UNTIL MINIMUM ACTION TAKEN	MINIMUM ACTION BY TRACK CONFIGURATION				OTHER ACTIONS
				SIZE	MEASUREMENT		CURVE ≤600M RADIUS		CURVE >600M RADIUS and TANGENT		
							ACTION	RESPONSE TIME	ACTION	RESPONSE TIME	
1	Transverse defect	- in rail head (transverse fissures, shelling)	TD	S	10 to 20 mm		Plate until Removed	7 days (P1)	Reassess until Removed	90 days (PR)	If TD is reported in shatter cracked rail, the full length shall be replaced weld to weld.
2	Defective Welds	Head	WT or WF	S	10 to 20 mm	-	Plate until Removed	7 days (P1)	Reassess or Plate until Removed	182 days	
				M	21 to 30 mm	-	Plate until Removed	1 day (E)	Reassess or Plate until Removed	90 days (PR)	
				L	over 30 mm	20	Remove	1 day (E)	Plate until Removed	1 day (E)	
5	Horizontal Split Head		HSH	S	25 to 100mm	-	Reassess until Removed	28 days (P2)	Reassess until Removed	90 days (PR)	
				M	101 to 200mm	-	Reassess until Removed	7 days (P1)	Reassess until Removed	28 days (P2)	



Table 1-24: Rail Defect Management for Heavy Haul

	TYPE OF DEFECT	CODE	SIZE DEFINITION		IMMEDIATE SPEED	REQUIRED ACTION		OTHER ACTIONS		
			SIZE	MEASUREMENT	RESTRICTION (KM/H) UNTIL MINIMUM ACTION TAKEN	ACTION	RESPONSE TIME			
1	Transverse defect	Head (Fissures or Shelling)	TD	S	5 to 20 mm	-	Plate until Removed	7 days (P1)	If TD is reported in shatter cracked rail, the full length shall be replaced weld to weld.	
				M	21 to 30 mm	20	Plate until Removed	1 day (E)		
				L	over 30 mm	20	Plate and Remove	Immediately 1 day (E)		Large defects to be plated prior to next train. Where this cannot be achieved this may be extended to a maximum of 2 hours.
		Web/Foot	SW	S	20 to 40mm	-	Remove	7 days (P1)		
				M	41 to 75mm	20	Remove	1 day (E)		
				L	over 75mm	20	Monitor after each train until removal. Stop trains if necessary.			
		Multiple Transverse Defects	TDX*	S	5 to 20 mm	40	Remove	7 days (P1)	*Multiple refers any TD found within 2m of any other TD - <b>Replace the full defect length.</b> TDX size is determined by the largest TD in the group.	
				M	21 to 30 mm	20	Remove	1 day (E)		
				L	over 30 mm	10	Monitor after each train until removal. Stop trains if necessary.			
2	Defective Welds	Head	WT or WF	Size and action as for TD.					For 47/53kg rail, suggest replacing full rail length – weld to weld.	
		Web		S	25 to 50mm	-	Plate until Removed	28 days (P2)		
				M	51 to 75mm	20	Plate until Removed	7 days (P1)		
				L	over 75mm	20	Plate and Remove	Immediately 1 day (E)		Large defects to be plated prior to next train. Where this cannot be achieved this may be extended to a maximum of 2 hours.
		Foot		M	15 to 35mm (If at edge: 10 to 35mm)	-	Plate until Removed	7 days (P1)		
				L	over 35mm	20	Plate and Remove	Immediately 1 day (E)		
		3		Wheel Burn	EB	Same as TD - If complete reading not possible treat as TDX.				
4	Wire Feed Weld	WFW	Sized and actioned as per TD.					As for TD if in switch or crossing, speed restriction and retest until removed.		
5	Horizontal Split Head	HSH	S	25 to 100mm	-	Remove	28 days (P2)	If any of the following exist, then upgrade to the next size and actions. • visible discolouration (Under Head Stressing), • and/or cracked out, • and/or if the defect runs into any other defect, • and/or if the defect comes within 100mm of a weld, bolthole or joint gap, • and/or if there is rail vertical top wear more than 10mm.		
			M	101 to 200mm	-	Remove	7 days (P1)			
			L	over 200mm	10	Monitor after each train until removal. Stop trains if necessary.				
6	Vertical Split Head	VSH	S	25 to 200mm	-	Remove	28 days (P2)			
			M	201 to 400mm	-	Remove	7 days (P1)			
			L	over 400mm	40	Remove	7 days (P1)			
			E	Visible cracking or rail head collapse (dip of VSH greater than 0.5mm measured with a 1m straightedge).	10	Monitor after each train until removal. Stop trains if necessary.				
7	Head and Web separation (If at weld or rail end – use HSW sizing)	HW	S	20 to 75mm	-	Remove	7 days (P1)			
			M	76 to 200mm	20	Remove	1 day (E)			
			L	over 200mm	10	Monitor after each train until removal. Stop trains if necessary.				
8	Foot and Web separation	FW	S	20 to 40mm	-	Remove	7 days (P1)			
			M	41 to 75mm	20	Remove	1 day (E)			
			L	over 75mm	10	Monitor after each train until removal. Stop trains if necessary.				
9	Horizontal Split Web	HSW	S	20 to 40mm	-	Remove	7 days (P1)			
			M	41 to 75mm	20	Remove	1 day (E)			
			L	over 75mm	10	Monitor after each train until removal. Stop trains if necessary.				
10	Vertical Split Web	VSW (PR if piped)	S	25 to 150mm	-	Remove	28 days (P2)	If any visible cracking action as large defect.		
			M	151 to 300mm	-	Remove	7 days (P1)	If piped rail, then replace full rail length weld to weld.		
			L	over 300mm	10	Monitor after each train until removal. Stop trains if necessary.				
11	Bolt Hole Crack (all angles)	BHC	S	0 to 10mm	-	Reassess until Removed	28 days (P2)	A speed restriction of 40 km/h shall be applied if the defect is not actioned within the response time (noting the restriction may be removed again once the overdue action is completed).		
			M	11 to 20mm	-	Reassess until Removed	7 days (P1)			
			L	21 to 40mm	60	Reassess daily until Removed	1 day (E)			
			E	Over 40mm	40	Reassess daily until Removed	1 day (E)			
12	Mechanical Joint Suspect	MJ	Remove plates and inspect within 7 days (P1). Refer to bolt hole cracks for actions.							



## 1.4.9 General & Detailed Inspection – Rail Wear

### 1.4.9.1 Inspection Requirements

GENERAL RAIL WEAR INSPECTION	
Applicability	All running lines not covered by Detailed Inspection below
Frequency	182 days on Heavy Haul lines where not specified by ETP-00-03
	365 days on all other lines where not specified by ETP-00-0
Competency Required	Track Examiner & Certifier

DETAILED INSPECTION AND ANALYSIS OF RAIL WEAR	
Applicability	All running lines inspected by Geometry Car
Frequency	Inspection: Same frequency as Detailed Inspection of Track Geometry
	Analysis: 365 days where not specified by ETP-00-03

The inspection of rail wear is undertaken to identify locations where the following risks are increased due to the rail wear.

- Rail defect growth rates due to the loss in rail cross sectional volume, or
- Undesirable wheel rail interface conditions due to excessive wide gauge from side wear on rail head.
- Difficulty in ultrasonic testing due to excessive gauge face side wear on the rail head

Any electronic measurements shall meet the following requirements:

1. Top wear shall be measured in the vertical rail plane in the centre of the head to an accuracy of 0.5mm
2. Side wear shall be measured at 90 degrees to the rail vertical plane 16mm from the running surface to an accuracy of 0.5mm
3. Head loss shall be measured as the loss of head area as a percentage of the original area to an accuracy of 2%
4. Gauge face angle shall be measured as the angle between a line perpendicular to the rail to rail plane (i.e. the plane across the top of both rails as contacted by the wheels) and the line tangent of the rail gauge where wheel flange contact occurs to an accuracy of 2 degrees.

*Note: For the track sections where the AK car does not run, the rail wear inspection should be carried out manually - form TE(P1)2F1 can be used for a walk-through inspection. Rail wear should be measured every 250m for straight tracks and 50m at curves (>600m) starting from the first observed rail wear location.*

### 1.4.9.2 Assessment

#### 1.4.9.2.1 Rail Wear Measurement

Table 1-25 gives the area of each rail size in new condition;

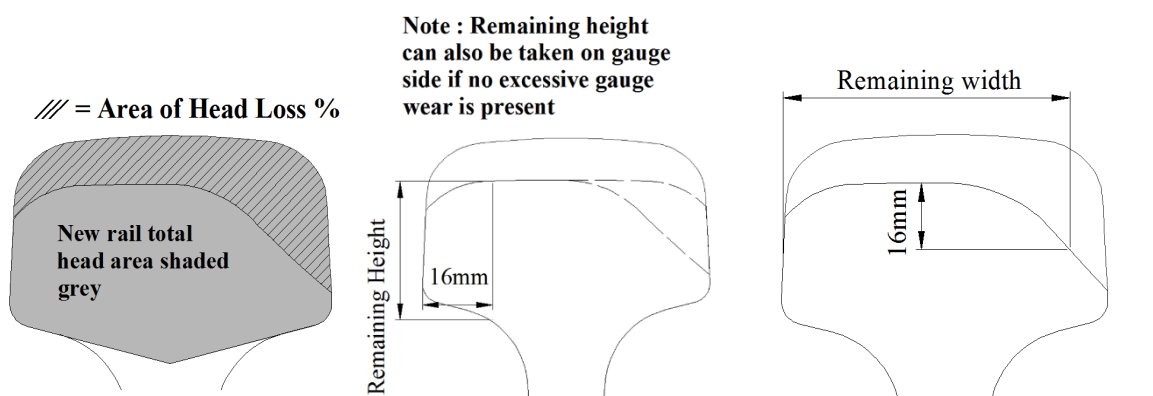
Table 1-25: Rail Size New Head Area to Be Used for Head Loss % Calculations

RAIL TYPE	HEAD AREA (MM <sup>2</sup> )	FULL HEIGHT (MM) AT 16MM FROM GAUGE FACE	FULL WIDTH (MM)
47AS	2548	37	70
50AS	2710	39	70
53AS	2721	39	70
60AS	2999	44	70

All worn rail measurements of remaining head width and head height are taken 16mm below or 16mm into the rail head as shown below.

Measurements are normally taken from running faces, however either side of the rail head is generally acceptable for taking head height (top wear) measurement as long as valid measurements are obtained. In cases where excessive side wear has occurred, it may be difficult or impossible to measure the head height at 16mm from the remaining gauge face edge without obtaining an invalid measurement. In this case it is recommended that the measurement be performed 16mm in from the field side of the rail head.

In locations with excessive metal flow on either the field side of rail head (flow at top edge) or the gauge side (lipping at top edge), the use of callipers or other rail measurement tools may be invalid. Wear limits of head height are designed to be referred 16mm in from the edge of the as-new rail profile (i.e. the flat unworn side face), metal flow beyond that face will distort the dimensions measured and cause invalid results. Checks should be made to ensure valid dimensions are being taken, if unsure then MiniProf, Railmate or equivalent laser methods shall be used.



Rail wear occurs in two planes.

1. Top Wear in the vertical plane. This is the dominant wear mechanism for tangent rail, low rails and high rails in wide radius curves. Also referred to as vertical or table wear.
2. Side Wear in the horizontal plane. This is the dominant wear mechanism for high rails in sharp radius curves.

Rails on main lines and crossing loops are to be examined for wear at the frequency, and using methods, described in 1.4.9.1.

As the rail wear approaches the absolute limit dimensions, the risk levels may need to be reviewed and additional controls implemented. Lines with very high traffic (greater than 20 MGT) rates may need special wear management regimes to give early prediction of risk control or re-rail locations so they are identified in time to enable the specified actions within this clause. Curves

with tight radius approximately <300m may also require re-rail planning much earlier than the specified re-rail limits due to very fast rates of wear.

Table 1-26 details the allowable limits for top wear and side wear, at which the capacity of the rail should be reviewed.

- These limits apply to the worst location, and not the average rail wear, for the segment of track being considered (such as a curve).
- The deciding wear limit is the first exceedance of any of the limits i.e., the specified limit action shall be taken when the rail wear reaches either the height or width.

Table 1-26: Rail Wear Limits

AXLE LOADS	RAIL TYPE (AS)	ABSOLUTE LIMITS		
		TOP WEAR ONLY	COMBINED TOP WEAR & SIDE WEAR	
		(WHERE <10MM SIDE WEAR HAS OCCURRED)	(WHERE >10MM SIDE WEAR HAS OCCURRED)	
		REMAINING HEIGHT LIMIT (MM)	REMAINING HEIGHT LIMIT (MM)	REMAINING WIDTH LIMIT (MM)
≤ 25 TAL	47kg/m (94lb)	24	24	55
	50kg/m	21	21	46
	53kg/m (107lb)	21	23	46
	60kg/m	20	24	46
Heavy Haul > 25 TAL (see note 3)	50kg/m	21	21	46
	53kg/m (107lb)	23	23	46
	60kg/m	24	24	46

**Notes:**

1. At high levels of side wear the rail may be reported as untestable by the contractor (due to loss of zero probe where rail is worn past the edge of the web), manual hand testing may thus be required.
2. ARTC currently operate to a maximum 32 TAL. Axle loads above this level shall require engineering review to determine acceptable wear limits under increased loading.
3. For non-standard rail section refer to Appendix C for wear limits, all actions shall be applied to these as per the standard section requirements.
4. ARTC Rail team should monitor rail wear and plan works strategically prior to reaching the absolute limit.

**1.4.9.2.2 Rail wear Absolute Limit**

Rails approaching this limit should be replaced before the limit is reached. If the rail has reached or exceeded this limit it shall be replaced as soon as is reasonably practical, and the following conditions shall apply until re-rail is completed:

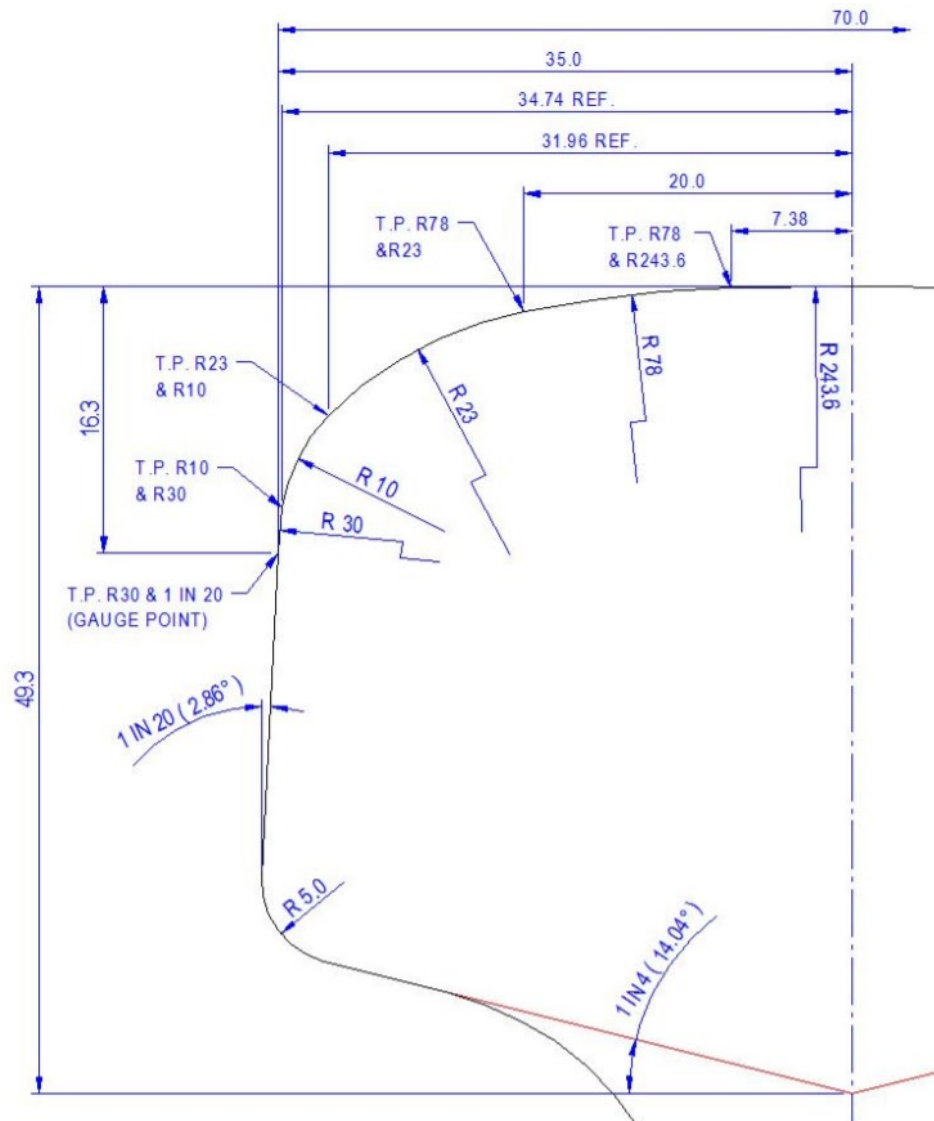
- Locations shall be recorded within the Asset Management System as rail wear exceedances, detailing the lengths exceeding wear limits. Areas which have been identified with wear at or exceeding the absolute limit and there is uncertainty about the length affected, should be manually measured at a maximum interval of 2m throughout the affected area, using methods accepted by ARTC.
- All sizes of internal rail defects shall be treated as large category response.
- If the rail wear recorded has exceeded any of the prescribed limits by less than or equal to 1mm the location shall be speed restricted to 40km/h for maximum 12 months.
- If the rail wear recorded has exceeded any of the prescribed limits by greater than 1mm or not meet the time condition of action #2, the location shall be speed restricted to 20km/h.

**1.4.9.2.3 Gauge Face Angle**

The gauge face angle of rails shall not exceed 26 degrees from vertical, over a length of rail of more than 2m.

Where the prescribed gauge face angle limits are exceeded, the action should be to reinstate an acceptable rail gauge face angle (e.g. profile grind) or re-rail the affected section. The Civil Engineering Representative shall determine the appropriate response actions to be implemented until the exceeded section is remedied. Due to the complexity of wheel climb factors, it is not possible to recommend speed restrictions under all circumstances.

## Appendix A – Modified 60KG/M Tangent Profile



## Appendix B – Rail Head Area Loss Conversion Tables

The tables provided in this appendix are intended to provide a rough estimation of head area loss using both head height and head width. The actual head area loss may vary from the values provided in this table due to variations in rail wear shape.

### 47KG RAIL HEAD AREA LOSS TABLE

94lb (47KG) RAIL															
		HEAD HEIGHT (MM)													
		37	36	35	34	33	32	31	30	29	28	27	26	25	24
HEAD WIDTH (MM)	70	0	4	8	11	13	16	18	20	24	27	30	33	35	38
	69	2	5	8	11	14	17	19	21	25	28	30	33	36	39
	68	3	6	8	11	14	17	19	22	25	28	30	33	36	39
	67	4	7	9	12	15	18	20	23	26	29	31	34	37	40
	66	5	8	10	13	15	18	21	24	26	29	31	34	37	40
	65	7	9	11	14	16	19	22	25	27	30	32	35	38	41
	64	8	10	12	15	17	20	22	26	28	31	33	36	38	41
	63	9	11	13	16	18	21	23	26	29	32	34	37	39	42
	62	10	12	14	17	19	22	24	27	29	32	34	37	39	42
	61	12	14	16	18	20	23	25	28	30	33	35	38	40	43
	60	13	15	17	19	21	24	26	29	31	34	36	39	41	44
	59	14	16	18	21	23	25	27	30	32	35	37	40	42	45
58	15	17	19	22	24	26	28	31	33	36	38	41	43	45	

**50KG RAIL HEAD AREA LOSS TABLE**

100lb (50KG) RAIL																					
	HEAD HEIGHT (MM)																				
	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	
HEAD WIDTH (MM)	70	0	3	6	9	11	14	16	19	21	24	26	29	32	35	37	40	42	45	47	50
	69	1	4	6	9	11	14	16	19	22	25	27	30	32	35	37	40	42	45	47	50
	68	2	4	6	9	11	14	16	19	22	25	27	30	32	35	37	40	42	45	47	50
	67	3	5	7	10	12	15	17	20	23	26	28	31	33	36	38	41	43	46	48	51
	66	4	6	8	11	13	16	18	21	23	26	28	31	33	36	38	41	43	46	48	51
	65	6	8	10	12	14	17	19	22	24	27	29	32	34	37	39	42	44	47	49	52
	64	7	9	11	13	15	18	20	23	25	27	29	32	34	37	39	42	44	47	49	52
	63	8	10	12	14	16	19	21	24	26	28	30	33	35	38	40	43	45	48	50	53
	62	9	11	13	15	17	20	22	25	27	29	31	34	36	39	41	43	45	48	50	53
	61	11	13	15	17	19	21	23	26	28	30	32	35	37	40	42	44	46	49	51	54
	60	12	14	16	18	20	22	24	27	29	31	33	36	38	40	42	45	47	50	52	54
	59	14	16	17	19	21	23	25	28	30	32	34	37	39	41	43	46	48	51	53	55
	58	15	17	18	20	22	24	26	29	31	33	35	37	39	42	44	46	48	51	53	56
	57	17	19	20	22	24	26	28	30	32	34	36	38	40	43	45	47	49	52	54	57
	56	18	20	21	23	25	27	29	31	33	35	37	39	41	44	46	48	50	52	54	57
	55	19	21	23	25	26	28	30	32	34	36	38	40	42	45	47	49	51	53	55	58
	54	20	22	24	26	27	29	31	33	35	37	39	41	43	45	47	50	52	54	56	58
	53	22	24	25	27	29	31	33	35	36	38	40	42	44	46	48	51	53	55	57	
	52	23	25	26	28	30	32	34	36	37	39	41	43	45	47	49	51	53	56	58	
	51	25	27	28	30	32	34	35	37	39	41	43	45	46	48	50	52	54	57	59	
	50	26	28	29	31	33	35	36	38	40	42	44	46	47	49	51	53	55	57	59	

**53KG RAIL HEAD AREA LOSS TABLE**

53KG RAIL																			
HEAD WIDTH (MM)	HEAD HEIGHT (MM)																		
	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	
	70	0	4	7	10	12	15	18	21	23	26	28	31	33	36	38	41	43	46
	69	2	5	8	11	13	16	18	21	23	26	28	31	34	37	39	42	44	47
	68	3	6	8	11	13	16	18	21	23	26	28	31	34	37	39	42	44	47
	67	4	7	9	12	14	17	19	22	24	27	29	32	35	38	40	43	45	48
	66	5	7	9	12	14	17	20	23	25	28	30	33	35	38	40	43	45	48
	65	6	8	10	13	15	18	21	24	26	29	31	34	36	39	41	44	46	49
	64	7	9	11	14	16	19	21	24	26	29	31	34	36	39	41	44	46	49
	63	9	11	13	15	17	20	22	25	27	30	32	35	37	40	42	45	47	50
	62	10	12	14	16	18	21	23	26	28	31	33	36	38	40	42	45	47	50
	61	11	13	15	18	20	22	24	27	29	32	34	37	39	41	43	46	48	51
	60	12	14	16	19	21	23	25	28	30	33	35	37	39	42	44	46	48	51
	59	14	16	18	20	22	25	27	29	31	34	36	38	40	43	45	47	49	52
	58	15	17	19	21	23	26	28	30	32	34	36	39	41	43	45	48	50	52
	57	17	19	20	22	24	27	29	31	33	35	37	40	42	44	46	49	51	53
	56	18	20	21	23	25	28	30	32	34	36	38	41	43	45	47	49	51	54
	55	20	22	23	25	27	29	31	33	35	37	39	42	44	46	48	50	52	55
	54	21	23	24	26	28	30	32	34	36	38	40	43	45	47	49	51	53	55
	53	22	24	26	28	29	31	33	36	38	40	42	44	46	48	50	52	54	56
	52	23	25	27	29	30	32	34	37	39	41	43	45	47	49	51	53	55	57
	51	25	27	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58
	50	26	28	29	31	33	35	37	39	41	43	45	47	49	51	53	55	56	58
	49	28	30	31	33	35	37	38	40	42	44	46	48	50	52	54	56	57	59
	48	29	31	32	34	36	38	39	41	43	45	47	49	51	53	54	56	58	60
	47	31	33	34	36	37	39	41	43	45	47	48	50	52	54	55	57	59	
	46	32	34	35	37	38	40	42	44	46	48	49	51	53	55	56	58	60	



## 60KG RAIL HEAD AREA LOSS TABLE

		60KG RAIL																					
		HEAD HEIGHT (MM)																					
HEAD WIDTH (MM)		44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23
	70	0	3	5	7	10	12	14	17	19	22	24	26	29	31	33	36	38	41	43	45	48	50
	69	1	3	5	8	10	12	15	17	19	22	24	26	29	31	33	36	38	41	43	45	48	50
	68	2	4	6	8	10	13	15	17	20	22	24	27	29	31	34	36	38	41	43	45	48	50
	67	3	4	6	9	11	13	16	18	20	22	25	27	29	32	34	36	39	41	43	46	48	50
	66	4	5	7	10	12	14	16	19	21	23	25	28	30	32	35	37	39	41	44	46	48	51
	65	5	7	9	11	13	15	17	19	22	24	26	29	31	33	35	38	40	42	44	46	49	51
	64	6	8	10	12	14	16	18	20	23	25	27	29	32	34	36	38	40	43	45	47	49	51
	63	8	9	11	13	15	17	19	21	24	26	28	30	32	35	37	39	41	43	45	48	50	52
	62	9	10	12	14	16	18	20	22	25	27	29	31	33	35	38	40	42	44	46	48	50	53
	61	10	12	14	16	17	19	22	24	26	28	30	32	34	36	38	40	43	45	47	49	51	53
	60	12	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	50	52	54
	59	13	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54
	58	14	16	18	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55
	57	16	17	19	21	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56
	56	17	19	20	22	24	26	27	29	31	33	35	37	39	41	43	45	47	49	51	52	54	56
	55	19	20	22	23	25	27	29	30	32	34	36	38	40	42	44	46	48	49	51	53	55	57
	54	20	21	23	25	26	28	30	32	33	35	37	39	41	43	45	47	48	50	52	54	56	58
	53	21	23	24	26	28	29	31	33	35	36	38	40	42	44	46	47	49	51	53	55	57	59
	52	23	24	26	27	29	31	32	34	36	38	39	41	43	45	47	48	50	52	54	56	58	59
	51	24	25	27	29	30	32	33	35	37	39	40	42	44	46	48	49	51	53	55	57	58	60
	50	26	27	28	30	31	33	35	36	38	40	42	43	45	47	49	50	52	54	56	57	59	
	49	27	28	30	31	33	34	36	38	39	41	43	44	46	48	50	51	53	55	57	58	60	
	48	29	30	31	33	34	36	37	39	41	42	44	46	47	49	51	52	54	56	58	59		
47	30	31	33	34	35	37	39	40	42	43	45	47	48	50	52	53	55	57	58	60			
46	32	33	34	35	37	38	40	41	43	45	46	48	50	51	53	55	56	58	59				

## Appendix C – Rail Wear and Limits for Non-Standard Rail Sections

APPROX KG/M	RAIL SECTION	WIDTH OF NEW RAIL HEAD (MM)	MINIMUM REMAINING HEIGHT (MM)	MINIMUM REMAINING WIDTH (MM)
51	103 AS 1936	70	23	46
45	90 AS 1928, 90 AS 1925	70	24	49
45	90 AS 1916	73	22	52
45	90 J 1913	70	24	48
41	80 ASB 1928	64	23	46
41	80 ASA 1928, 80 A 1916	70	21	52
41	80 AA 1906	64	25	44
41	80 A 1900	64	24	47
41	80 A (1) 1897	64	28	48
41	80 A (2) 1895	64	28	47
41	80 A (3) 1890	64	32	47
41	80lb ASCE	64	32	47
39	78 H 1903	70	21	53
37	75 BHP 1917	62	26	46
36	71 2 D 1875	57	27	43
35	70 AS 1928, 70 AS 1925	64	23	48
35	70 AS 1916	60	25	44
35	70lb 1910	60	25	44
31	60 ASB 1928	64	24	49
31	60 ASA 1928, 60 AS 1916	64	22	52
31	60 BA 1907	58	27	43
31	60 B 1896	58	26	44
31	60 B 1890	57	29	43

**Note:** Dimensions indicate rail head remaining not actual wear

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