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Rail

Section 1

Applicability

ARTC Network Wide SMS

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MANDATORY REQUIREMENTS ALSO EXIST IN OTHER DOCUMENTS.

WHERE A CONFLICT OF REQUIREMENTS OCCURS, 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.

Amendment Record

AMENDMENT VERSION #	DATE REVIEWED	CLAUSE	DESCRIPTION OF AMENDMENT
4.0	01 Jun 20	All	Document updated to include content from:
			ETG-01-01, ETC-01-04, ETC-01-06, ETF-01-01, ETM-01-01, ETM-01-03, ETI-01-01 and RCSI019
		1.4.4	Editorial and format updates
		Appendix	Updated content for lubrication
5.0	15 Jun 21	All	Document restructured
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			ETD-01-02, ETG-01-02, ETM-01-04, ETA-01-01 and ETI-01-05
			Procedural weld content moved to ETN-01-06
			Added rail head area wear tables
		Appendix	Added Modified 60KG/M Rail Profile

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1 Section 1: Rail

1.1 General

1.1.1 Reference Documents

The following documents support this standard:

- 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
- ETE-01-03 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 38ºC.
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 – • Risk assessment • Risk control measures • Time bound action plan to return to compliance
Equivalent Standard	A suitable alternative standard approved by the Manger Standards.
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 and Rating

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 must 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 joint method (welded and non-welded)

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

1. Non-welded rail (i.e. mechanically jointed rail).
2. A combination of welded and non-welded rail (e.g. long welded rail). Noting;
    a. joints shall have adequate strength and the rail shall be adequately restrained.
    b. the central portion of long lengths may need to be treated as CWR.
3. Continuously welded rail (CWR).

Associated construction and maintenance guidelines to control the build-up of longitudinal stresses in the rail are specified in ARTC Standards for Track lateral stability.

1.2.4.1 Welded rail Joints

Weld processes for joining rails include the following:

1. Aluminothermic
2. Flashbutt

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

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.

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

On plain track (main line or siding), aluminothermic welds may 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.

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 1.2.8.

1.2.4.1.1 Fixed structures

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.

1.2.4.1.2 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.

1.2.4.1.3 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.

1.2.4.1.4 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 Standards who may require a type approval.

1.2.4.2 Non-welded rail joints

Non-welded rail joints should not be used on concrete sleepered track with a speed >40km/h.

Non-welded rail 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.

1.2.4.2.1 Permanent rail joints

1. 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:
    a. Fishplates AS 1085.2
    b. Fishbolts and nuts AS 1085.4
    c. Spring washers AS 1085.7
2. Joints should be centrally suspended between sleepers.
3. 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 non-welded joint, that is not an insulated joint, should not be closer than 9 metres from any other non-welded rail join in either rail.

4. Where a closure rail is required to remain permanently jointed in track using non-welded joints at either end this closure must not be shorter than 10m, however;
    a. In an emergency a shorter rail may be used as a temporary measure, but the non-welded rail joints must be welded out as soon as possible.
    b. 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
5. Where fish plated joints are being installed permanently a minimum of 6 hole/6 bolts should be utilised.
6. Where non-welded rail joints, other than insulated joints, are in electrified or signalling track circuited areas appropriate electrical bonding must be installed across the joint.
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.
8. Where a mechanical joint has been repaired all bolts should be fully tightened and have a maximum dip of 1mm over 1 metre.

1.2.4.2.2 Temporary rail joints

Temporary joints are those 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.

1. Temporary joints shall have a speed restriction of 30km/h or less imposed.
2. Temporary joint 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 must be used for safety reasons.
    b. Risk of joint failure and clamp failure demands accurate setting of torque as per supplier’s installation methods.
    c. Temporary joints consist of clamped fishplates (for example "G" or Robel clamps) and are used to join broken or cut rails. This type of assembly may be secured additionally by fishbolt(s) if suitable hole(s) are present in the rail.
3. They shall only be used under the following circumstances:
    a. To permit the passage of trains during work possessions.
    b. To plate broken rails or welds where;
        i. the break is vertical
        ii. Multiple defects are not present
        iii. The joint is bolted in place
4. Temporary fishplates (for example bow plates) shall only be used to plate defective rails or welds or as required as a precautionary action.
5. A plated defect where the rail breaks cannot be considered a temporary rail joint and must be treated as a broken rail.

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

1.2.5 Insulated Joints

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

1.2.5.1 Design

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 ±1mm
8. Insulated joints placed in curves should be pre-curved to suit the radius of the track.

1.2.5.2 Application

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

1.2.6 Rail lubrication

1.2.6.1 General

Lubrication is 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 to type approved designs and shall be installed, adjusted, cleaned, maintained and used in accordance with the manufacturer's instructions.

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

1.2.6.2 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.

1.2.6.3 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.

1.2.6.4 Performance Requirements

Rail lubrication systems should be designed to meet the following performance requirements:

- 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.

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

1.2.6.5 Rail Lubricants

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

- Four Ball Weld Load >315kg minimum, >500kg preferred
- Oil Separation (40deg C, 168hrs) < 7% mass maximum, less than 5%w preferred
- Ambient Temp range (storage): -10degC to 45degC
- Operating temp range (under normal load on rail): -10degC to 85degC
- Flash Point >200deg C
- Drop Point temperature: Must 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 -20degC
- Good resistance to drooping (of beads)
- High adhesion to rail steel in normal track use

Any deviations below these values must 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 still 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.

1.2.6.6 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.

1.2.6.7 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.

1.2.7 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 must 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 set-outs 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.

1.2.8 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.

1.3 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).

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 1-23 and Table 1-24 in clause 1.4.10.2 must not be reused.

Worn rails being cascaded from curves to straights must 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
41	80 ASB 1928	64	49	26
41	80 ASA 1928, 80 A 1916	70	56	25

APPROX. KG/M	RAIL SECTION	WIDTH OF NEW RAIL HEAD (MM)	MINIMUM REMAINING WIDTH (MM)	TOP REMAINING HEIGHT (MM)
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 1.4.7, 1.4.9	Refer to 1.4	Ultrasonic testing as required by Figure 1-1	Refer to 1.4.7,1.4.8,1.4.9	Rail to be free of internal and surface defects including squats and wheel burns
Wear limits	Refer to Table 1-22	Gauge or measurement of wear	Once only prior to unrestricted service	Refer Clause 1.4.10.1	
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	

FACTOR	SPECIFICATION	METHOD OF TEST	FREQUENCY / TIMING OF TEST	METHOD OF ASSESSMENT	COMMENTS
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
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 4 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 1.3.7.4 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.

FACTOR	SPECIFICATION	METHOD OF TEST	FREQUENCY / TIMING OF TEST	METHOD OF ASSESSMENT	COMMENTS
Discontinuities	Refer to1.3.7.4	Refer to1.3.7.4	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.
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 1.4.10.4	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 should not be less worn than the parent rail.	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		
Rail Head Condition	No end batter present No crushed or laminated head	Visual	Once only prior to use		End batter must be cut off

1.3.2 Rerailing

Rail that is placed in preparation for re-railing must 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 must be well clear of the running rails, stood upright on their feet and spiked to enough sleepers to ensure they will not move.

When replacing rail:

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

All rail inserted into track must 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 must 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 must be checked to ensure they are correctly installed, adjusted and functioning as per the manufacturer's instructions.

1.3.3 Repair of Rails

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

DEFECT	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.

DEFECT	COMMENT ON ACTIONS
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 using wide gap welds if no bolt holes exist.
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 using 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.

1.3.4 Cutting of rail

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

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 (refer Standard for rail – monitoring and maintenance)
- 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 must 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 must 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 must be replaced as soon as possible by welding in a new section, or by replacing the affected rail with a saw cut rail.

1.3.5 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 must 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 must 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.

1.3.6 Rail Stress Control

1.3.6.1 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.

1.3.6.2 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 any;
    - 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 Clause 1.3.6 were not used.

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

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*

1.3.7 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.

1.3.7.1 Flashbutt welding

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

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.

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.

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

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.

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.

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.

1.3.7.1.1 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.

1.3.7.1.2 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.

1.3.7.2 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 1-6.

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.

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

1.3.7.3 Electric arc welding

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

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

Type and proof testing of these methods shall be carried out using the method and frequency defined in AS 1085.15.

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.

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 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 1.4.7 (Rail and welded joints) and 1.3.7.4 (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 1.4.7 and 1.3.7.4	As specified in 1.4.7 and 1.3.7.4
	Internal inspection as specified in 1.4.7 (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 1.4.7	As specified in Clause 1.4.7

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 1-6: 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: • 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 1.4.7 (Rail and welded joints) and 1.3.7.4 (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 1.4.7 and 1.3.7.4	As specified in 1.4.7 and 1.3.7.4
	Internal Inspection as specified in 1.4.7 (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 1.4.7	As specified in 1.4.7

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	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 1.4.7 (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 Clauses 1.4.7 and 1.3.7.4 (See Note)	As specified in Clauses 1.4.7 and 1.3.7.4 (See Note)
	Internal inspection as specified in Clause 1.4.7 (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 1.4.7	As specified in Clause 1.4.7

Ultrasonic Test Flow Diagram

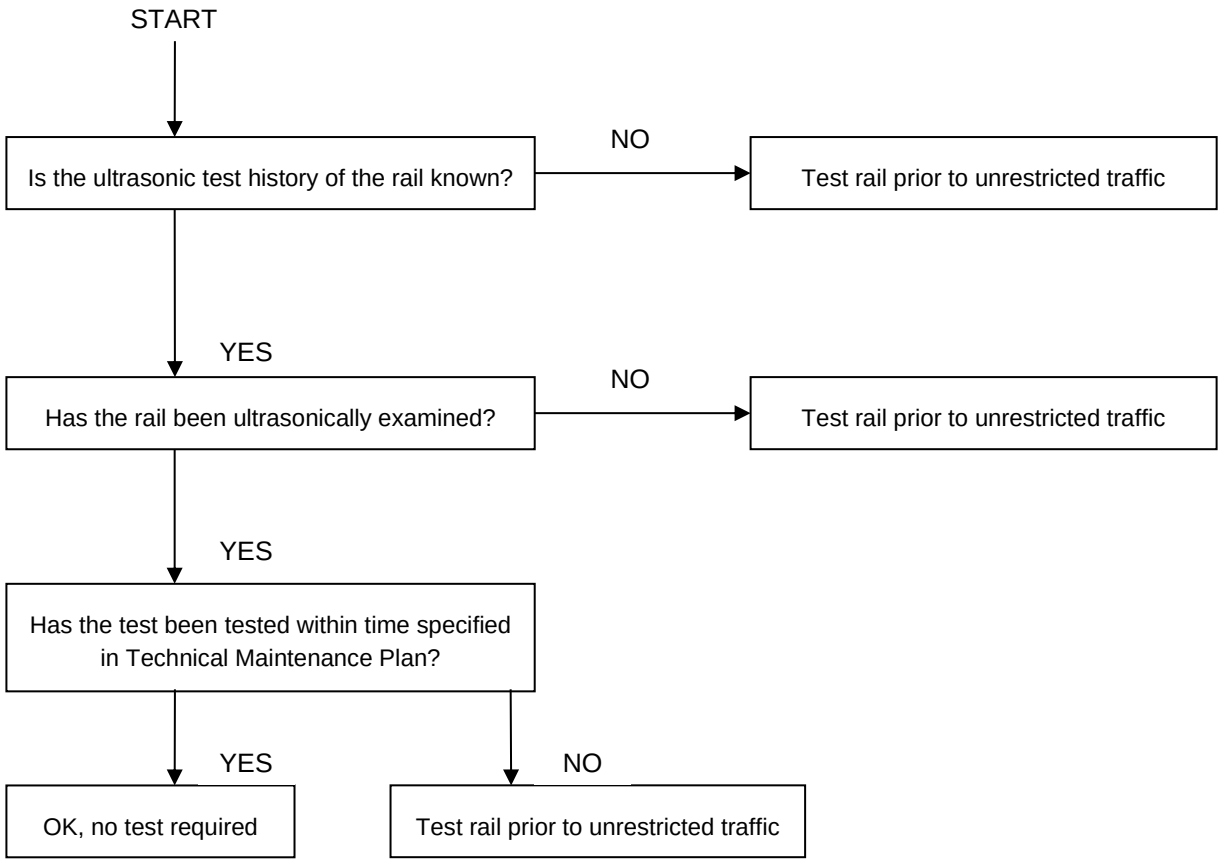

Figure 1-1: Rail Acceptance - Ultrasonic Test Flow Diagram

1.3.7.4 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.

1.3.7.4.1 Visual Inspection

Each weld must 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

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 restrict, plate or remove *(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)*
Flashing / Finning	
90 Days	Grind or remove

1.3.7.4.2 Ultrasonic testing of new welds

Ultrasonic testing of new welds is to be completed within the timeframe specified in ETE-01-03 Non-Destructive Testing of Rail (for Internal & Surface Defects).

Internal rail flaw defects detected ultrasonically shall be actioned in accordance with the responses detailed in Table 1-13,Table 1-15 and Table 1-16 as required.

1.3.7.4.3 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 ±2mm preferred, absolute maximum ±4mm

1.3.7.4.1 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 must 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 must have a curvature consistent with the curvature of the existing rails and the gauge face of the weld must be smooth and continuous.

The vertical alignment of the weld is to be checked to confirm it has been installed perpenticular 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 (gauge narrowing or widening)	0.5mm over 1m	1m reference and alignment difference measure	Remove or bend
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
Collar alignment (Vertical)	Vertical ±2mm preferred, absolute maximum ±4mm	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

1.3.7.4.2 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 Scheduled rail and welded joint inspection

The following 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.

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

1.4.1.1 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:

- Broken rails and rail welds
- Rail and rail weld deformations and discontinuities
- Wheel burns, Squats or Rolling Contact Fatigue (RCF)
- Damage to rail surface or section
- Unusual patterns of gauge face contact
- Unusual vehicle tracking patterns
- Rail corrugation
- Rail crippling
- 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.

1.4.1.2 General inspection

A general inspection of rail surface 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.

A general visual inspection shall be carried out;

- for all new welds (see Table 1-5, Table 1-6, and Table 1-7); and
- where the response following detection of a rail or weld defect is 'monitor or reassess'.

1.4.1.3 Detailed inspection

Detailed inspection internal rail defects should be carried out as follows:

1.4.1.3.1 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 must 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'.
- 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.

1.4.1.3.2 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.
- 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

1.4.1.3.3 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.

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

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1.4.2 Scheduled non-welded joint inspection

The inspection of non-welded rail joints is undertaken to identify conditions which if left unattended have the potential to result in failure of rail joints.

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

1.4.2.1 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:

1. Broken, missing or loose bolts.
2. Worn, cracked or broken plates.
3. Metal flow across joint.
4. Vertical deformation or pumping joints.
5. Rail end batter.
6. Excessive joint gap which may indicate elongated bolt holes or bent bolts.
7. Not working as a sliding joint to accommodate designed rail movement
8. Insulation breakdown.
9. Track circuit bond wire damage.
10. 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.

1.4.2.2 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 'monitor or re-assess'.

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

1. Cracked and broken plates.
2. Pumping joints.
3. Excessive joint gap which may indicate elongated bolt holes or bent bolts.
4. Worn fishplates.
5. Frozen joints.
6. Other defects or missing components.

1.4.2.3 Detailed inspection

A detailed 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.

1.4.3 Scheduled rail wear inspection

The inspection of rail wear is undertaken to identify locations where the risk of rail failure is increased due to the loss in rail cross sectional volume.

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

1.4.3.1 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:

- High wear rates (e.g. presence of filings).
- Other unusual and obvious wear patterns and defects indicating for example poor vehicle tracking, sharp points in curves or excess/deficiency in track superelevation.
- High levels of rail wear approaching wear limits, particularly on curves.
- Excessive gauge-face angle on rail.
- 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.

1.4.3.2 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.

1.4.3.3 Rail corrosion examinations

In addition to the above requirements, rails in tunnels and wet locations shall be examined for corrosion during track patrols. 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.

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

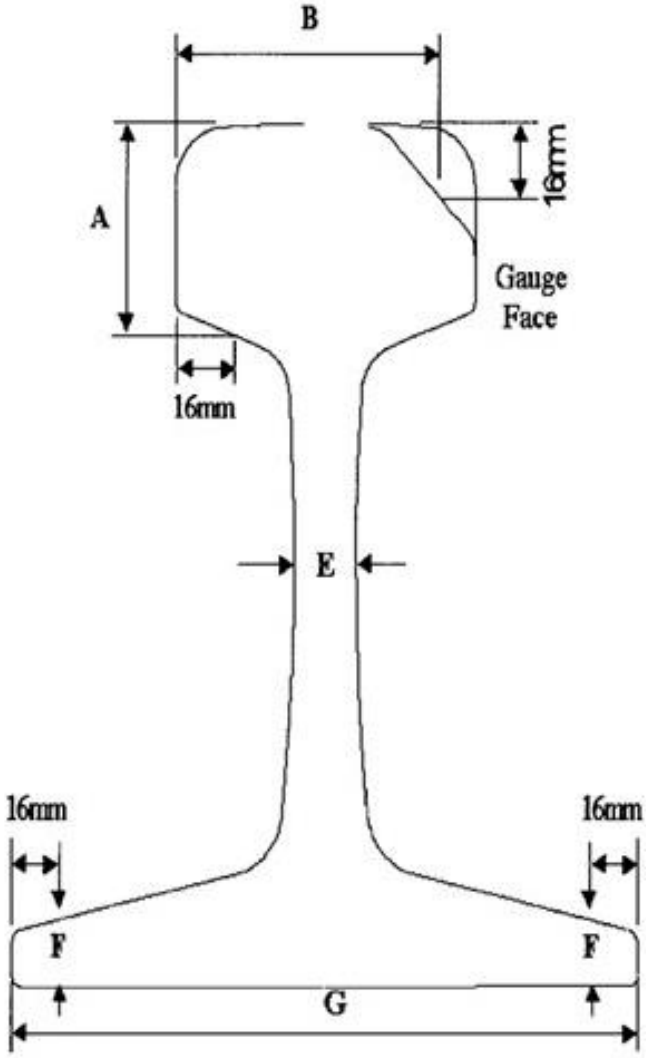


Figure 1-2: Rail cross-section locations of where to take corrosion measurements for 53 and 60 kg/m rail

The corrosion limits for 53 and 60 kg/m rail can be seen in Table 1-12.

Table 1-12: Original and Allowable Rail Limits Due to Corrosion

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

1.4.3.4 Electronic measurement of rail wear

Any electronic measurements must meet the following requirements:

1. Top wear must be measured in the vertical plane in the centre of the head to an accuracy of 0.5mm
2. Side wear must be measured laterally 16mm from the running surface to an accuracy of 0.5mm
3. Head loss must be measured as the loss of head area as a percentage of the original area to an accuracy of 2%
4. Gauge face angle must be measured as the angle between a line perpendicular to the sleeper plane (i.e. plane of the track) and the line tangent of the rail gauge where wheel flange contact occurs to an accuracy of 2 degrees.

Any electronic system of measurement must be suitably calibrated and should have its outputs monitored for indications of failure, at which point the system should be recalibrated.

1.4.4 Scheduled inspection and assessment for rail lubrication

On curves where rail lubrication is required, enough rail lubricant shall be applied on the gauge face of the outer rail of curves so that wheel squeal from flanging is minimised.

Indications of severe wear, in the form of wear debris or rough surface on the gauge face, should be investigated and the lubrication functioning checked. If lubricators are found to be functioning correctly the strategy should be reviewed and may need to be modified.

1.4.4.1 Patrol Inspection

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:

1. Contamination of the rail surface (e.g. oil spills)
2. Obvious over or under lubrication;
3. 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).
4. Combinations of top-lubrication, flange-lubrication and dry rail are variously applied for specific purposes at individual locations.
5. Signs of excessive side wear, shiny wear marks on the gauge face and/or steel flakes along the rail foot.
6. 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.

1.4.4.2 General inspection

General inspections of rail and rail lubrication devices shall be carried out at the prescribed intervals 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 inspections should be reported on the applicable form.

General inspections should look for those defects and conditions identified in patrol inspections in addition to the following:

1. Carry of lubrication
2. Optimisation of rail wear
3. Minimisation of wheel squeal
4. Obvious damaged or loose components
5. Blade height and conditions
6. Plunger settings and operation
7. Filler valve condition
8. Grease leakages
9. 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.

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

1. Visual inspection
2. Tribometer
3. Gauge.

1.4.4.3 Un-scheduled Inspection for Rail Lubrication

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

1.4.4.4 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 appropriate actions taken.

1.4.4.5 Maintenance Procedures

Maintenance servicing and repair of lubricators is to 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.

Maintenance servicing should be undertaken in accordance with Appendix B – Lubricators: Removal, Re-installation and Servicing

1.4.5 Scheduled guard rail inspection

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

The inspection of guard rails shall incorporate the following guidelines.

1.4.5.1 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:

1. Missing or ineffective rail/sleeper fastenings.
2. Lack of guard rail continuity.
3. 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.

1.4.5.2 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.

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).

1.4.6 Insulated rail joint inspections

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

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

1.4.6.1 Patrol inspection

The interval between patrol inspections for visible insulated rail joint inspections 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, joint component and insulating material defects and conditions (i.e. indicators of a defect) that may affect the integrity of the Insulated Joint including the following:

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

1.4.6.2 Detailed inspection

Detailed inspections shall be undertaken at maximum 12 months intervals or as specified otherwise by ARTC e.g. in an approved Technical maintenance Plan. Undesirable conditions including those listed in 1.4.6.1 below should be assessed and actions taken in an appropriate time frame.

1.4.7 Rail and welded joint internal defect assessment

1.4.7.1 Minimum Action

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

- 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.
- If there is growth in the size of an existing defect with minimum response action of ‘plate or reassess’, it should be prioritised for removal, as this is a sign it could lead to failure.

1.4.7.2 Dispensation for exceedance of maximum allowable response times

This clause is to be used to manage occasional temporary dispensation to the maximum allowable response times 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.

Short-term dispensations for rail defects removal response times shall be entered into the AMS.

This dispensation can only be granted by the CER.

The following are examples where a dispensation may be justified subject to risk assessment 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.

Where the defined action is to reassess, there shall be no dispensation to exceed the defined timescale.

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

1.4.7.3 Action required for rail defects 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.

1.4.7.4 Untestable rail

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

1.4.7.5 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 to the dispensation clause in this procedure.

1.4.7.6 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)

1.4.7.7 Minimum remedial action to protect or correct bolt hole cracks

For the application of responses and actions to bolt hole crack defects, determine the track risk type in Table 1-13 below and apply the minimum response required.

Table 1-13: Minimum response time and actions bolt hole cracks

BOLT HOLE CRACK SIZE (MM)	**FOR TRACK WITH ANY OF THE FOLLOWING; HEAVY HAUL TRACKS. 2 OR MORE SCHEDULED PASSENGER TRAINS A DAY. DEFECT IS IN CURVE <600M RADIUS. RAIL SECTION IS SMALLER THAN 47KG.**		**FOR ALL OTHER TRACK**	
	RESPONSE TIME	**ACTION**	**RESPONSE TIME**	**ACTION**
0 - 10	28 days	Reassess until removed	90 days	remove
11 - 20	7 days	Reassess until removed	28 days	remove
21 - 40	1 day	Speed restriction (60 km/h maximum) and reassess every day until removed	7 days	Reassess until removed
>40	Prior to the passage of the next train	Speed restriction (40 km/h maximum) and reassess every day until removed	Prior to the passage of the next train	Speed restriction (60 km/h maximum) and reassess every day until removed

*Note: * 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).*

1.4.7.8 Broken rail defects

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, 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 must be considered when using them for longer than several days,
    b. they must be protected by speed restrictions according to ARTC Rail standards,
    c. they should be condition monitored at a higher frequency, typically daily when under high loads or at elevated risk locations.
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

1.4.7.9 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 (Interstate Version)
- Form ETE0101F-02 Rail Break Report (Hunter Valley Only)

1.4.7.9.1 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 (Hunter Valley) 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).

1.4.7.9.2 Standard Investigation Process

If there is no doubt about the cause of the break, ETE0101F-01 or ETE0101F-02 (Hunter Valley) 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.

1.4.7.9.3 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 (Hunter Valley) 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 (left/right), 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 (Hunter Valley) 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 a NATA accredited laboratory for metallurgical examination and report.

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.

1.4.7.10 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 1-15, Table 1-16 and Table 1-17 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.
- Defects that are actioned through re-assessment (where allowed) without being plated shall be 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 must 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.

Table 1-14 Defect Code Alignment to Attributes as listed in Ellipse

ACRONYM	DEFINITION
TD	Transverse Defect
TD	Rail Head Transverse Crack (TD)
SC	Rail Head Transverse Crack in Shatter Crack Rail (SC)
TDX	Rail Head Multiple Transverse Cracks (TDX)
WT or WF Head	Rail Head Transverse Weld Defect (T or FB)
WT or WF Web	Rail Web Transverse Weld Defect (T or FB)
WT or WF Foot	Rail Foot Transverse Weld Defect (T or FB)
EBF	Rail Head Transverse Crack From Wheel Burn (EBF)
TS	Rail Head Transverse Crack From Shelling or Squat (TS)
WFW	Rail Head Repair Weld Defect (WFW)
HSH	Rail Head Horizontal Split (HSH)
VSH	Rail Head Vertical Split (VSH)
HW	Rail Head Web Separation (HW)
FW	Rail Foot Web Separation (FW)
HSW	Rail Web Horizontal Split (HSW)
SW	Rail Web Transverse Vertical Split (SW)
VSW	Rail Web Longitudinal Vertical Split (VSW)
PR	Rail Web Piped Rail (PR)
BH	Rail Web Bolt Hole Crack (BH)
MJ	Suspect Internal Rail Flaw
CR	Rail web corroded
CR	Rail foot corroded
NO	Rail foot bruised or notched by strike impact
BR	Broken Rail
BR	Broken Weld
BR	Broken insulated joint

1.4.7.11 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 1-15.

An exception to Table 1-15 is shown further below in Table 1-16. 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.

Table 1-15: Rail defect management non-heavy haul

	TYPE OF DEFECT		CODE	SIZE DEFINITION		IMMEDIATE SPEED RESTRICTION (KM/H) UNTIL MINIMUM ACTION TAKEN	MINIMUM ACTION BY TRACK CONFIGURATION				OTHER ACTIONS
							CURVE ≤600M RADIUS		CURVE >600M RADIUS & TANGENT		
				SIZE	MEASUREMENT		MINIMUM ACTION	RESPONSE TIME	MINIMUM ACTION	RESPONSE TIME	
1	**Transverse defect**	**- in rail head (transverse fissures, shelling)**	**TD**	S	5 to 10% (10 to 20 mm)	-	Plate or Remove	7 days	Reassess or Plate or Remove	90 days	Refer to Table 1-16 for exceptions to defect responses on Transverse defects.
				M	11 to 30% (21 to 30 mm)	20	Plate or Remove	1 day	Plate or Remove	28 days	
				L	over 30% (over 30 mm)	20	Plate & Remove	2 hours 1 day	Plate or Remove	1 day	
		- in Shatter Cracked rail head	**SC**	-	0 to 5% (< 10 mm) treat as TD small	-	-	-	-	-	If TD is reported in shatter cracked rail, the full length must be replaced weld to weld when the defect is removed.
		- Multiple Transverse Defects	**TDX**	S	5 to 10% (10 to 20 mm)	40	Remove	7 days	Remove	7 days	Multiple refers to more than one TD found in any rail length (continuous rolled piece). Replace full rail length – weld to weld.
				M	11 to 30% (21 to 30 mm)	20	Remove	1 day	Remove	1 day	
				L	over 30% (over 30 mm)	10	Monitor after each train until removal. Stop trains if necessary.				
2	**Defective Welds**	**Head**	**WT or WF**	Size as for TD, noting exceptions in Table 1-16 in SA/WA/Vic.							Refer to Table 1-16 for exceptions to defect responses.
		Web		S	25 to 50mm	-	Plate or Remove	28 days	Reassess or Plate or Remove	90 days	
				M	51 to 75mm	20	Plate or Remove	7 days	Reassess or Plate or Remove	28 days	
				L	over 75mm	20	Remove	1 day	Plate or Remove	1 day	
		Foot		M	15 to 35mm (If at edge: 10 to 35mm)	20	Plate or Remove	7 days	Plate or Remove	7 days	
				L	over 35mm	20	Remove	1 day	Plate or Remove	1 day	
3	**Engine Burn Fracture**		**EBF**	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	Remove	90 days	Refer to Table 1-16 for SA/WA/Vic exceptions to defect responses.
				M	101 to 200mm	-	Remove	7 days	Remove	28 days	
				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	Reassess	90 days	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	Remove	7 days	
				L	over 400mm	40	Remove	7 days	Remove	7 days	
				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	Remove	7 days	
				M	76 to 200mm	20	Remove	1 day	Remove	1 day	
				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	Remove	7 days	
				M	41 to 75mm	20	Remove	1 day	Remove	1 day	
				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	Remove	7 days	
				M	41 to 75mm	20	Remove	1 day	Remove	1 day	
				L	over 75mm	10	Monitor after each train until removal. Stop trains if necessary.				
10	**Split Web Vertical (transverse)**		**SW**	S	20 to 40mm	-	Remove	7 days	Remove	7 days	
				M	41 to 75mm	20	Remove	1 day	Remove	1 day	
				L	over 75mm	10	Monitor after each train until removal. Stop trains if necessary.				
11	**Vertical Split Web (longitudinal)**		**VSW (PR if piped)**	S	25 to 150mm	-	Remove	28 days	Remove	28 days	If any visible cracking action as large defect. If piped rail, then replace full rail length weld to weld.
				M	151 to 300mm	-	Remove	7 days	Remove	7 days	
				L	over 300mm	10	Monitor after each train until removal. Stop trains if necessary.				
12	**Bolt Hole Crack (all angles)**		**BH**	Refer to clause 1.4.7.7 of this standard.							
13	**Mechanical Joint Suspect**		**MJ**	Remove plates and inspect within 7 days. Refer to Table 1-13 on bolt hole cracks for actions.							
14	**Corroded Rail**		**CR**	If reported by ultrasonics car, track staff to inspect in accordance with standards for rail inspection in tunnels.							
15	**Notches**		**NO**	Assessed by a competent worker and include consideration of the location, extent and geometry of each isolated notch or cut.							Dented or bruised rail, e.g. due to a hammer blow, may not generally require removal.
16	**Broken Rail**		**BR**	Refer to clause 1.4.7.8 of this standard.							

Table 1-16: Exceptions to non-heavy haul defect responses in 47kg rail 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 & TANGENT		
							MINIMUM ACTION	RESPONSE TIME	MINIMUM ACTION	RESPONSE TIME	
1	**Transverse defect**	**- in rail head (transverse fissures, shelling)**	**TD**	S	5 to 10% (10 to 20 mm)		Plate or Remove	7 days	Reassess or Remove	90 days	If TD is reported in shatter cracked rail, the full length must be replaced weld to weld when the defect is removed.
		- in Shatter Cracked rail head	**SC**	-	0 to 5% (< 10 mm) treat as TD small	-	Reassess or Plate or Remove	90 days	Reassess or Plate or Remove	365 days	
					>5% (greater than 10 mm) treat as TDX in Table 1-15						
2	**Defective Welds**	**Head**	**WT or WF**	S	5 to 10% (10 to 20 mm)	-	Plate or Remove	7 days	Reassess or Plate or Remove	182 days	
				M	11 to 30% (21 to 30 mm)	-	Plate or Remove	1 day	Reassess or Plate or Remove	90 days	
				L	over 30% (over 30 mm)	20	Remove	1 day	Plate or Remove	1 day	
5	**Horizontal Split Head**		**HSH**	S	25 to 100mm	-	Reassess or Remove	28 days	Reassess or Remove	90 days	
				M	101 to 200mm	-	Reassess or Remove	7 days	Reassess or Remove	28 days	

1.4.7.12 Minimum remedial action to protect or correct rail defects for heavy haul

The minimum actions and response time for rail defects are provided in Table 1-17.

Table 1-17: Rail defect management heavy haul

	TYPE OF DEFECT		CODE	SIZE DEFINITION		IMMEDIATE SPEED RESTRICTION (KM/H) UNTIL MINIMUM ACTION TAKEN	REQUIRED ACTION		OTHER ACTIONS
				SIZE	MEASUREMENT		MINIMUM ACTION	RESPONSE TIME	
1	**Transverse defect**	**- in Shatter Cracked rail head**	**SC**	-	0 to 5% (< 10 mm) treat as TD small	-	-	-	If TD is reported in shatter cracked rail, the full length must be replaced weld to weld.
		- Rail head (transverse fissures or shelling)	**TD**	S	5 to 10% (10 to 20 mm)	-	Plate or Remove	7 days	
				M	11 to 30% (21 to 30 mm)	20	Plate or Remove	1 day	Large defects to be plated prior to next train. Where this cannot be achieved this may be extended to a maximum of 2 hours.
				L	over 30% (over 30 mm)	20	Plate & Remove	Immediately 1 day	
2	**Defective Welds**	**Head**	**WT or WF**	Size and action as for TD.					
		Web		S	25 to 50mm	-	Plate or Remove	28 days	
				M	51 to 75mm	20	Plate or Remove	7 days	
				L	over 75mm	20	Plate & Remove	Immediately 1 day	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 or Remove	7 days	
				L	over 35mm	20	Plate & Remove	Immediately 1 day	
3	**Engine Burn Fracture**		**EBF**	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	**Multiple Transverse Head Defects**		**TDX**	S	5 to 10% (10 to 20 mm)	40	Remove	7 days	
				M	11 to 30% (21 to 30 mm)	20	Remove	1 day	Replace full rail length – weld to weld.
				L	over 30% (over 30 mm)	10	Monitor after each train until removal. Stop trains if necessary.		
6	**Horizontal Split Head**		**HSH**	S	25 to 100mm	-	Remove	28 days	
				M	101 to 200mm	-	Remove	7 days	
				L	over 200mm	10	Monitor after each train until removal. Stop trains if necessary.		
7	**Vertical Split Head**		**VSH**	S	25 to 200mm	-	Remove	28 days	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	
				L	over 400mm	40	Remove	7 days	
				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.		
8	**Head and Web separation (If at weld or rail end – use HSW sizing)**		**HW**	S	20 to 75mm	-	Remove	7 days	
				M	76 to 200mm	20	Remove	1 day	
				L	over 200mm	10	Monitor after each train until removal. Stop trains if necessary.		
9	**Foot and Web separation**		**FW**	S	20 to 40mm	-	Remove	7 days	
				M	41 to 75mm	20	Remove	1 day	
				L	over 75mm	10	Monitor after each train until removal. Stop trains if necessary.		
10	**Horizontal Split Web**		**HSW**	S	20 to 40mm	-	Remove	7 days	
				M	41 to 75mm	20	Remove	1 day	
				L	over 75mm	10	Monitor after each train until removal. Stop trains if necessary.		
11	**Split Web Vertical (transverse)**		**SW**	S	20 to 40mm	-	Remove	7 days	
				M	41 to 75mm	20	Remove	1 day	
				L	over 75mm	10	Monitor after each train until removal. Stop trains if necessary.		
12	**Vertical Split Web (longitudinal)**		**VSW (PR if piped)**	S	25 to 150mm	-	Remove	28 days	If any visible cracking action as large defect. If piped rail, then replace full rail length weld to weld.
				M	151 to 300mm	-	Remove	7 days	
				L	over 300mm	10	Monitor after each train until removal. Stop trains if necessary.		
13	**Bolt Hole Crack (all angles)**		**BH**	Refer to clause 1.4.7.7 of this standard.					
14	**Mechanical Joint Suspect**		**MJ**	Remove plates and inspect within 14 days. Refer to Table 1-13 on bolt hole cracks for actions.					
15	**Corroded Rail**		**CR**	If reported by ultrasonics car, track staff to inspect in accordance with standards for rail inspection in tunnels.					
16	**Notches**		**NO**	Assessed by a competent worker and include consideration of the location, extent and geometry of the notch or cut.					Isolated dented or bruised rail, e.g. hammer blow, often may not require removal.
17	**Broken Rail**		**BR**	Refer to clause 1.4.7.8 of this standard.					

1.4.8 Rail and welded joint surface assessment

The assessment of discontinuities in rail (rail welds and joints) should incorporate the following guidelines:

1.4.8.1 Running surface discontinuities in welded joints

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

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 1.3.7.4). The limits are not intended to indicate best practice as discontinuities of the magnitude defined in Table 1-18 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 sleeper track has a better inherent ability to tolerate impacts resulting in a lower rate of deterioration than for concrete sleeper track.

Table 1-18: Welded Rail Discontinuities (Maintenance)

FACTOR	OPTIMUM MAINTENANCE LIMIT [4]	NORMAL MAINTENANCE LIMIT [5]
Peak in running surface	1mm over 1m	2mm over 1m
Dip in running surface	0.5mm over 1m	2mm over 1m
Gauge widening due to change in rail	0.5mm over 1m	2mm over 1m
Gauge narrowing due to change in rail	0.5mm over 1m	2mm over 1m
Vertical deviations in rail running surface (Ramp angle)	8 milliradians	10 milliradians

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. *Gives limits for best practice that have been shown to give optimal maintenance results in ARTC. No action is required.*
5. *When discontinuities of the sizes shown are left in track, problems with track geometry deterioration and impacts causing track component deterioration can be expected.*

1.4.8.2 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	Train operation at reduced speed appropriate to 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.

1.4.8.3 Rolling contact fatigue

Rolling contact fatigue defects should be managed as per Table 1-19.

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 1-19: Rolling contact fatigue defect response

SEVERITY	REPONSE
RCF resulting in shielding (LBWE)	Manage as per ETE-01-03
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	Escalate to local engineering authority

1.4.9 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 1-20. The actions for response codes for A1 to A7 are shown in Table 1-21.

Table 1-20 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 1-20: 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 for 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 1-21: 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 Table 1-21 is permitted with appropriate documentation and approval by the Civil Engineering Representative or nominated representative.*

1.4.10 Rail wear assessment

1.4.10.1 Rail wear measurement

Table 1-22 gives the area of each rail size in new condition; this figure must be used for all head loss % calculation methods.

Table 1-22: Rail Size new head area to be used for head loss % calculations

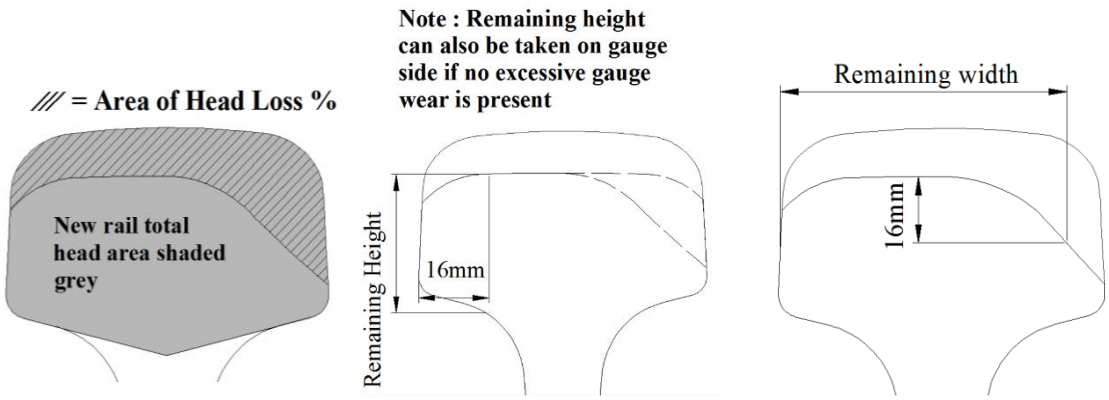
RAIL TYPE	NEW RAIL HEAD AREA (MM^2)	FULL HEIGHT (MM) AT 16MM
47AS	2548	37
50AS	2710	39
53AS	2721	39
60AS	2999	44

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.



1.4.10.2 Rail wear management

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.

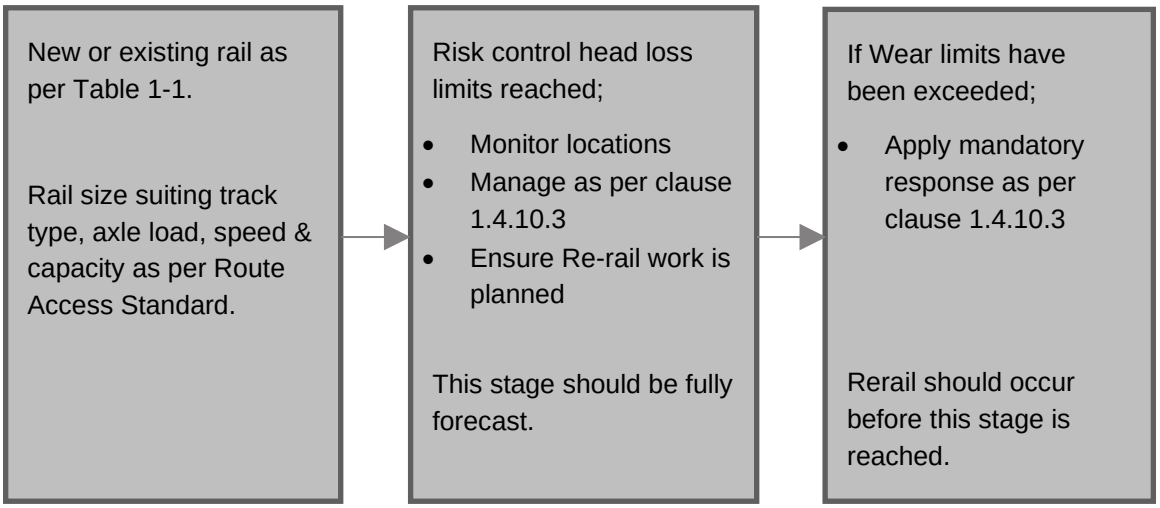
Rails on main lines and crossing loops are to be examined for wear at the frequency, and using methods, described in clause 1.4.3

Table 1-23 details the allowable limits for top wear and side wear, at which the capacity of the rail should be reviewed. The limits for rail head wear as detailed in these tables are divided into 2 levels; Risk Control & Absolute 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 risk control limits detailed in Table 1-23 is designed to ensure that appropriate risk-based mitigation controls, as detailed in clause 1.4.10.3, 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.



For both Table 1-23 and Table 1-24 the deciding wear limit is the first exceedance of any of the limits i.e. 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 absolute limits are reached or exceeded.

Table 1-23: Rail Wear Limits

		RISK CONTROL LIMITS		**ABSOLUTE LIMITS**		
		% LOSS OF HEAD AREA		**TOP WEAR ONLY** **(WHERE <10MM SIDE WEAR HAS OCCURRED)**	**COMBINED TOP WEAR & SIDE WEAR** **(WHERE >10MM SIDE WEAR HAS OCCURRED)**	
AXLE LOADS	**RAIL TYPE (AS)**	**IF SIDE WEAR <10MM**	**IF SIDE WEAR >10MM**	**REMAINING HEIGHT LIMIT (MM)**	**REMAINING HEIGHT LIMIT (MM)**	**REMAINING WIDTH LIMIT (MM)**
≤ 25 TAL	47kg/m (94lb)	32%	32%	24	24	55
	50kg/m	45%	32%	21	21	50/46 (see note 2)
	53kg/m (107lb)	35%	35%	21	23	50/46 (see note 2)
	60kg/m	45%	40%	20	24	46
Heavy Haul > 25 TAL **(see note 3)**	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

Notes:

1. *The limits listed under 'Risk Control Limit' must not be exceeded without first considering the risk control factors as described within clause 0.*
2. *If it can be shown that all risk control factors in section 0 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.*

Table 1-24: 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
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

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

1.4.10.3 Rail wear

Once rail wear reaches the risk control head loss % limits, as detailed in Table 1-23 and Table 1-24, 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 at or exceeding the absolute 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 1-23 and Table 1-24 are exceeded the actions listed below for 'Risk Control Limit' or 'Absolute 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).
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. 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 absolute 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.

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:

1. All sizes of internal rail defects shall be treated as large category response.
2. The location shall be speed restricted to 20km/h unless approval has been provided for an alternative response by a person with CER competency.

1.4.10.4 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.

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.

1.4.11 Guard rail assessment

Guard rails are not required on bridges.

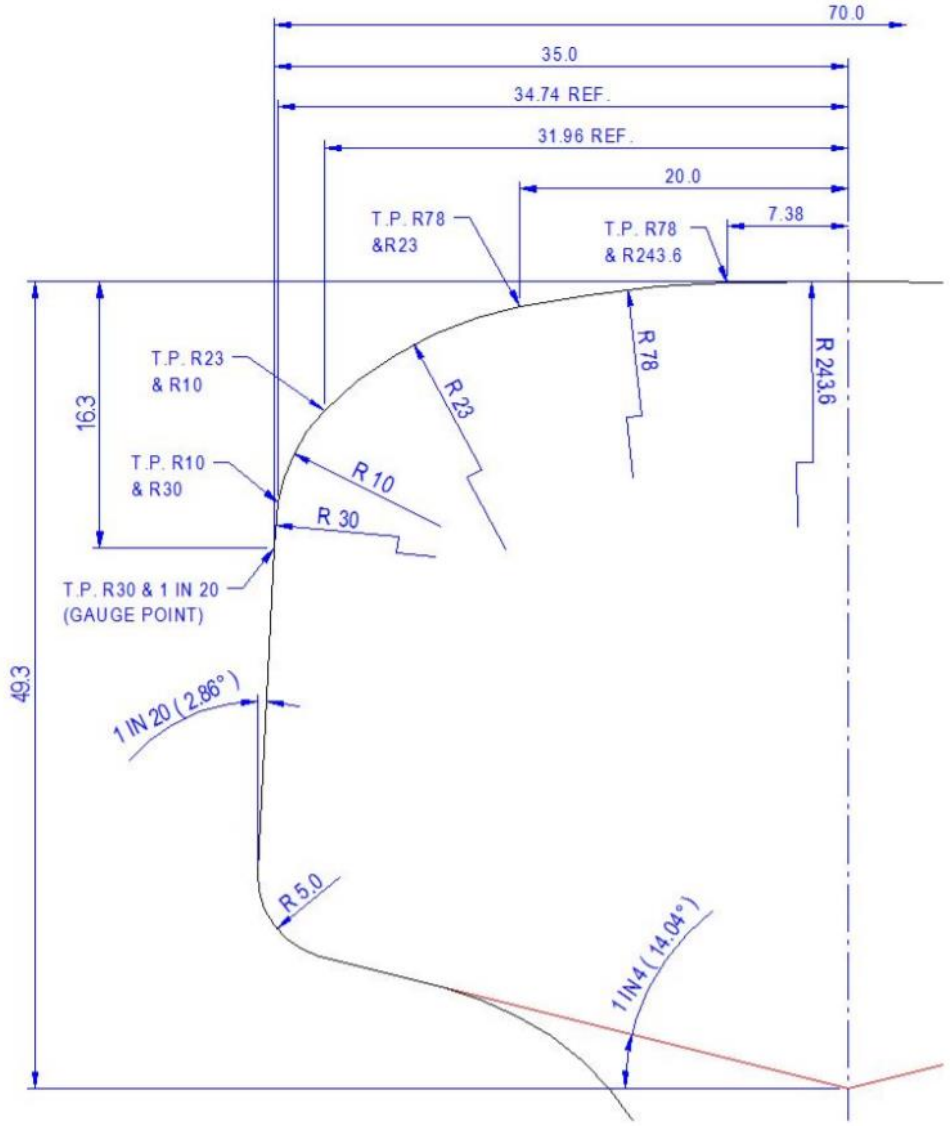
All existing guard rails shall be safely maintained in accordance with the Table 1-25 until they are removed.

Table 1-25: Responses for Guard Rail Condition

DEFECT NAME (TYPE CODE, POSITION CODE)		
DEFECT SIZE	**RESPONSE TIME**	**ACTION**
SLEEPER FASTENINGS MISSING OR INEFFECTIVE [Note]		
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: These defect sizes and responses apply to all configurations of guard rail fasteners.

Appendix A – Modified 60KG/M Tangent Profile



Appendix B – Lubricators: Removal, Re-installation and Servicing

General

Rail lubricators can suffer considerable damage during ballasting, re-railing and other mechanised track maintenance operations such as tamping, re-sleepering, sledding, ballast cleaning and ballast regulating.

Removal and Re-installation for Track Maintenance

Regardless of lubricator type, lubricators do not require removal for ballasting operations. Minor adjustment is necessary for P & M type lubricators. No adjustments are required for Tamper lubricators.

For P&M type lubricators, the only requirement is to lower the plungers and pump casting below the top of the rail head to avoid fouling ballast ploughs etc. To achieve this:

1. Loosen the two-pump casting retaining bolts on each side of the anchor block
2. Lower plungers below top rail head
3. Tighten retaining bolts.

After ballasting is completed, plunger heights need to be readjusted to the correct height.

Removal and Re-installation for Major Track Maintenance

Procedures for removal and installation of lubricators for rerailing and major track maintenance activities are detailed in Table A 1.

Table A 1: Removal and installation of lubricators

P&M type lubricators	
For bolt on lubricators:	For clamp on lubricators:
Removal	
	Loosen grease delivery hose clamps and remove grease delivery hose(s) from blade(s).
	Remove blade(s) by loosening blade retaining bolts and rail clamps.
	Loosen anchor block retaining clamps and rail clamps and withdraw anchor block and main container. Note: Main container is still attached to the anchor block.
	Remove rail clamps from foot of rail.
Installation	
After rerailing, determine whether the rail size and lubricator components are compatible. 80 lb (40 kg) anchor blocks can be used on larger rail sections by changing the two chairs on the underside of the anchor block. This is achieved by removing the two Allen screws retaining the chairs and fitting two appropriate size chairs. The correct size blades are then used, and all other components are interchangeable.	
Determine the correct location to fit the lubricator in relation to the curve tangent point on the correct rail.	
Remove excess ballast and position main container into correct location.	

Position the lubricator and mark the location of the two holes for the main attachment bolts on the web of the rail.	Fit two rail clamps to the foot of the rail. Do not tighten.
Drill the two holes (30 mm diameter).	Fit anchor block and tighten rail clamps.
With main container positioned on the field side of the rail line up holes in the rail and main container. (Note: Main container on C4 includes anchor block).	Tighten anchor block retaining bolts.
	Position and fit rail clamps for blade(s). Do not tighten.
Fit blade(s). Fit millboard packing between the rail and the greasing plate assembly and assemble to rail. (when re-installing always fit new packing)	
The two main attachment bolts pass through the greasing plate assembly, millboard packing and rail web, and into the main container. Two cork stops should be used in this operation. The cork stops are fitted into the grooves in each end of the greasing plate assembly. The two main attachment bolts are securely tightened.	Fit new cork stops between blade assembly and rail in the grooves provided. Partially tighten blade retaining bolts.
Blade height is adjusted to 20 – 23 mm below the top of the rail. This is achieved by loosening the two large retaining bolts near the end of the blade. Once the correct blade height is obtained, tighten the two bolts.	Adjust height of blade(s) by loosening the four height adjusting bolts and moving the blade(s) up or down. Tighten blade retaining bolts and blade height adjusting bolts.
Replace bolt head covers and retaining bolts and secure.	Fit grease delivery hose(s).
Check pump plunger heights and adjust if necessary. This is done by releasing the two retaining bolts in each pump and moving the complete pump casting up or down. When correctly positioned, tighten retaining bolts. The correct plunger height setting is between 1 mm and 5 mm (for C4) or between 2 mm and 4 mm (for M4, M5, M6, M7 and M30).	
Fill main container with approved grease. Filling is carried out either by mechanical or pneumatic operation of pumping grease into the main container via a non-return valve.	
Activate plungers by striking rapidly with a ball peen hammer. This should deliver a bead of grease along the greasing plate. If no grease is present, pumps are likely to contain air and this must be bled. (Note: Pump can be primed while filling if assistance is available to depress plungers). Loosen both bolts securing pumps to main container (or anchor block) and allow air to be dispelled. Reset plunger heights and re-tighten bolts.This procedure may need to be repeated until all air is expelled	
Clean up worksite after lubricator is operating correctly.	
Tamper clamp-on C20 type lubricator	
Removal	
Remove grease delivery hose(s) from main container and blade(s).	
Loosen blade retaining bolts one each end of each blade. Remove blade(s).	

Remove pump activating shaft (flexible or universal type) from main container and actuating arm assembly.
Remove actuating arm assembly complete with height adjusting shims.
Remove rail clamps from under actuating arm assembly and also the two outer rail clamps for blade assembly.
Remove main container. The main container may have to be emptied of grease to allow the main container to be moved.
Place all components in a secure location away from worksite
Installation
Fit rail clamps to the foot of the rail to mount actuating arm assembly
Mount actuating arm assembly - adjust height of actuating arm by the use of shims between rail clamps and assembly. Tighten all bolts.
Determine correct distance and height for main container and dig hole. Place main container in hole.
Fit pump activating shaft to main container and actuating arm assembly.
Back fill hole to secure main container.
Determine correct location and fit outer rail clamps for blades
Fit blades to rail clamps. DO NOT TENSION BOLTS
The blade height is adjusted by rotating the Allen screws on end of blade (height adjustment screws).
Adjust blade to just contact rail on gauge face. Tighten blade retaining bolts
Fit grease delivery hoses to blades and main container
Fill main container with approved grease
Prime pumps and blades.
Fine tune grease delivery at pump adjustment height directly above pump in main container.

Inspection and Maintenance

Inspection and maintenance procedures are detailed in Table A 2.

Table A 2: Inspection and maintenance of lubricators

INSPECTION	MAINTENANCE
Main container	
Check the grease status of the main container. Does it need filling?	Fill main container.
Check main container for signs of damage especially for cracks around bolts holes in back cover.	Check for leaks at the hose connections. Leaks can be the result of loose hose fittings or damaged hoses. Tighten all back-cover bolts. Check reservoir for damage such as cracks especially near the back-cover bolts.
Check that filler valve is clean and has cover fitted.	
Pump assembly	
Check plunger condition	Check plunger condition, replace plungers if necessary; if pump not operating replace assembly with exchange service unit.

INSPECTION	MAINTENANCE
Check plunger height above rail.	Check plunger heights and adjust as required. Check height of plungers to establish that passing wheels actuate pumps. If plunger height is too low adjust pump casting to obtain correct height.
Activate plungers to ensure grease is being delivered to blade.	Activate plungers to ensure grease is delivered to the greasing plate. This may require the pump to be primed to remove air locks.
Greasing plate assembly	
Check blade for signs of wear	Inspect condition of blade(s) for wear and leaks around cork stops. Repair or replace damaged parts. Check plates for loose fittings and faulty gaskets. Tighten fittings and replace gaskets if necessary. Adjust grease plate to correct height after service is complete
Check blade height below rail head	Adjust blade height and tighten bolts.
Observe rail around lubricator grease plate for excessive grease delivery to the rail head and adjacent track structure.	Visually examine the greasing plate for wear and/or damage. Check height of greasing plate. Adjust as required. Remove excessive grease and prime greasing plate.
Observe rail around lubricator greasing plate for insufficient grease delivery.	Adjust greasing plate height as required.
General	
Check hoses for obvious damage.	Replace any damaged hoses.
Check all hoses, blade ends and pumps for grease leakages.	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.
Check that grease is being carried around curve providing an adequate lubrication to protect the curve. The gauge face of the rail should be smooth in texture and display good coverage of the lubricant.	
Observe for excessive curve wear; such as shiny wear marks on the gauge face.	
Look for steel shavings along the rail foot.	

Plunger and blade settings are given in Table A 3.

Table A 3: Plunger and blade settings

SETTING	P&M	RTE25
Plunger height (above top of rail head) (see notes)	1 – 3 mm	2 – 3 mm
Blade height (below top of rail head)	20 – 23 mm	15 – 20 mm

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 must be reduced.

Appendix C – 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 WIDTH (MM)	HEAD HEIGHT (MM)													
	37	**36**	**35**	**34**	**33**	**32**	**31**	**30**	**29**	**28**	**27**	**26**	**25**	**24**
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 WIDTH (MM)	HEAD HEIGHT (MM)																				
	40	**39**	**38**	**37**	**36**	**35**	**34**	**33**	**32**	**31**	**30**	**29**	**28**	**27**	**26**	**25**	**24**	**23**	**22**	**21**
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			

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