ARTC

Division / Business Unit:	Enterprise Services
Function:	Track & Civil
Document Type:	Code of Practice

Rail

Section 1

Applicability

ARTC Network Wide SMS

Publication Requirement

Internal / External

Primary Source

Document Status

Version #	Date Reviewed	Prepared by	Reviewed by	Endorsed	Approved
3.3	22 Jul 16	Standards	Stakeholders	Manager Standards	General Manager Technical Standards 27 July 2016

Amendment Record

Amendment Version #	Date Reviewed	Clause	Description of Amendment
3.0	02 Nov 12	1.1.1(b)(c)(d), 1.4.3, 1.4.12 & Table 1.2A	Reissue of document. Supersedes version 2.8. Significant re-write due to a change of methodology of managing rail wear limits. Further updates made following stakeholder consultation.
3.1	12 Aug 13	1.4.13	Updated to state that no guard rails are required on bridges.
3.2	02 May 16	1.1.1, 1.1.2, 1.1.7(h)(k)(q), 1.1.8, 1.2.1(a), 1.2.5, 1.2.8, 1.4.4 note 2 & 1.4.11.	Use of head hardened rail. Changes to rail top wear limits. Split rail wear limits table to ≤25 TAL and > 25TAL.Combined wear limits for 60SC and 60HH.Rail head area for all rail sizes to match AS. Included full height dimensions for new rail. Clarifications. Editorial.

3.3	22 Jul 16	1.1.1	Return changes not intended for 50kg and 53kg rail wear limits for > 25 TAL to status in version 3.1. Revised changes combining 60SC and 60HH for >25 TAL to match HH limits in version 3.1. Flow chart showing steps to manage rail wear. Note to clarify maximum axle loads for table 1.2B. Clarifications. Combined new rail dimensions for 60HH and SC.
		1.4.11	Actions and response by CER. Clarifications.

This ARTC CoP has drawn on the Rail Industry Safety and Standards Board (RISSB) National Code of Practice Volume 4, Track and Civil Infrastructure, but is not identical. The ARTC CoP has been subject to Risk Assessment as required by the various State Rail Safety Regulators. The results of these risk assessments have made it necessary to deviate from the RISSB CoP in some areas. ARTC maintains traceability of the differences.

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Mandatory requirements also exist in other documents.

Where alternative interpretations occur, the Manager Standards shall be informed so the ambiguity can be removed. Pending removal of the ambiguity the interpretation with the safest outcome shall be adopted.

1 Section 1: Rail

1.1 Design and Rating

1.1.1 Rail Selection

With the exception of Heavy Haul head hardened rail should not be installed on tangent or curves greater than 800m.

Guidelines for the design and selection of rail are as follows:

Rail size

The recommended minimum rail sizes are given in Table 1.1A.

Table 1.1A - Rail Size Selection

Track classification	Rail size (kg/m) [see note 1]	
	Existing track	New construction
Heavy Haul	60	60
Interstate Lines	47/53/60 [see note 2]	60
Main Intrastate Lines	47	50
Light Weight Intrastate Lines	40	40/50 [see note 3]

Notes:

1. *Rail sizes other than those specified in Table 1.1A may be used subject to demonstration, through appropriate analysis or testing that they are suitable for the operational task. Rail wear limits for these alternative rail sizes should be determined during this process.*
2. *Use of 47 kg/m rail under these operating conditions may require higher levels of maintenance, particularly where rail and weld geometry are not of good quality.*
3. *Most 40kg/m rail types have the same foot size as 50kg/m rail.*
4. *It is normal practice to provide CWR in Heavy Haul and Interstate Lines, and Intrastate Lines and Relief Lines, but not on Light Weight Intrastate Lines.*

Rail wear

There are generally two rail wear mechanisms, top wear where the rail head is worn or ground down, and side wear where the rail wears from the gauge face. Top wear is the dominant wear mechanism for low rails of curves, tangent tracks and curves with radius greater than about 600m. Side wear is the dominant (or at least equal ratio to top wear) wear mechanism for the high rail of curves sharper than about 600m radius.

Rails on main lines and crossing loops are to be examined at the frequency and using methods described in clause 1.4.3. The gauge face angle of the rails should also be monitored and the actions specified in clause 1.4.11 taken when the limits are exceeded. The allowable limits for top wear and side wear, at which the capacity of the rail should be reviewed, are given in Table 1.2A and 1.2B. The limits for rail head wear as detailed in these tables are divided into 2 levels; Risk Control & Re-rail limit. 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 acceptance limits for worn rails being transposed from curves to straights, beyond which the rails are not to be reused, are detailed in columns “C” and “D” in Table 1.3.

The risk control limits detailed in Table 1.2A and 1.2B are designed to ensure that appropriate risk based mitigation controls, as detailed in clause 1.4.11, are implemented as the total percentage head loss passes these limits. These controls are recommended to ensure the risks due to the higher rail loading forces and general track risk conditions experienced as the rails wear are reduced to acceptable levels.

There are two risk control limits detailed for each rail size based on whether the amount of side wear loss of width on the gauge face is less or greater than 10mm. Locations where gauge face wear is lower than 10mm normally align to tangent track or wider radius curves that are not generally exhibiting high lateral forces and side wear. Once the side wear has exceeded 10mm, particularly on tighter radius curves, the increased side loading being experienced by the rail and the reduced rail sectional strength means more conservative limits are required when extra risk controls become necessary.

The following flow chart summarises steps required to manage the rail wear over the full rail life.

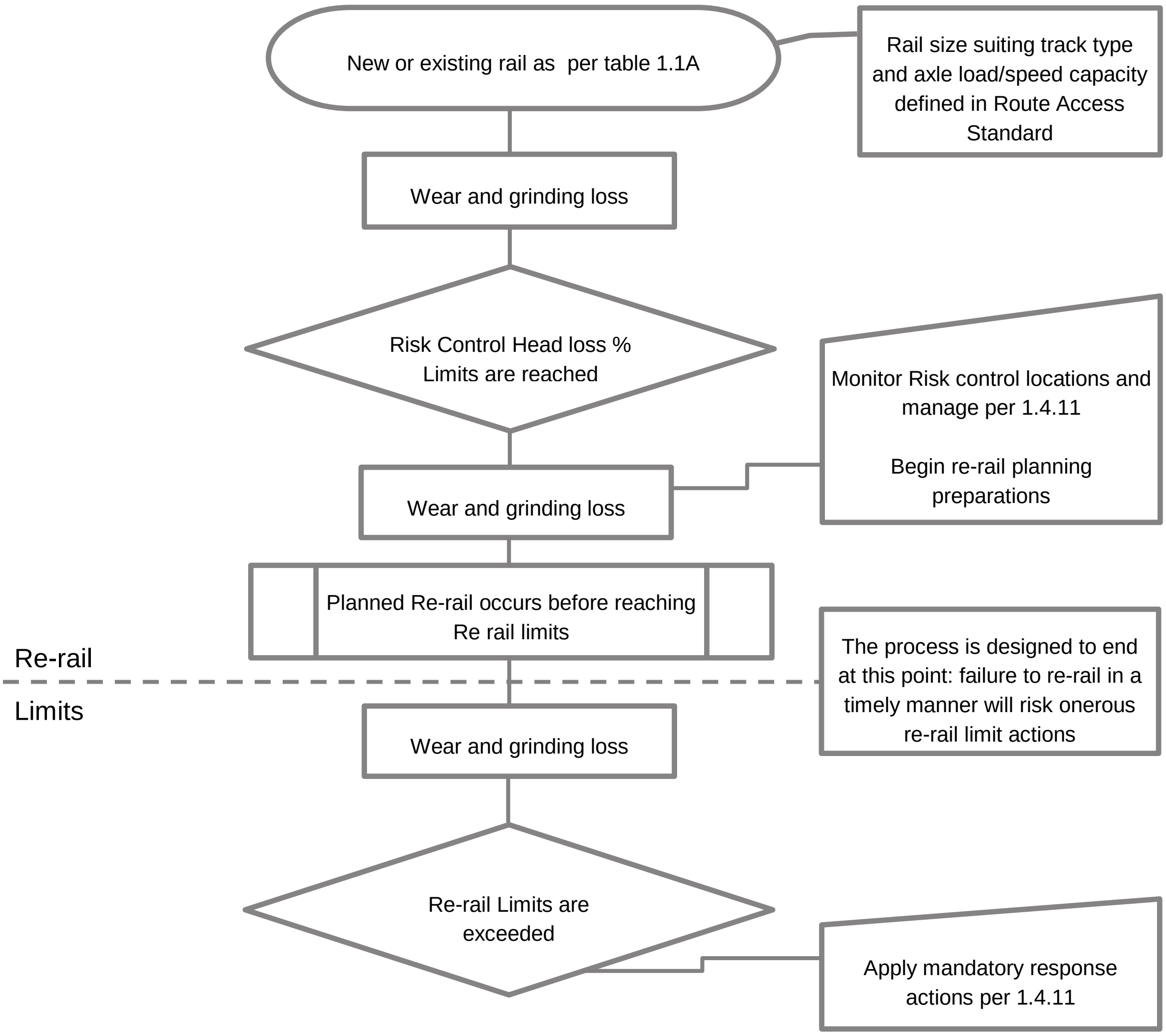


Table 1.2A – Rail Wear Limits for 25 TAL or less

<table>
<tr><th rowspan="3">Rail Type (AS)</th><th colspan="2">Risk Control Limits</th><th colspan="3">Re-rail Limits</th><th>Actions</th></tr>
<tr><th colspan="2">% Loss of Head Area</th><th>Top Wear Only
(where <10mm side wear has occurred)</th><th colspan="2">Combined Top & Side Wear
(where >10mm side wear has occurred)</th><td rowspan="6">The deciding wear limit is the first exceedance of any of the limits. The specified limit action must be taken when the rail wear reaches either the height, width or head loss %.
Once the risk control limits are reached, monitoring of rail wear data to identify rail wear locations that require imminent re-rail, should be performed at no less frequent than 10MGT intervals. This frequency allows preparation for re-rail to occur before re-rail limits are reached or exceeded in practice.</td></tr>
<tr><td>If Side wear <10mm</td><td>If Side wear >10mm</td><td>Remaining Height Limit</td><td>Remaining Height Limit
(mm)</td><td>Remaining Width Limit
(mm)</td></tr>
<tr><td>47kg/m (94lb)</td><td>32%</td><td>32%</td><td>24</td><td>24</td><td>55</td></tr>
<tr><td>50kg/m</td><td>45%</td><td>32%</td><td>21</td><td>21</td><td>50/46 (see note 2)</td></tr>
<tr><td>53kg/m (107lb)</td><td>35%</td><td>35%</td><td>21</td><td>23</td><td>50/46 (see note 2)</td></tr>
<tr><td>60kg/m</td><td>45%</td><td>40%</td><td>20</td><td>24</td><td>46</td></tr>
</table>

1. The limits listed under 'Risk Control Limit' must not be exceeded without first considering the risk control factors as described within clause 1.4.11.
2. If it can be shown that all risk control factors in section 1.4.11 are being adequately controlled, then the extended side wear limits of 46mm can be used on 50kg/m and 53kg/m rails. The extended side wear locations must be ultrasonically tested at no greater than 6MGT intervals. Also noting that 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.

Table 1.2B – Rail Wear Limits for greater than 25 TAL (see note 3)

Rail Type (AS)	**Risk Control Limits**		**Re-rail Limits**			**Actions**
	% Loss of Head Area		**Top Wear Only (where <10mm side wear has occurred)**	**Combined Top & Side Wear (where >10mm side wear has occurred)**		The deciding wear limit is the first exceedance of any of the limits. The specified limit action must be taken when the rail wear reaches either the height, width or head loss %. Once the risk control limits are reached, monitoring of rail wear data to identify rail wear locations that require imminent re-rail, should be performed at no less frequent than 10MGT intervals. This frequency allows preparation for re-rail to occur before re-rail limits are reached or exceeded in practice.
	If Side wear <10mm	If Side wear >10mm	Remaining Height Limit (mm)	Remaining Height Limit (mm)	Remaining Width Limit (mm)	
50kg/m	45%	32%	21	21	50/46 (see note 2)	
53kg/m (107lb)	35%	32%	23	23	50/46 (see note 2)	
60kg/m	45%	34%	24	24	46	

1. The limits listed under 'Risk Control Limit' must not be exceeded without first considering the risk control factors as described within clause 1.4.11.
2. If it can be shown that all risk control factors in section 1.4.11 are being adequately controlled, then the extended side wear limits of 46mm can be used on 50kg/m and 53kg/m rails. The extended side wear locations must be ultrasonically tested at no greater than 6MGT intervals. Also noting that 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.
3. 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.

Rail Size Variations

A comprehensive historic list of the maximum allowable rail wear for other potential rail sections is shown in Table 1.2C. When the limits are exceeded actions specified in clause 1.4.11 for 'Re-rail Limit' are to be implemented.

Where rails are to be transposed from curves to straights, the allowable dimensions to be used are the combined wear limits in Table 1.3.

Table 1.2C - Rail wear limits for non-standard rail sections.

Dimensions indicate rail head remaining not actual wear

Approx. kg/m	Rail Section	Width of new rail Head (mm)	Maximum allowable rail Top Wear - remaining height (mm)	Maximum allowable rail Side Wear -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
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

Table 1.3 - Maximum allowable rail wear for all curve worn rail sections to be re-used in tangent track (transposed/cascaded). Dimensions shown indicate rail head remaining not actual wear

Approx. kg/m	Rail Section	Width of new rail Head (mm)	Minimum remaining Width (mm)	Top remaining height (mm)
60	60AS 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
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

Rail wear measurement and calculation summary:

Head Loss %, loss of width and loss of height measurement and calculation methods:

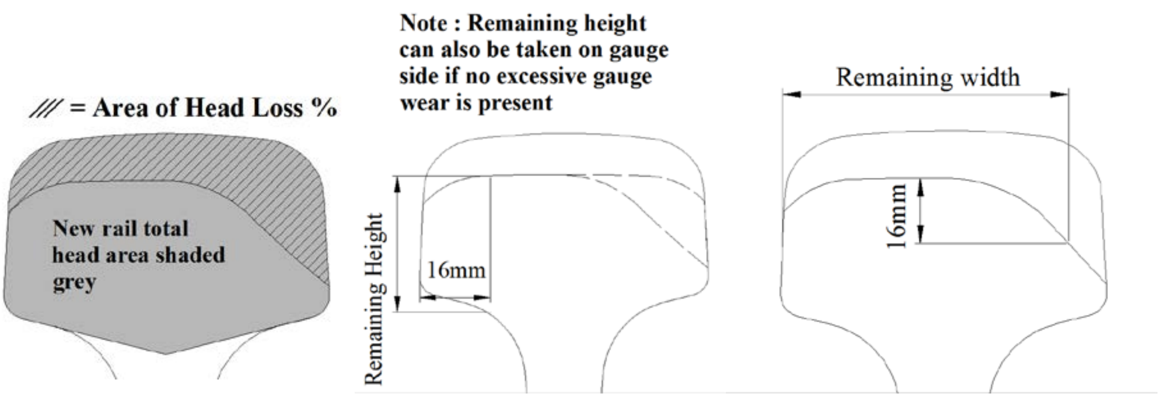
- Table 1.4 gives the area of each rail size in new condition; this figure must be used for all head loss % calculation methods.

Table 1.4 – Rail Size new head area to be used for head loss % calculations

Rail type	New rail head area (mm^2)	Full Height (mm) at 16mm
47AS	2548	37
50AS	2710	39
53AS	2721	39
60AS	2999	44

- Measurements should be taken to an accuracy of 0.5mm, with the gauge face angle measured to an accuracy of 2 degrees. The head area loss should be measured to an accuracy of 2%.
- All 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. Special checks must be made to ensure valid dimensions are being taken, if unsure then MiniProf, Railmate or equivalent laser methods must be used.



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.

1.1.2 Rail joint method (welded and non-welded)

Methods of joining rail to provide continuous support include the following:

a. Non-welded rail (i.e. mechanically jointed rail).

b. A combination of welded and non-welded rail (e.g. long welded rail), see Note.

c. Continuously welded rail (CWR).

Associated construction and maintenance guidelines to control the build up of longitudinal stresses in the rail are specified in Clauses 1.2.7 and 1.2.8 and Section 6, Track lateral stability.

Note: Joints shall have adequate strength and the rail shall be adequately restrained. The centre portion of long lengths may need to be treated as CWR.

1.1.3 Rail welding

a. Rail joint weld process

Weld processes for joining rails include the following:

i. Aluminothermic

ii. Flashbutt

b. Rail surface repair weld process

Recommended types of weld processes for rail surface repair include:

i. Aluminothermic.

ii. Manual Metal Arc.

iii. Metal Inert Gas.

c. Other weld processes

Welding process types other than the above (e.g. gas pressure welding to join rail) shall only be used following testing and commissioning involving a stringent validation process involving metallurgical analysis and thorough laboratory and field-testing.

1.1.4 Non-welded rail joint

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. Permitted permanent and temporary rail joints are as follows:

a. Permanent rail joints

In crossings, turnouts and other locations where fixed joints are used, the use of swage lock fastenings in lieu of bolts is an alternative method of fastening. 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.

Permitted types of permanent rail joints are as follows:

i. Fish plated joints

The types of fish plated joints recommended are 6 hole/6 bolts or 6 hole/4 bolts with the two centre bolts not used, see Note 1.

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.

Joints should be centrally suspended between sleepers.

Fish plated rail joint components should be manufactured to conform to the appropriate Australian Standard [see Note 2] as follows:

Fishplates	AS 1085.2
Fishbolts and nuts	AS 1085.4
Spring washers	AS 1085.7

Notes:

[1] *6 hole/4 bolt joints should only be used where it is intended to weld the track. The "two centre bolts not used" refers to the bolt on either side of, or closest to the interface of the two rails.*

[2] *These standards generally define the materials, material tests, manufacture, design and specification of the component, and component testing and compliance.*

ii. Other Joints

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

b. Temporary rail joints

Temporary joint components shall be supplied in compliance with the specified design.

A closure rail if required to remain in track permanently must not be shorter than 10m. In an emergency a shorter rail may be used as a temporary measure.

1.1.5 Insulated Joints

a. Pre-assembled glued insulated joints with 6 hole joint bars in accordance with AS1085.12 shall be installed in all new welded tracks. They are also to be used as replacement for existing mechanical insulated joints or field assembled glued insulated joints on these lines when renewal is required.

b. In welded tracks field assembled glued insulated joints are not approved as replacement for pre-assembled glued insulated joint excepting that they may replace the insulated components and the fish plates of an existing mechanical joint that cannot be replaced with a pre-assembled glued insulated joint.

c. Pre-assembled glued insulated joints should incorporate swage lock fastenings. In general insulating materials that encapsulate fishplates are unsuitable for swage lock fastenings without the application load spreading plates.

d. Pre-assembled glued insulated joints containing rails heavier than 47 kg/m rail shall be manufactured from head hardened rail. Standard joint lengths are 3.43 and 4.47 m with the standard versine range specified in ARTC specifications for use in curved tracks.

e. Rail ends shall be angle cut as provided for in AS1085.12. Where angle cutting is required it should be at 15 degrees to a line square across the rail head.

f. The insulated joint is to be centrally suspended between sleepers and located within 700 mm of its design location. When placed on curves pre-assembled glued insulated joints must be pre-curved to suit the radius of the track.

g. Pre-assembled double insulated glued joints with components in accordance with AS1085.12 - 1999 Railway Permanent Way Materials – Insulated Joint Assemblies are approved for use at locations where there is a recorded serious failure of track circuiting reliability from “steel scale”. They may be used on straight and curved track however where the radius of curvature is less than 600m they shall only be used on the high rail of the curve if their design conforms to the requirements for Grade A joints in AS 1085.12 – 1999.

   Each joint of the Double insulated joint must be new and shall conform in all respects to the requirements of ARTC Standard ETA-01-01 Manufacture and testing of Pre-Assembled Glued Insulated Rail Joints except when stated in this Section. Second hand joints may not be reused.

   The double block joints shall consist of 2 glued insulated joints at 2.325m apart. The length of the double block joint is 5.765 m and is composed of three lengths of rail (1.720m, 2.325m and 1.720m) rigidly joined by a pair of fishplates at each joint, adhesive insulating material and high strength bolts with nuts and washers.

1.1.6 Rail lubrication

Recommendations for rail lubricators are as follows:

a. Where specified sufficient rail lubricant shall be applied to the gauge face of the outer rail of curves, clear of the wheel/rail contact band, so that rail wear and wheel squeal is minimised.

b. Rail lubricant equipment and assembly details shall be to an approved design and shall be installed, adjusted, cleaned, maintained and used in accordance with the manufacturer’s instructions.

c. The lubricating system shall comply with relevant environmental statutory requirements for the control of excess lubricant and friction modifiers.

d. A register shall be established and maintained which specifies where rail lubricators are to be used and the method of application.

1.1.7 Guard rails

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

a. 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.

b. 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.

c. 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.

d. 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 must be in place for replacing the guard rails, when tamping ballast top bridges, and the rails at the bridge ends.

e. 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.

f. Splay rail bends shall be formed without cutting the rail.

g. Splay rail sleepers should be fully supported for their entire length.

h. Guard rails may extend past the end of structure or other hazard being protected if required.

i. Guard rails and guard rail ends shall be fastened to every sleeper. They may be connected directly to timber sleepers with no plates.

j. 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.

k. The guard rail end design is to —

   i. be flared away from the running rails;

   ii. 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.

   iii. extend parallel for a minimum of 3m beyond the structure end.

   iv. Installed at both ends of the bridge where traffic is bi-directional.

l. Where transoms are bolted to girders the spikes are to be adjacent to the rail flange.

m. When transoms are clipped to girders the spikes are to be installed through holes drilled in the guard rail flange.

n. Block out holes for guard rail fastenings in concrete sleepers shall be grouted with an approved high strength grout.

o. Suitable isolation arrangements are to be made where required in track circuit areas.

p. For fixing details, dimensional set-outs and componentry detail and sizes, Standard Guard Rail drawings are available.

q. 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.

1.1.8 Junction Rails

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

a. 60 kg/m to 50 kg/m;

b. 60 kg/m to 53 kg/m;

c. 53 kg/m to 50 kg/m;

d. 53 kg/m to 47 kg/m;

e. 47 kg/m to 50 kg/m ;

f. 47 kg/m to 41 kg/m .

1.2 Construction and Maintenance

1.2.1 Rail materials

Guidelines for the acceptance of rail and associated materials are as follows:

a. New rail

New rail should comply with the criteria in the following standards:

i. 53 kg/m rail cross section should comply with the superseded AS 1085.1 (1980). All other properties should comply with AS 1085.1

ii. 50 kg/m and 60 kg/m rail should comply with AS 1085.1 or equivalent standard.

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

b. Closure rails

In addition to the requirements of Table 1.5 closure rails should conform to the following criteria:

i. Longer lengths are often used to improve the track geometric quality and reduce track maintenance;

ii. The closure rail head profile shall comply with Table 1.10 and be compatible with the rail head profile of the rail to be removed such that rail misalignments are not introduced into the track.

c. Part worn rail

Prior to its reuse in track part worn rail shall be assessed for conformance with Table 1.5.

1.2.2 Rail welding processes

Guidelines for rail welding processes are as follows:

a. Flash butt welding

Welding rail ends together using flash butt welding shall be carried out using a specified process as set out in Table 1.6.

b. Aluminothermic welding

Aluminothermic weld materials shall be supplied in accordance with AS 1085.15. Type and proof testing shall be carried out using the method and frequency defined in AS 1085.15.

Welding rail ends together using aluminothermic welding shall be carried out using a specified process as set out in Table 1.7.

Transport and storage of weld consumables shall be in accordance with AS1085.15. Consumables affected in any way which will impact on the integrity of the final weld shall not be used.

c. Manual Metal Arc or Metal Inert Gas Welding

Repairing the rail running surface using manual metal arc (MMA) or metal inert gas (MIG) welding shall be carried out using a specified process as set out in Table 1.8.

These welding processes shall not be used for joining rail.

Table 1.5 – Assessment of Part Worn 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 Clauses 1.4.8, 1.4.9 and 1.4.10	Refer Clause 1.4	Ultrasonic testing as required by Figure 1.1	Refer Clauses 1.4.8, 1.4.9 and 1.4.10	
Wear limits	Refer Clause 1.1.1(b), (c) and (d)	Gauge or measurement of wear	Once only prior to unrestricted service	Refer Clause 1.4.11	
Metallurgical properties	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.	N/A	N/A	N/A	
	Otherwise for each rail type determine suitability in terms of: • Ultimate yield strength • Chemical composition • Inclusions • Impact resistance • Hardness • Microstructure	Applicable Australian and International Standards	Once only prior to use of rail type	Review by metallurgist competent in rail examination/testing/ evaluation	
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	Welds shall be no closer than 4 m from the next weld or the end of a rail. Welds or rail ends shall not be located closer than 1.5 m from the centre of a glued insulated joint	Direct measurement	Once only prior to welding	Compare with the Specification	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. In turnouts aluminothermic welds may be placed closer than 2.2 m to a minimum of 1.2 m to a flashbutt weld, aluminothermic weld or rail joint (mechanical or glued) provided that: • The flashbutt weld or joint is ultrasonically tested and no defects are found • 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.
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 1.2.4 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 Clause 1.2.4	Refer Clause 1.2.4	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 Clause 1.4.11 (b)	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	Closure rail head profiles shall be compatible with the rail head profile of the rail to be removed.	Direct measurement	Once only prior to use	Compare with the specification	Prevention of rail misalignments into the track.

Table 1.6 – 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 Performance specification shall include at least: • Welding current • Upset force or pressure • Upset displacement • Welding time	Weld completion report by welder certifying conformance with specification. Visual observation of welding process. Check graph or meter	Every weld immediately after completion	Against specification	When a process non-conformance is identified possible corrective actions include: • Stop welding • Reassess process • Readjust settings • Rework
Worker competency and training	Welder to be competent and hold current certification in flashbutt welding	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 [see note 1]	External visual inspection. Refer to Clauses 1.4.8 (Rail and welded joints) and 1.2.4 (Rail discontinuities)	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 Clauses 1.4.8 and 1.2.4	As specified in Clauses 1.4.8 and 1.2.4
	Internal inspection as specified in Clause 1.4.8 (Rail and welded joints)	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	As specified in Clause 1.4.8	As specified in Clause 1.4.8

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

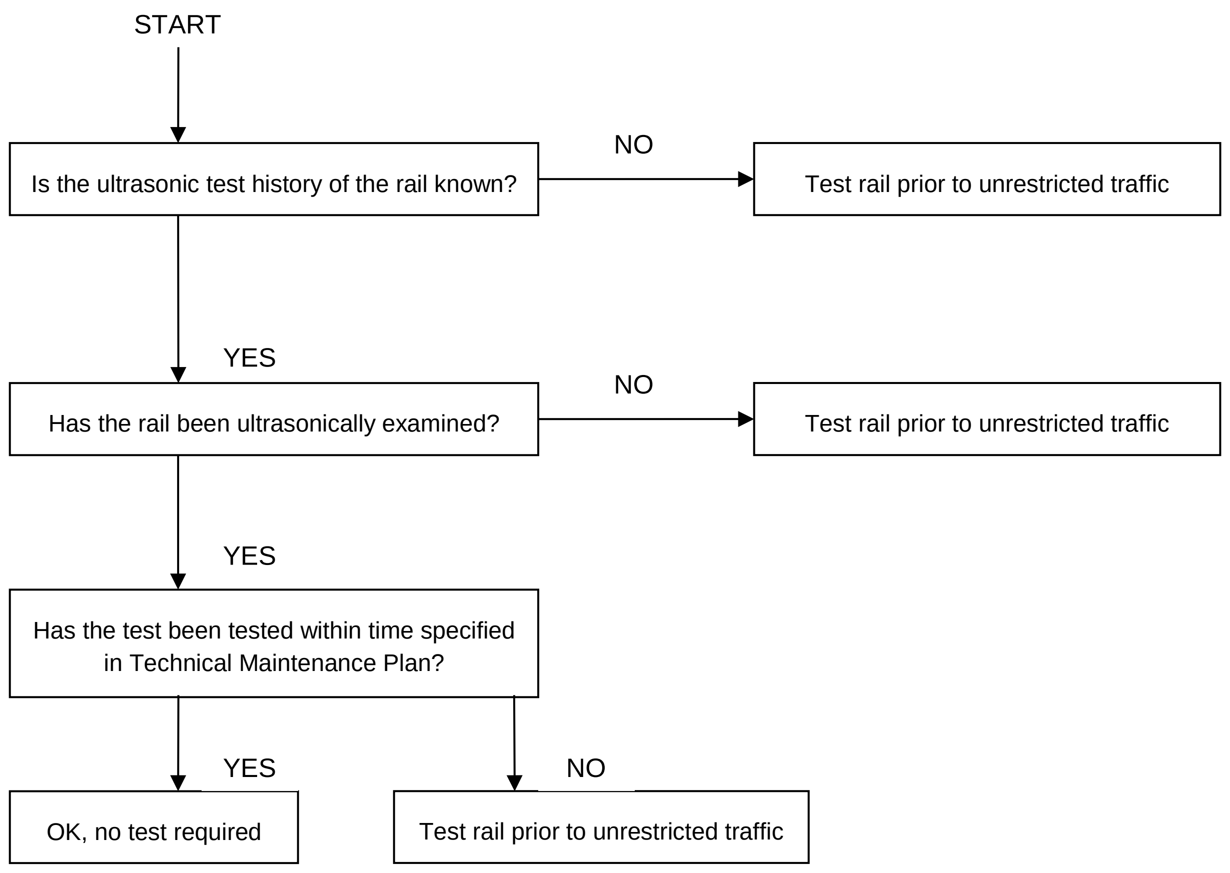
Table 1.7 – Aluminothermic Welding – Process

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: • Stop welding • Reassess process • Rework
Worker competency and training	Welder to be competent and hold current certification in Aluminothermic welding	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 Clauses 1.4.8 (Rail and welded joints) and 1.2.4 (Rail discontinuities)	Visual: Weld certification that the weld has been visually inspected and no recordable defects have been found	Every weld prior to unrestricted traffic immediately after welding	As specified in Clauses 1.4.8 and 1.2.4	As specified in Clauses 1.4.8 and 1.2.4
	Internal Inspection as specified in Clause 1.4.8 (Rail and welded joints)	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 ETE-01-03	As specified in Clause 1.4.8	As specified in Clause 1.4.8

Table 1.8 – 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 owners standard	Prior to use	Against the specification	As necessary
Welding practices	Owner's practices for surface preparation and weld process	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	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 Clauses 1.4.8 (Rail and welded joint) and 1.2.4 (Rail discontinuities).	Visual: Weld certification that the weld has been visually inspected and no recordable defects have been found	Immediately after all welds	As specified in Clauses 1.4.8 and 1.2.4	As specified in Clauses 1.4.8 and 1.2.4
	Internal inspection as specified in Clause 1.4.8 (Rail and welded joints). 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 ETE-01-03	As specified in Clause 1.4.8	As specified in Clause 1.4.8

Figure 1.1 – Rail Acceptance: Ultrasonic Test Flow Diagram



1.2.3 Repair of defective rails and welds

Repair of defective rails and welds shall be carried out in accordance with Table 1.9. 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 1.9 – Rail and Weld Repair Guidelines [1]

DEFECT [2]	COMMENT ON ACTIONS
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.
Broken foot	Defects shall be cut out and replaced by a closure rail.
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.
Corroded rail	The defective portion of rail should be replaced.
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.
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.
Mechanical joint	The necessary repair shall be determined by a competent worker.
Mill defect	Repair is not normally required until growth is detected. The defect should then be reclassified according to the nature of propagation or failure.
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.
Notches	Defects shall be cut out and the rail welded or replaced by a closure rail.
Unclassified Defect	The necessary repair shall be determined by a competent worker.
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.
Rail surface (e.g. rolling contact fatigue)	The necessary repair shall be determined by a competent worker and include consideration of the location, extent and the impact on the ability to carry out ultrasonic testing of the rail affected.
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.
Transverse Defect (including those from shells or wheel burns)	The defect shall be removed and the rail restored by welding.
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.
Weld defect (head, web or foot)	Repairs shall be carried out by removing the weld and replaced by a closure rail, or by the use of wide gap welds if no bolt holes exist.

DEFECT [2]	COMMENT ON ACTIONS
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, or by the use of wide gap welds if no bolt holes exist.
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.
Wheel burn	Defects shall be repaired by repair welding or replaced by a closure rail. Small wheel burns may be ground out.

Note:

1. *All repairs shall meet the rail surface guidelines defined in Clause 1.2.4.*

1.2.4 Rail discontinuities in welded rails

The control of rail running surface discontinuities during the following processes are given in Table 1.10:

a. Laying of rail in track.

b. Production of rail lengths for installation.

c. Insertion rail welds into track including those for closure rails.

Table 1.10 - Welded Rail Discontinuities (New Welds)

Factor	Recommended limits (see Note 5)	Method of test	Corrective action to achieve tolerances
Peak in running surface	+0.0 to +0.3 mm over 1 m. Absolute max peak 0.5mm	1 m reference and height difference measure (2)	Remove or grind
Dip in running surface	Nil	1 m reference and height difference measure	Remove or lift
Gauge widening due to change in rail	0.5 mm over 1 m	1 m reference and height difference measure	Remove or bend
Gauge narrowing due to change in rail	0.5 mm over 1 m	1 m reference and height difference measure	Remove or grind
Vertical deviation in rail running surface (Ramp angle)	7 milliradians or +/- 0.35mm over 50mm.	Measured with dipped weld (P1) gauge or electronic straightedge over 1m.	Remove or grind
Vertical step in rail running surface	±0.15 mm over 100 mm	100 mm reference and height difference measure	Remove or grind
Horizontal step in rail running surface	±0.15 mm over 100 mm	100 mm reference and height difference measure	Remove or grind

Notes:

1. *Guidelines for rail with non-welded rail joints are to be determined*
2. *For example a 1m straightedge and feeler or taper gauges.*

3. *Tolerances are applied only to areas of the rail where wheel contact may occur*
4. *The critical factor in the rail surface limits is the ramp angle measured with a dipped weld gauge (P1) over 50mm over the full extent of grinding of the weld.*
5. *The minimum standard for new welds should be as per the column titled "recommended limits".*

1.2.5 Cutting of rail

Rail cutting shall only be carried out using a specified process.

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

Rail ends in insulated joints shall comply with AS 1085.12. The cut shall be in a vertical plane and in the plan view may be at an angle as specified in section 1.1.4 (a).

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 permitted when welding is to be carried out but subject to the conditions set out below:

a. The method may not be used in any circumstances on head hardened rail except where welding is to be carried out within 30 minutes. If this is not possible 30 mm should be cut off the cooled rail ends immediately prior to welding.
b. For standard carbon rails, flame cut rails should be welded in the same work shift. If this is not possible 30 mm should be cut off the cooled rail ends immediately prior to welding.
c. Flame cutting shall not be used in preparing rail ends for installation of a permanent non-welded rail joint.

Both ends of the rail to be welded must be of the same type i.e. either both flame cut or both sawn.

Other than when used during the welding process as specified above flame cut rail ends under traffic are only permitted in emergency conditions and shall be plated as a temporary joint, have a speed restriction of 20 km/h or less (dependent on the joint design) imposed and be kept under close observation. Under no circumstances are trains permitted to proceed over these rails at normal speeds. The flame cut rail end must be replaced as soon as possible by welding in a new section or replacing the affected rail with a saw cut rail.

1.2.6 Drilling holes in rail

Rail drilling shall only be carried out using a specified process.

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.

The location of boltholes for the installation of mechanical rail joints should be in accordance with the dimensions defined in AS 1085.2 and AS 1085.12. In all other cases the centre of drilled holes should be within 5 mm of the neutral axis of the rail and for rail sizes of 41 kg/m and greater should not be greater than 27 mm in diameter.

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 must be removed prior to increasing the speed restriction

1.2.7 Stress control—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 by the use of independent datum points.

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

a. prior to cutting the rail; and

b. after the rail has been welded into track.

Comparison of these two measurements shall be within 2 mm.

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

i. rail stresses should be readjusted, or

ii. the guidelines in Section 6, Track lateral stability, should be implemented.

1.2.8 Stress control—stress adjustment of continuously welded rail (CWR)

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

iii. New or recycled rail is being laid into track.

iv. A stress check is being carried out.

v. The rail adjustment is suspect, for example due to the presence of—
   - buckles;
   - break-aways / pull-aparts;
   - mechanical joint failure; or
   - significant rail creep.

vi. Significant changes in track alignment.

vii. The rail is cut and practices described in Clause 1.2.7 have not been used

During execution of the rail stressing process, measurements shall be taken to ensure that it has been carried out correctly.

1.3 Commissioning

****** To Be Determined (to be addressed in RISSB Standards) ******

1.4 Inspection and Assessment

1.4.1 Scheduled rail and welded joint inspection

The inspection of rail and welded rail joints shall incorporate the following guidelines:

a. Patrol inspection

The interval between patrol inspections for visible rail defects shall not exceed 7 days or as specified otherwise by ARTC e.g. in an approved Technical Maintenance Plan. 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 including the following:

i. Broken rails and rail welds

ii. Rail and rail weld deformations and discontinuities

iii. Wheel burns

iv. Damage to rail surface or section

v. Unusual patterns of gauge face contact

vi. Unusual vehicle tracking patterns

vii. Rail corrugation

viii. Rail crippling

ix. Other obvious indications of defects.

Patrols may be carried out from an on-rail vehicle travelling at a speed consistent with the scope of the inspection, by walking or in a locomotive cabin.

Where track circuits are used, these should be employed as an additional method to detect rail failures.

b. General inspection

A general visual inspection shall be carried out—

i. for all new welds (see Tables 1.6, 1.7 and 1.8); and

ii. where the response following detection of a rail or weld defect is 'observe'.

c. Detailed inspection

Detailed inspection should be carried out as follows:

i. 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 should also supply reports to ARTC or nominated representative indicating whether rail testing has been inhibited by “shielding” from gauge corner fatigue damage or other rail surface defects. Any loss of testing shall be investigated using hand-held ultrasonic testing equipment. 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'.

ii. 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 flash butt 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 1085.15 for weld test procedure

iii. 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.

New welds shall be checked for alignment and meet the requirements of Table 1.10.

d. Documentation

The following documentation relating to rail and weld defects shall be maintained:

i. Rail tonnages over nominal track sections.

ii. Specifications or work instructions for ultrasonic testing.

iii. Defective rail/weld report.

iv. Defect listing and status.

v. Report of defect removal.

e. Continuous ultrasonic inspection and rail lubricators

Prior to ultrasonic inspection of rails by rail flaw detection vehicles the rail surface in the vicinity of rail lubricators shall be inspected. Where there is a build up of grease on the head of the rail the lubricator shall 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.

1.4.2 Scheduled non-welded joint inspection

The inspection of rail and non-welded rail joints should incorporate the following guidelines:

a. Patrol inspection

The interval between patrol inspections of visible rail and non-welded rail joint defects shall not exceed 7 days or as specified otherwise by ARTC e.g. in an approved Technical Maintenance Plan. Track patrol inspections should keep a lookout for defects and conditions (i.e. indicators of a defect) that may affect the integrity of the track structure including the following:

i. Broken, missing or loose bolts.
ii. Worn, cracked or broken plates.
iii. Metal flow across joint.
iv. Vertical deformation or pumping joints.
v. Rail end batter.
vi. Excessive joint gap which may indicate elongated bolt holes or bent bolts.
vii. Not working as a sliding joint to accommodate designed rail movement
viii. Insulation breakdown.
ix. Track circuit bond wire damage.
x. Other obvious defects or missing components.

Inspections may be carried out from an on-rail vehicle travelling at a speed consistent with the scope of the inspection, by walking or by engine.

b. General inspection

A general visual inspection shall be carried out at intervals not exceeding twelve (12) months or as specified otherwise by ARTC e.g. in an approved Technical Maintenance Plan or at lesser intervals if specified in the joint design (including temporary joint installations). A general inspection should also be done where the response following detection of a defect is 'observe'.

General inspections should look for those conditions inspected for in Patrol inspections in addition to the following:

i. Cracked and broken plates.
ii. Pumping joints.
iii. Excessive joint gap which may indicate elongated bolt holes or bent bolts.
iv. Worn fishplates.
v. Frozen joints.
vi. Other defects or missing components.

c. Detailed inspection

A detailed inspection shall be carried out when a joint is suspected to contain additional defects that cannot be detected by visual inspection.

d. Documentation

Documentation of track sections with non-welded rail joints should be maintained.

1.4.3 Scheduled rail wear inspection

The inspection of rail wear condition should incorporate the following guidelines:

a. Patrol inspection

The interval between patrol inspections of rail for unusual signs of rail wear shall not exceed 7 days or as specified otherwise by ARTC e.g. in an approved Technical Maintenance Plan. Track patrol inspections should keep a lookout for rail wear and other defects and conditions (i.e. indicators of a defect) that may affect the integrity of the track structure including the following:

i. High wear rates (e.g. presence of filings).

ii. Other unusual and obvious wear patterns and defects indicating for example poor vehicle tracking, sharp points in curves or excess/deficiency in track superelevation.

iii. High levels of rail wear approaching wear limits, particularly on curves.

iv. Excessive rail gauge face angle.

v. Locations of wheel burns and corrugations and any other deformation of the rail head

Inspections may be carried out from an on-rail vehicle travelling at a speed consistent with the scope of the inspection, or by walking.

b. General inspection

The amount of rail wear on all main lines and crossing loops shall be measured and recorded at a period no longer than 6 months apart on Heavy Haul Lines and 12 months apart on all other lines. The measurement of rail head profile wear may be done by mechanical non-contact means such as by the AK Car, or other approved track measurement vehicle. Measurement of wear by non-contact mechanical means such as hand-held Railmate, Miniprof etc are also acceptable. Measurements shall be taken at intervals of maximum 10m apart when using the AK car.

c. Rail in tunnels

In addition to the above requirements, rails in tunnels and wet locations shall be examined for corrosions during track patrols. The examination should preferably 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. The original and allowable limits for 53kg/m and 60 kg/m are shown on the form. Care should be taken to ensure the worst dimensions in the area are recorded.

Once reduction in size is noted a copy of the report is to be retained by the Length inspector/examiner 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.

1.4.4 Scheduled inspection for rail lubrication

Inspection of rail with lubrication shall be carried out in accordance with the following guidelines:

a. Patrol inspection

The interval between patrol inspections for rail for lubrication shall not exceed 7 days or as specified otherwise by ARTC i.e. in an approved Technical Maintenance Plan. Track patrol inspections should keep a lookout for defects and conditions (i.e. indicators of a defect) that may affect the integrity of the track structure including the following:

i. Contamination of the rail surface (e.g. oil spills).

ii. Obvious over or under lubrication, see Notes 1 and 2.

iii. Signs of excessive side wear, shiny wear marks on the gauge face and/or steel shavings along the rail foot.

iv. Other obvious unusual conditions.

Inspections may be carried out from an on-rail vehicle travelling at a speed consistent with the scope of the inspection, or by walking.

b. General inspection

General inspections of rail and rail lubrication devices shall be carried out at prescribed intervals not greater than 12 months or as specified otherwise by ARTC e.g. in an approved Technical Maintenance Plan to identify conditions that may contribute to undesirable wheel/rail interaction (e.g. poor traction or braking, or high L/V ratios) or other hazardous conditions. Results of the inspection should be reported on the appropriate form. They should look for those conditions identified in Patrol Inspections in addition to the following:

i. Carry of lubrication.

ii. Obvious damaged or loose components.

iii. Blade height and conditions.

iv. Plunger settings and operation.

v. Filler valve condition.

vi. Grease leakages.

vii. Other defects, unusual conditions or missing system components.

Rail lubricator condition, operation and adjustment should be checked during normal servicing to refill lubricator storage tanks. Adjustments to application rates should also be made to suit variations in climatic conditions.

c. Level of lubrication

The level of lubrication can be detected or measured by the following:

i. Visual inspection.

ii. Tribometer.

iii. Gauge.

Notes:

1. *This includes 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).*
2. *Combinations of top-lubrication, flange-lubrication and dry rail are variously applied for specific purposes at individual locations.*

1.4.5 Un-scheduled inspection for rail lubrication

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

1.4.6 Scheduled guard rail inspection

The inspection of guard rails shall incorporate the following guidelines.

a. Patrol inspection

The interval between patrol inspections of guard rails shall not exceed 7 days *or as specified otherwise by ARTC e.g. in an approved Technical Maintenance Plan*. Track Patrols which should keep a lookout for visible guard rail defects and conditions (i.e. indicators of a defect) that may affect the integrity or function of the guard rail including the following:

i. Missing or ineffective rail/sleeper fastenings.

ii. Lack of guard rail continuity.

iii. Obvious damage to components.

Inspections may be carried out from an on-rail vehicle travelling at a speed consistent with the scope of the inspection, or by walking.

b. General inspection

A general visual inspection of guard rail condition shall be carried out at intervals not exceeding twelve (12) months or as specified otherwise by ARTC e.g. in an approved Technical Maintenance Plan.

i. General inspections should look for those conditions inspected for in Patrol Inspections in addition to damaged and defective components (e.g. mechanical joints where used).

1.4.7 Insulated rail joint inspections

Inspection of insulated rail joints shall be undertaken during regular track patrols.

Detailed inspections shall be undertaken at maximum 12 months intervals or as specified otherwise by ARTC e.g. in an approved Technical maintenance Plan. The results shall be reported on the appropriate forms. Undesirable conditions including those shown below should be assessed and actions taken in an appropriate time frame.

- Joint insulation material lost, visibly cracked or disintegrated;
- Failure of glue in glued joint, particularly between the end post and the first bolt hole and beyond;
- Rail end damage and flow across joint;
- Excessive rail head wear;
- Loose, bent or broken bolts with joint pulling apart or closing up;
- Cracked or broken fishplates;
- Pumping joint;
- Ineffective ties or fastenings;
- Excessive or deficient ballast;
- Ineffective drainage;
- Metal conductors across the joint which could short circuit the insulation.

1.4.8 Rail and welded joint assessment

The assessment of rail and welded rail joint condition is specified in ARTC Standard ETE-01-03.

1.4.9 Rail discontinuities assessment

The assessment of discontinuities in rails should incorporate the following guidelines:

a. Running surface discontinuities in welded rails

This Clause gives limits for the control of rail running surface discontinuities in welded rails identified from track inspection.

The limits given are recommended limits only for existing welded track, and are not recommended for normal track construction and upgrading work (refer to Clause 1.2.4). The limits are not intended to indicate best practice as discontinuities of the magnitude defined in Table 1.15 may lead to a need for a significantly higher maintenance input than track with good rail geometry.

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

Table 1.15 – Welded Rail Discontinuities (Maintenance)

Factor	Optimum maintenance limit Column 1 See note 4	Normal maintenance limit Column 2 See note 5
Peak in running surface	1mm over 1 m	2 mm over 1 m
Dip in running surface	0.5 mm over 1 m	2 mm over 1 m
Gauge widening due to change in rail	0.5 mm over 1 m	2 mm over 1 m
Gauge narrowing due to change in rail	0.5mm over 1 m	2 mm over 1 m
Vertical deviations in rail running surface (Ramp angle)	8 milliradians	10 milliradians
Vertical step in rail running surface	1 mm over 100mm	2 mm over 100 mm
Horizontal step in rail running surface	1 mm over 100mm	2 mm over 100 mm

Notes:

1. *Guidelines for rail with non-welded rail joints are not specified.*
2. *Linear measurements taken with a 1 metre straightedge and feeler or taper gauge*
3. *Vertical deviations in rail running surface should be measured with a dipped weld gauge.*
4. *Column 1 gives limits for best practice that have been shown to give optimal maintenance results in ARTC. No action is required*
5. *When the discontinuities of the magnitudes shown in column 2 are left in track, problems with track geometry deterioration and high impact causing track component deterioration can be expected.*
6. *Gaps in the running rail*

At any time, but generally at construction sites, the following applies to the movement of traffic over a gap (or break) in the running rail which is unplated:

- Gap < 30 mm — Operation of trains at a reduced speed appropriate to the assessed track conditions.
- Gap > 30 mm and < 100 mm — Pilot trains across the gap
- Gap > 100 mm — Stop traffic

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 temporary plating of a gap (or break) should also be determined. In the case of a break the nature of the rail break should be considered in the assessment.

Note: *Imperfections that may have damaged rollingstock should be advised to the train operator.*

1.4.10 Non-welded joint 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 Section 6.

Detected defects in non-welded rail joints shall be assessed and reported in accordance with the classification, position and sizing as specified in Table 1.16. The actions for response codes for A1 to A7 are shown in table 1.16A.

Table 1.16 applies to non-welded tracks only. For these joints however, “repair or replace” should be interpreted to mean maintenance or reinstallation of the joint to the design specifications.

Table 1.16 – Non-Welded Joint Assessment Responses

Component Parameter	**Dimension Limit**	**Track Speed (freight/passenger) km/h**					
		20/20	**40/40**	**60/65**	**80/90**	**100/115**	**115/160**
Fishplates [1]							
Visual cracks	1 or both plates	A6	A6	A6	A6	A6	A6
Complete failure	1 fishplate	A4	A4	A4	A4	A4	A4
	Both fishplates	A1	A1	A1	A1	A1	A1
Fishbolts [2]							
Effective	≥ 2 on both rail ends	A7	A7	A7	A7	A7	A7
	1 only on either rail end	A6	A6	A6	A6	A6	A6
	Nil on one rail end [3]	A2	A2	A2	A2	A2	A2
	Nil on both rail ends [3]	A1	A1	A1	A1	A1	A1
Insulated Joints [4]							
Insulation material	Defective	A6	A6	A6	A6	A6	A6
Gap between rail ends	≥ 4mm	A7	A7	A7	A7	A7	A7
	< 4mm	A6	A6	A6	A6	A6	A6
Rail Ends							
Batter	> 2mm over 100mm	A6	A6	A6	A6	A6	A6
Rail end gap	≤ 20mm	A7	A7	A7	A7	A7	A7
	21mm to 30mm	A6	A6	A6	A6	A6	A6
	> 30mm [5]	A3	A3	A3	A3	A3	A3
Rail end mismatch misalignment	> 3mm [5]	A2	A2	A2	A2	A2	A2
Rail defects	Surface or internal defects	In accordance with Clause 1.4.8					

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.*

Table 1.16A – Definition of Response Codes

Response Code	Description [2]
A1	Temporary speed restriction of 10/10 [1] with pilot or repair prior to the passage of the next train [3].
A2	Temporary speed restriction of 20/20 [1] or repair prior to the passage of the next train [3].
A3	Temporary speed restriction of 40/40 [1] or repair prior to the passage of the next train [3].
A4	Temporary speed restriction of 60/65 [1] or repair prior to the passage of the next train [3].
A5	Temporary speed restriction of 80/90 [1] or repair prior to the passage of the next train [3].
A6	An appropriate increase in the monitoring [2] and follow up action as required.
A7	**Routine Inspection [4]**

Notes:

1. *Where a speed restriction is applied rectification work should be programmed on a priority basis. The speed restriction is shown for both freight operations (shown first) and passenger operations (shown second) separated by a "/".*
2. *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.*
3. *If repairs cannot be made prior to the passage of the next train, the speed restriction should be implemented along with an appropriate increase in the monitoring [see Note 2] until actions are taken to restore the track.*
4. *Routine refers to normal scheduled inspections.*
5. *If the cause of a defect is known and it is known that it will not deteriorate into an unsafe condition an alternate response to that shown in table1.16A is permitted with appropriate documentation and approval by the Civil Engineering Representative or nominate representative.*

1.4.11 Rail wear assessment

Rail wear defects shall be reported and action taken when any of the wear limits prescribed are exceeded as follows:

a. Rail wear

Once rail wear reaches the risk control head loss % limits, as detailed in Table 1.2A and 1.2B, they are to be recorded as defects within the Asset Management System. The maximum amounts for the worst reading for percentage head loss, top wear and side wear are to be noted for each location. These records are to be updated each subsequent inspection to allow for priority locations to be identified during re-railing planning management reviews.

Areas which have been identified with wear limits at or exceeding re-rail limit should be manually measured at a maximum interval of 2m throughout the affected area, using methods accepted by ARTC. Location and details of the deformations shall be recorded within the Asset Management System.

Where the prescribed wear limits as detailed in Table 1.2A and 1.2B are exceeded the actions listed below for 'Risk Control Limit' or 'Re-rail Limit' are to be implemented.

Risk Control Limit: When rail wear exceeds the Risk Control Limit, the following risk based mitigation regimes are to be implemented.

Compulsory actions:

1. Ultrasonic testing response to defects strategy shall be shifted one level higher in priority i.e. the current response for a small defect is upgraded to match the response for a medium defect, and the response for a medium defect is elevated to match the same action response for a large defect. Due to the high risks of a large defect in high wear locations it is recommended that response should be upgraded to consider urgent actions such as 10km/h speed restrictions or stopping all trains if deemed necessary. Increased risk factors due to rail surface shielding (untestable rail) shall be reviewed as specified in ARTC standard ETE-01-03 Non-Destructive Testing of Rail (for Internal & Surface Defects), section; 4.7 Assessment Required of any Ultrasonic Shielding.
2. The track geometry shall be in condition to support the higher head losses and must meet Engineering (Track & Civil) Category: Code of Practice, Track Geometry Section 5. In addition all sleepers must provide vertical support to the rails, track shall meet all requirements of Engineering (Track & Civil) Category: Code of Practice Sleepers and Fastenings Section 2, as a minimum quality level. Sleepers which are not bearing shall not be allowed to remain uncorrected for longer than 28 days or substantial detriment to fatigue life of the rail will be incurred. These track quality requirements will reduce the tendency for worn rail locations to fail in the common modes of broken rail and corrugation bending.

Recommended actions:

1. Welds in the section of rail worn beyond the Risk Control Limit values should be maintained at lower than 0.3mm (zero-to-peak amplitude) dip or peak under a 1m rule. AK car corrugation data shall be monitored to detect if impact levels exceed +/-0.5mm in the displacement parameters for 1.5m wavelengths. Where data exceeds these impact levels, on-site inspections, and confirmation using equipment such as CAT or Electronic straightedge is recommended to further plan mitigating action.
2. Ultrasonic (car) testing frequency should be reviewed and it is strongly recommended that testing frequency decisions are based on guidance from Manual for Non-Destructive Testing of Rail ETN-01-04 9.5 Appendix E – Guidance on ETE-01-03 Section 3.1: Testing Frequency of Existing Rail & Welds. If increased testing frequency is not a viable option at locations with rail wear above the Risk Control Limit, then other risk mitigating methods as below should be fully adopted over the affected section. Extra manual ultrasonic testing at these locations is an acceptable alternative to increased car testing, focussing on welds in particular

3. Rail surface profile is controlled by rail grinding such that the locations worn beyond these limits should be targeted to meet ARTC grind standards for both lateral and longitudinal profile as specified in ETM-01-02 Rail Grinding Standard for Plain Track.
4. Apply temporary speed restrictions, depending on operating conditions and other risk factors it may be desirable to introduce a speed restriction to minimise general risks and to reduce ongoing dynamic impact (dip/peaks/corrugation) levels until re-railing occurs. This would be of particular use in locations where other measures are impractical to achieve at acceptable costs until re-rail can be completed. Note that low legs of curves with heavy wear may not benefit from speed restriction as the wheel loads will be increased due to superelevation.

The risk controls listed above are to ensure the likelihood of broken rails is reduced to acceptable risk levels. Each individual high wear location must be treated as a unique situation and numerous variables should be considered when assessing the risks involved, example factors include; curvature, MGT, axle loads, track speeds, stress free temperature and ambient temperatures , grade, rail type/age, typical rolling stock condition (wheel flats), track geometry, sleeper conditions, and drainage/mud holes.

As the rail wear approaches the Re-rail Limit dimensions, clearly the risk levels and associated control actions need to be reviewed and potentially made more stringent. 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.

Re-rail Limit: Rails approaching this limit should be replaced before the limit is reached. If the rail is allowed to reach or exceed this limit it shall be replaced as soon as is reasonably practical, and the following conditions shall apply until re-rail is completed:

I. All sizes of internal rail defects shall be treated as large category response.

II. The location shall be speed restricted to 20km/h.

b. Gauge face angle

The gauge face angle is measured as the angle between a line perpendicular to the sleeper plane and the line tangential to the rail gauge face where the wheel flange contact occurs.

The gauge face angle of rails shall not exceed 26 degrees from vertical, over a length of rail of more than 2m. The reportable limit for gauge face angle wear is 24 degrees.

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.

1.4.12 Rail lubricator assessment

Undesirable rail conditions resulting from application of lubrication or friction modifying agents including excessive lubrication, ineffective lubrication and uneven lubrication should be assessed, reported and actions taken in an appropriate timeframe.

1.4.13 Guard rail assessment

No guard rails are required on bridges.

All existing guard rails shall be safely maintained in accordance with the following table until they are removed.

Table 1.17 – Responses for Guard Rail Condition

Defect Name (Type Code, Position Code)		
Defect size	**Response time**	**Action**
Sleeper fastenings missing or ineffective [1]		
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
Component Damage		
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.
Rail joint condition		
Ineffective rail joint	13 Weeks	Ineffective joint components should be replaced or restored as necessary.

Note [1] These defect sizes and responses apply to all configurations of guard rail fasteners.

1.5 Decommissioning and Disposal

1.5.1 Components Sorted for Reuse, Quarantine or Disposal

All rails should be quarantined until sorted and classified.

All rails and associated components when removed from track should be sorted and segregated into one of the following categories:

a. Reuse

Rail that has the potential for reuse should be marked in such a manner that its reuse potential is clear and unambiguous. In particular the rail should be marked, and be segregated into stacks differentiated by:

- Rail size and length
- Amount of wear

b. Quarantine

Where rail requires further classification they should be quarantined from reusable rail to prevent its use back in track.

c. Disposal

All non-reusable rail components should be clearly marked and disposed of as soon as practicable after release from the track.