Rail

Section 1

Applicability

ARTC Network Wide  SMS

Publication Requirement

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Primary Source

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<td>01 Jun 20</td>
<td>Standards</td>
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Amendment Record

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<td>Updated content for lubrication.</td>
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This ARTC CoP has drawn on the Rail Industry Safety and Standards Board (RISSB) National Code of Practice Volume 4, Track and Civil Infrastructure, but is not identical. The ARTC CoP has been subject to Risk Assessment as required by the Office of the National Rail Safety Regulator (ONRSR). The results of these risk assessments have made it necessary to deviate from the RISSB CoP in some areas. ARTC maintains traceability of the differences.
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1 Section 1: Rail

1.1 Design and Rating

1.1.1 Rail Grades

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

Table 1.1A - Rail Size Selection

<table>
<thead>
<tr>
<th>Track classification</th>
<th>Rail size (kg/m) [see note 1]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Existing track</td>
</tr>
<tr>
<td>Heavy Haul [see note 6]</td>
<td>60 HH</td>
</tr>
<tr>
<td>Interstate Lines [see note 5]</td>
<td>47/53/60 [see note 2]</td>
</tr>
<tr>
<td>Main Intrastate Lines</td>
<td>47</td>
</tr>
<tr>
<td>Light Weight Intrastate Lines</td>
<td>40 [see note 3]</td>
</tr>
</tbody>
</table>

Notes:

1. Rail sizes other than those specified in Table 1.1A may be used subject to demonstration, through appropriate analysis or testing that they are suitable for the operational task. Rail wear limits for these alternative rail sizes should be determined during this process.

2. Use of 47 kg/m rail under these operating conditions may require higher levels of maintenance, particularly where rail and weld geometry are not of good quality.

3. Most 40kg/m rail types have the same foot size as 50kg/m rail.

4. It is normal practice to provide CWR in Heavy Haul and Interstate Lines, and Intrastate Lines and Relief Lines, but not on Light Weight Intrastate Lines.

5. Head hardened rail may be desirable in other lines for tight curves or other areas showing excessive rail wear such as steep grades, areas of heavy braking and any tracks subject to 25TAL

6. Standard Carbon rail may be more economical for Heavy Haul tracks <20MGT and with curvature >500m radius
1.1.2 Rail wear

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 1.2A 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 1.2A is designed to ensure that appropriate risk-based mitigation controls, as detailed in clause 1.4.10, 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.

| New or existing rail as per table 1.1.A | Risk control head loss limits reached; |
| Rail size suiting track type, axle load, speed & capacity as per Route Access Standard | • Monitor locations |
| | • Manage as per clause 1.4.10 |
| | • Ensure Re-rail work is planned |
| | This stage should be fully forecast |
| If Wear limits have been exceeded; | |
| | • Apply mandatory response as per clause 1.4.10 |
| Rerail should occur before this stage is reached |
For both Tables 1.2A and 1.2B 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 1.2A – Rail Wear Limits**

<table>
<thead>
<tr>
<th>Axle Loads</th>
<th>Rail Type (AS)</th>
<th>Risk Control Limits</th>
<th>Absolute Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>% Loss of Head Area</td>
<td>Top Wear Only</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If Side wear &lt;10mm</td>
<td>Remaining Height Limit (mm)</td>
</tr>
<tr>
<td>≤ 25 TAL</td>
<td>47kg/m (94lb)</td>
<td>32% 32%</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>50kg/m</td>
<td>45% 32%</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>53kg/m (107lb)</td>
<td>35% 35%</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>60kg/m</td>
<td>45% 40%</td>
<td>20</td>
</tr>
<tr>
<td>Heavy Haul &gt; 25 TAL (see note 3)</td>
<td>50kg/m</td>
<td>45% 32%</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>53kg/m (107lb)</td>
<td>35% 32%</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>60kg/m</td>
<td>45% 34%</td>
<td>24</td>
</tr>
</tbody>
</table>

1. The limits listed under ‘Risk Control Limit’ must not be exceeded without first considering the risk control factors as described within clause 1.4.10.

2. If it can be shown that all risk control factors in section 1.4.10 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.
### 1.1.3 Rail Size Variations

A comprehensive historic list of the maximum allowable rail wear for other potential rail sections is shown in Table 1.2B. When the limits are exceeded actions specified in clause 1.4.10 for ‘Re-rail Limit’ are to be implemented.

The acceptance limits for worn rails being transposed from curves to straights, beyond which the rails are not to be reused, are detailed in columns “C” and “D” in Table 1.3.

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

Dimensions indicate rail head remaining not actual wear.

<table>
<thead>
<tr>
<th>Approx kg/m</th>
<th>Rail Section</th>
<th>Width of new rail Head (mm)</th>
<th>Maximum allowable rail Top Wear - remaining height (mm)</th>
<th>Maximum allowable rail Side Wear - remaining width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>103 AS 1936</td>
<td>70</td>
<td>23</td>
<td>46</td>
</tr>
<tr>
<td>45</td>
<td>90 AS 1928, 90 AS 1925</td>
<td>70</td>
<td>24</td>
<td>49</td>
</tr>
<tr>
<td>45</td>
<td>90 AS 1916</td>
<td>70</td>
<td>24</td>
<td>52</td>
</tr>
<tr>
<td>41</td>
<td>80 J 1913</td>
<td>64</td>
<td>23</td>
<td>46</td>
</tr>
<tr>
<td>41</td>
<td>80 ASB 1928</td>
<td>70</td>
<td>21</td>
<td>52</td>
</tr>
<tr>
<td>41</td>
<td>80 ASA 1928, 80 A 1916</td>
<td>64</td>
<td>21</td>
<td>52</td>
</tr>
<tr>
<td>41</td>
<td>80 AA 1906</td>
<td>64</td>
<td>25</td>
<td>44</td>
</tr>
<tr>
<td>41</td>
<td>80 A 1900</td>
<td>64</td>
<td>24</td>
<td>47</td>
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<tr>
<td>41</td>
<td>80 A(1) 1897</td>
<td>64</td>
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<td>41</td>
<td>80 A(2) 1895</td>
<td>64</td>
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<tr>
<td>41</td>
<td>80 A(3) 1890</td>
<td>64</td>
<td>32</td>
<td>47</td>
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<tr>
<td>39</td>
<td>78 H 1903</td>
<td>70</td>
<td>21</td>
<td>53</td>
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<tr>
<td>37</td>
<td>75 BHP 1917</td>
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<td>36</td>
<td>71 D 1875</td>
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<td>70 AS 1928, 70 AS 1925</td>
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<td>44</td>
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<tr>
<td>35</td>
<td>70lb 1910</td>
<td>60</td>
<td>25</td>
<td>44</td>
</tr>
<tr>
<td>35</td>
<td>60 ASB 1928</td>
<td>64</td>
<td>24</td>
<td>49</td>
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<tr>
<td>31</td>
<td>60 ASA 1928, 60 AS 1916</td>
<td>64</td>
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<td>31</td>
<td>60 BA 1907</td>
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<td>43</td>
</tr>
<tr>
<td>31</td>
<td>60 B 1896</td>
<td>58</td>
<td>26</td>
<td>44</td>
</tr>
<tr>
<td>31</td>
<td>60 B 1890</td>
<td>57</td>
<td>29</td>
<td>43</td>
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</table>
Table 1.3 - Maximum allowable rail wear for all curve worn rail sections to be re-used in tangent track (transposed/cascaded). Dimensions shown indicate rail head remaining not actual wear.

<table>
<thead>
<tr>
<th>Approx. kg/m</th>
<th>Rail Section</th>
<th>Width of new rail Head (mm)</th>
<th>Minimum remaining Width (mm)</th>
<th>Top remaining height (mm)</th>
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<tr>
<td>60</td>
<td>60 AS 1977 1981 HH</td>
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<td>60 AS 1977 1981</td>
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<td>29</td>
</tr>
<tr>
<td>53</td>
<td>53 AS 1977 1981</td>
<td>70</td>
<td>49</td>
<td>26</td>
</tr>
<tr>
<td>53</td>
<td>107 AS 1936 1964</td>
<td>70</td>
<td>49</td>
<td>26</td>
</tr>
<tr>
<td>51</td>
<td>103 AS 1936</td>
<td>70</td>
<td>49</td>
<td>26</td>
</tr>
<tr>
<td>50</td>
<td>50 AS 1977 1981</td>
<td>70</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>50</td>
<td>100 AS 1928</td>
<td>70</td>
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<tr>
<td>50</td>
<td>100 AS 1916</td>
<td>76</td>
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<td>26</td>
</tr>
<tr>
<td>50</td>
<td>100 C 1907</td>
<td>70</td>
<td>51</td>
<td>26</td>
</tr>
<tr>
<td>50</td>
<td>100 C 1901</td>
<td>70</td>
<td>52</td>
<td>27</td>
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<td>47</td>
<td>94 AS 1937</td>
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<td>45</td>
<td>90 AS 1916</td>
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</tr>
<tr>
<td>45</td>
<td>90 J 1913</td>
<td>70</td>
<td>52</td>
<td>27</td>
</tr>
<tr>
<td>41</td>
<td>80 ASB 1928</td>
<td>64</td>
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<td>26</td>
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<td>80 ASA 1928, 80 A 1916</td>
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<td>41</td>
<td>80 A 1900</td>
<td>64</td>
<td>51</td>
<td>27</td>
</tr>
<tr>
<td>41</td>
<td>80 A(1) 1897</td>
<td>64</td>
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</tr>
<tr>
<td>41</td>
<td>80 A(2) 1895</td>
<td>64</td>
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<tr>
<td>41</td>
<td>80 A(3) 1890</td>
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<td>49</td>
<td>33</td>
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<tr>
<td>39</td>
<td>78 H 1903</td>
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<tr>
<td>37</td>
<td>75 BHP 1917</td>
<td>62</td>
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<tr>
<td>36</td>
<td>71 2 D 1875</td>
<td>57</td>
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<td>30</td>
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<tr>
<td>35</td>
<td>70 AS 1928, 70 AS 1925</td>
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</tr>
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<td>35</td>
<td>70 AS 1916</td>
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<td>28</td>
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<tr>
<td>35</td>
<td>70lb 1910</td>
<td>60</td>
<td>48</td>
<td>28</td>
</tr>
</tbody>
</table>
1.1.4 **Rail wear measurement and calculation summary:**

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

<table>
<thead>
<tr>
<th>Rail type</th>
<th>New rail head area (mm(^2))</th>
<th>Full Height (mm) at 16mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>47AS</td>
<td>2548</td>
<td>37</td>
</tr>
<tr>
<td>50AS</td>
<td>2710</td>
<td>39</td>
</tr>
<tr>
<td>53AS</td>
<td>2721</td>
<td>39</td>
</tr>
<tr>
<td>60AS</td>
<td>2999</td>
<td>44</td>
</tr>
</tbody>
</table>

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

1.1.6 **Rail joint method (welded and non-welded)**
Methods of joining rail to provide continuous support include the following:

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

ii. 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..

iii. 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.

1.1.6.1 **Rail welding**

1.1.6.1.1 **Joining rails**
Weld processes for joining rails include the following:

i. Aluminothermic

ii. 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.

1.1.6.1.2 **Rail surface repair**
Recommended types of weld processes for rail surface repair include:

i. Aluminothermic.

ii. Manual Metal Arc.

iii. Metal Inert Gas.

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

1.1.6.2 **Non-welded rail joint**
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.

1.1.6.2.1 Permanent rail joints

i. 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

ii. Joints should be centrally suspended between sleepers.

iii. 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.

iv. 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

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

vi. 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.

vii. 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.

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

1.1.6.2.2 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.

i. Temporary joints shall have a speed restriction of 30km/h or less imposed.

ii. 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.

iii. They shall only be used under the following circumstances:

iv. To permit the passage of trains during work possessions.

v. To plate broken rails or welds including those from rail profile rectification work.

vi. The following temporary joint elements may be used as appropriate:

   a. Clamped straight for vertical breaks

vii. Temporary fishplates (for example bow plates) shall only be used to plate defective rails or welds or as required as a precautionary action.

viii. Temporary fishplates should not remain in place once the weld has broken.

ix. Where electrical bonding is provided for temporary joints in electrically circuited areas it shall be installed such that it fails if the temporary joint fails. Temporary signal bonding may be used where:

   a. staff are trained by a Signal Engineer in the use of bonds,

   b. bonds are of an approved type and in good condition (tagged etc) and

   c. Approved by signalling staff.

### 1.1.7 Insulated Joints

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

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

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

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

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

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

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

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

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

1.1.8 Rail lubrication

1.1.8.1 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.

1.1.8.2 Strategies to Improve Performance

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

i. 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

ii. 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.

1.1.8.3 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.

1.1.8.4 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.

1.1.8.5 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% 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.

1.1.8.6 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.

1.1.8.7 Statutory Requirements

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

To allow for a managed changeover process from use of mineral based greases to biodegradable greases, the mandated use of only biodegradable greases at all locations will be staged over a 24-month period starting from the publishing date of this standard. Once the transition period has expired the use of only biodegradable greases shall be mandated, with any special exceptions managed by the waiver process if required.
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.

1.1.9 Guard rails

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

a. Guard rail size of AS80lb/yd, CR80lb/yd, AS40kg/m, or AS41kg/m or greater with rail head wear not exceeding 40%, or other equivalent sections. Asymmetrical rail sections may be used with the approval of ARTC.

b. Both sides of the track shall be protected, unless the identified hazard is only on one side of the track where a single guard rail may be installed for protection from that hazard.

c. The top of the guard rail shall be at the level of the adjacent running rail surface, or below it by no more than 50 mm.

d. The working face of the guard rail that comes into contact with derailed wheels shall be a minimum of 200mm and a maximum of 380mm from the gauge face of the running rail, and be located to keep derailed wheels on sleeper ends and avoid rolling stock impacts with structures. The maximum clearance is preferable and if a smaller clearance is adopted an effective maintenance regime must be in place for replacing the guard rails, when tamping ballast top bridges, and the rails at the bridge ends.

e. The working face of the splay rail which comes into contact with the derailed wheels should start approximately 600mm from the gauge face of the running rail and be angled towards the running rails to ensure derailed wheels pass the correct side of the guard rail end or vee.

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

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

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

i. Guard rails and guard rail ends shall be fastened to every sleeper. They may be connected directly to timber sleepers with no plates.
j. Guard rail lengths shall be joined using four-hole fish plated joints as a minimum or their equivalent with at least two bolts on each side. No joints are permitted in the vee.

k. The guard rail end design is to;

l. be flared away from the running rails;

m. 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.

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

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

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

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

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

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

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

u. For special installations, such as where noise and vibration limiting track fixings are used or where expansion joints exist, specific design details of guard rail installations to suit will be required. Approved track fixings are to be used. The design is to be certified by a person with appropriate competencies for approving track design.

1.1.10 Junction Rails

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

- 60 kg/m to 50 kg/m;
- 60 kg/m to 53 kg/m;
- 53 kg/m to 50 kg/m;
- 53 kg/m to 47 kg/m;
- 47 kg/m to 50 kg/m;
- 47 kg/m to 41 kg/m.
1.2 Construction and Maintenance

1.2.1 Rail materials

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

1.2.1.1 New rail

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

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

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

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

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

1.2.1.2 Closure rails

Closure rails should conform with the criteria in Table 1.5

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

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

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

iii. Rails that are satisfactory for re-use should be marked with a white stripe

1.2.1.3 Part worn rail

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

Rails that are unsuitable for re-use should be cut into lengths no longer than 2m and marked as such.

1.2.2 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:

i. Ineffective pads shall be replaced

ii. The rail seat shall be cleared of all ballast

iii. Ineffective spacers shall be replaced

iv. 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.

1.2.3 Rail welding processes

Guidelines for rail welding processes are as follows:

1.2.3.1 Flash but welding

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

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

i. 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.

ii. 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 grade formulation is from the same supplier and does not vary for either rail type SC or HH.

iii. 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 flash butt 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.

1.2.3.1 Mobile flash butt 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.

1.2.3.2 Quality

The contractor shall have in place a quality system accepted by ARTC. A system conforming to AS 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 Flash Butt 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, see Figure 1.1 below.
1.2.3.2 **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 1.7.

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

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

1.2.3.3 **Manual Metal Arc or Metal Inert Gas Welding**

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

These welding processes shall not be used for joining rail.
<table>
<thead>
<tr>
<th>Factor</th>
<th>Specification</th>
<th>Method of Test</th>
<th>Frequency / Timing of Test</th>
<th>Method of Assessment</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defects in rails and welds</td>
<td>Defects shall be identified and classified as detailed in Clauses 1.4.7, 1.4.7, 1.4.9</td>
<td>Refer Clause 1.4</td>
<td>Ultrasonic testing as required by Figure 1.2</td>
<td>Refer Clauses 1.4.7, 1.4.8, 1.4.9</td>
<td>Rail to be free of internal and surface defects including squats and wheel burns</td>
</tr>
<tr>
<td>Wear limits</td>
<td>Refer Clause 1.1.2</td>
<td>Gauge or measurement of wear</td>
<td>Once only prior to unrestricted service</td>
<td>Refer Clause 1.4.10</td>
<td></td>
</tr>
<tr>
<td>Metallurgical properties</td>
<td>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. Otherwise for each rail type determine suitability in terms of: Ultimate yield strength, Chemical composition, Inclusions, Impact resistance, Hardness, Microstructure</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Review by metallurgist competent in rail examination/testing/evaluation</td>
</tr>
<tr>
<td>Location of bolt holes in rail to be welded</td>
<td>The distance from the edge of the bolt hole to the rail end shall be no less than 65 mm</td>
<td>Direct measurement</td>
<td>Once only prior to welding</td>
<td>Compare with the Specification</td>
<td>Distances less than 65 mm may cause masking of weld defects during ultrasonic testing and poor heat distribution during welding</td>
</tr>
<tr>
<td>Factor</td>
<td>Specification</td>
<td>Method of Test</td>
<td>Frequency / Timing of Test</td>
<td>Method of Assessment</td>
<td>Comments</td>
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</tbody>
</table>
| Adjacent welds                 | Welds shall be no closer than 4 m from the next weld or the end of a rail. | Direct measurement     | Once only prior to welding | Compare with the Specification | Longer lengths of closure rails and insulated joints are often used to improve the geometric quality of the final weld/rail surface and reduce track maintenance. In turnouts aluminothermic welds may be placed closer than 2.2 m to a minimum of 1.2 m to a flashbutt weld, aluminothermic weld or rail joint (mechanical or glued) provided that:  
  - The flashbutt weld or joint is ultrasonically tested and no defects are found  
  - The rail length is well secured by two ties with the ties held by more than two rails such that they will not skew if the rail breaks in two places. |
<p>| Adjacent non welded joints     | Joints shall be no closer than 6 m. Not to be applied retrospectively, in points and crossings and in tracks with loose rail. | Direct measurement     | Once only prior to installation | Compare with the Specification | Special consideration should be given in turnouts where shorter lengths may be necessary. |
| Rail end straightness          | The rail end straightness shall be limited to that which permits the final weld or mechanical joint to comply with Clause 1.3.4 on rail discontinuities. | Direct measurement     |                           | Compare with the Specification | Care should be taken with rail end straightness due to excess loading on the fastenings, sleepers and rail in service. |
| Rail Twist                     |                                                                               |                         |                           |                      | Care should be taken with twist and other rail distortions that may induce excess loading on the fastenings and sleepers, gauge variation and eccentric loading of the rail in service. |
| Discontinuities                | Refer Clause 1.3.4                                                           | Refer Clause 1.3.4      | 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). |</p>
<table>
<thead>
<tr>
<th>Factor</th>
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<th>Method of Test</th>
<th>Frequency / Timing of Test</th>
<th>Method of Assessment</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gauge face angle</td>
<td>Refer Clause 1.4.10.2</td>
<td>Gauge or profile measurement</td>
<td>Once only prior to use</td>
<td>Compare with the Specification</td>
<td></td>
</tr>
<tr>
<td>Closure rail length</td>
<td>Closure rails shall be a minimum length of 4 metres</td>
<td>Direct measurement</td>
<td>Once only prior to use</td>
<td>Compare with the specification</td>
<td></td>
</tr>
<tr>
<td>Matching profiles</td>
<td>Closure rail head profiles shall be compatible with the rail head profile of the rail to be removed.</td>
<td>Direct measurement</td>
<td>Once only prior to use</td>
<td>Compare with the specification</td>
<td>Prevention of rail misalignments into the track.</td>
</tr>
<tr>
<td>Corrosion</td>
<td>No corrosion causing loss of section of discontinues</td>
<td>Direct measurement</td>
<td>Once only prior to use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rail Head Condition</td>
<td>No end batter present No crushed or laminated head</td>
<td>Visual</td>
<td>Once only prior to use</td>
<td>End batter must be cut off</td>
<td></td>
</tr>
</tbody>
</table>
### Table 1.6 – Flashbutt Welding – Process

<table>
<thead>
<tr>
<th>Factor</th>
<th>Specification</th>
<th>Method of Test</th>
<th>Frequency / Timing of test</th>
<th>Method of Assessment</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding practices</td>
<td>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</td>
<td>Weld completion report by welder certifying conformance with specification. Visual observation of welding process. Check graph or meter</td>
<td>Every weld immediately after completion</td>
<td>Against specification</td>
<td>When a process non-conformance is identified possible corrective actions include: • Stop welding • Reassess process • Readjust settings • Rework</td>
</tr>
<tr>
<td>Worker competency and training</td>
<td>Welder to be competent and hold current certification in flashbutt welding</td>
<td>Audit of welder competency.</td>
<td>Welders shall be recertified at least every two years. More frequent assessment may be necessary where evidence of non-conformance is identified.</td>
<td>Competency assessment against specification</td>
<td>Retraining of welder or withdraw certification.</td>
</tr>
<tr>
<td>Post weld testing [see note 1]</td>
<td>External visual inspection. Refer to Clauses 1.4.7 (Rail and welded joints) and 1.3.4 (Rail discontinuities)</td>
<td>Visual: Weld certification that the weld has been visually inspected and no recordable defects have been found</td>
<td>Every weld immediately after welding</td>
<td>As specified in Clauses 1.4.7 and 1.3.4</td>
<td>As specified in Clauses 1.4.7 and 1.3.4</td>
</tr>
<tr>
<td></td>
<td>Internal inspection as specified in Clause 1.4.7 (Rail and welded joints)</td>
<td>Ultrasonic testing: Weld certification that correct practices and equipment have been used and that no recordable defects have been found</td>
<td>Every weld at production or within 90 days of installation into track</td>
<td>As specified in Clause 1.4.7</td>
<td>As specified in Clause 1.4.7</td>
</tr>
</tbody>
</table>

**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>
<thead>
<tr>
<th>Factor</th>
<th>Specification</th>
<th>Method of test</th>
<th>Frequency / Timing of test</th>
<th>Method of assessment</th>
<th>Corrective actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding practices</td>
<td>Manufacturer’s method or other method approved by ARTC</td>
<td>Weld completion report by welder certifying conformance with specification. Visual observation of welding process.</td>
<td>Every weld immediately after welding</td>
<td>Against specification</td>
<td>When a process non-conformance is identified possible corrective actions include:</td>
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<td></td>
<td>• Stop welding</td>
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<td></td>
<td>• Reassess process</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>• Rework</td>
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<tr>
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<td>Audit of welder competency</td>
<td>Welders shall be recertified at least every two years. More frequent assessment may be necessary where evidence of non-conformance is identified.</td>
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</tr>
<tr>
<td>Post weld testing</td>
<td>External visual inspection. Refer to Clauses 1.4.7 (Rail and welded joints) and 1.3.4 (Rail discontinuities)</td>
<td>Visual: Weld certification that the weld has been cleaned of mould material then visually inspected and no recordable defects have been found</td>
<td>Every weld prior to unrestricted traffic immediately after welding</td>
<td>As specified in Clauses 1.4.7 and 1.3.4</td>
<td>As specified in Clauses 1.4.7 and 1.3.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Inspection as specified in Clause 1.4.7 (Rail and welded joints)</td>
<td>Ultrasonic Testing: Weld certification that correct practices and equipment have been used and that no recordable defects have been found</td>
<td>Welds to be tested ultrasonically within the timeframe specified in ARTC standard ETE-01-03</td>
<td>As specified in Clause 1.4.7</td>
<td>As specified in Clause 1.4.7</td>
<td></td>
</tr>
</tbody>
</table>
### Table 1.8 – Manual Metal Arc and MIG Repair Welds - Process

<table>
<thead>
<tr>
<th>Factor</th>
<th>Specification</th>
<th>Method of test</th>
<th>Frequency / Timing of test</th>
<th>Method of assessment</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>All materials shall be supplied to Australian Standard or equivalent to owner's specification</td>
<td>As per owner's standard</td>
<td>Prior to use</td>
<td>Against the specification</td>
<td>As necessary</td>
</tr>
<tr>
<td>Welding practices</td>
<td>Owner’s practices for surface preparation and weld process</td>
<td>Weld completion report by welder certifying conformance with specification</td>
<td>Every weld immediately after welding</td>
<td>Against specification</td>
<td>Stop the use of the welding procedure. Reassess Process.</td>
</tr>
<tr>
<td>Worker competency and training</td>
<td>Welders shall be assessed as competent. Dependant on the risk this may necessitate certification similar to that under AS 1554 for special purpose welding</td>
<td>Audit of welder competency</td>
<td>Welders shall be recertified at least every two years.</td>
<td>Competency assessment against specification</td>
<td>Retraining of welder or withdraw certification.</td>
</tr>
<tr>
<td>Post weld testing</td>
<td>External visual inspection. Refer to Clauses 1.4.7 (Rail and welded joint) and 1.3.4 (Rail discontinuities). 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.</td>
<td>Visual: Weld certification that the weld has been visually inspected and no recordable defects have been found 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.</td>
<td>Immediately after all welds</td>
<td>As specified in Clauses 1.4.7 and 1.3.4</td>
<td>As specified in Clauses 1.4.7 and 1.3.4</td>
</tr>
</tbody>
</table>
Figure 1.2 – Rail Acceptance: Ultrasonic Test Flow Diagram

START

Is the ultrasonic test history of the rail known?

NO

Test rail prior to unrestricted traffic

YES

Has the rail been ultrasonically examined?

NO

Test rail prior to unrestricted traffic

YES

Has the test been tested within time specified in Technical Maintenance Plan?

NO

Test rail prior to unrestricted traffic

YES

OK, no test required
1.2.4 Repair of defective rails and welds

Repair of defective rails and welds shall be carried out in accordance with Table 1.9. Defective rails removed from track shall be immediately rendered unsuitable for reuse. When a defect is to be removed consideration should be given to removal of any other identified rail and weld defects in the vicinity.

Table 1.9 – Rail and Weld Repair Guidelines

<table>
<thead>
<tr>
<th>DEFECT [2]</th>
<th>COMMENT ON ACTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt hole (crack, elongation or non-conforming)</td>
<td>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.</td>
</tr>
<tr>
<td>Broken foot</td>
<td>Defects shall be cut out and replaced by a closure rail.</td>
</tr>
<tr>
<td>Broken rail</td>
<td>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.</td>
</tr>
<tr>
<td>Corroded rail</td>
<td>The defective portion of rail should be replaced.</td>
</tr>
<tr>
<td>Foot/web separation and head/web separation</td>
<td>Repairs shall be carried out by replacing the complete rail between welds unless the rail has been examined in detail by manual ultrasonic examination.</td>
</tr>
<tr>
<td>Horizontal split (head or web)</td>
<td>Repairs shall be carried out by replacing the complete rail between welds, unless the rail has been examined in detail by manual ultrasonic examination.</td>
</tr>
<tr>
<td>Mechanical joint</td>
<td>The necessary repair shall be determined by a competent worker.</td>
</tr>
<tr>
<td>Mill defect</td>
<td>Repair is not normally required until growth is detected. The defect should then be reclassified according to the nature of propagation or failure.</td>
</tr>
<tr>
<td>Multiple transverse defects</td>
<td>Repairs shall be carried out by replacing the complete rail between welds, unless the rail has been inspected in detail by manual ultrasonic examination. The rail removed should be immediately rendered unsuitable for reuse.</td>
</tr>
<tr>
<td>Notches</td>
<td>Defects shall be cut out and the rail welded or replaced by a closure rail.</td>
</tr>
<tr>
<td>Unclassified Defect</td>
<td>The necessary repair shall be determined by a competent worker.</td>
</tr>
<tr>
<td>Piped Rail</td>
<td>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.</td>
</tr>
<tr>
<td>Rail surface (e.g. rolling contact fatigue)</td>
<td>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.</td>
</tr>
<tr>
<td>Shatter Crack</td>
<td>Repairs shall be carried out by replacing the complete rail between welds, unless the rail has been inspected in detail by manual ultrasonic examination. The rail removed should be immediately rendered unsuitable for reuse.</td>
</tr>
<tr>
<td>Transverse Defect (including those from shells or wheel burns)</td>
<td>The defect shall be removed, and the rail restored by welding.</td>
</tr>
<tr>
<td>Vertical Split (head or web)</td>
<td>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.</td>
</tr>
<tr>
<td>Weld defect (head, web or foot)</td>
<td>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.</td>
</tr>
<tr>
<td>Weld defect: surface (e.g. gas hole, hot tear, shrinkage, porosity)</td>
<td>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.</td>
</tr>
<tr>
<td>Weld defect: repairs of surface defects</td>
<td>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.</td>
</tr>
<tr>
<td>Wheel burn</td>
<td>Defects shall be repaired by repair welding or replaced by a closure rail. Small wheel burns may be ground out.</td>
</tr>
</tbody>
</table>
1.2.5 Cutting of rail

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

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

Rail ends in insulated joints shall comply with AS 1085.12. The cut shall be in a vertical plane and in the plan-view may be at an angle as specified in clause 1.1.7

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:

i. In emergencies (refer Standard for rail – monitoring and maintenance)

ii. 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:

i. 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

ii. 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

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

iv. 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.

1.2.6 Drilling holes in rail

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

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

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

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

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

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.
1.2.7 Stress control—maintenance of the existing rail stress condition

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

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

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

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

Comparison of these two measurements shall be within 2 mm.

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

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

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

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

   i. New or recycled rail is being laid into track.
   ii. A stress check is being carried out.
   iii. The rail stress is suspect, for example due to the presence of any;
      a. buckle;
      b. break-away / pull-apart;
      c. mechanical joint failure; or
      d. significant rail creep.
   iv. Significant changes in track alignment.
   v. The rail was cut, and practices described in Clause 1.2.7 were not used

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

This section covers:

a. Minimum geometry tolerances for the rail running surface in new finished welds.

b. How these tolerances should be measured.

c. The corrective action that shall be taken if the weld geometry does not comply with the standard.

### 1.3.1 General

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

#### 1.3.1.1 Weld finish standards and testing apply to welds formed during:

a. Laying rail in track,

b. Production of rail lengths for installation, and

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

#### 1.3.1.2 Recycled Rail – Sidings

Recycled rail intended for use in sidings shall be visually examined for corrosion, external defects, cracking, or excessive wear.

Bolt holes must be a minimum of 65 mm clear of any weld.

#### 1.3.1.3 Junctions and step-welds

Rails of dissimilar section (either by weight, design or wear) can usually be welded together using the Thermit SKV or SMW-f process and correct junction rails. The correct approved junctions shall be used.

#### 1.3.1.4 Ultrasonic testing prior to welding

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.

#### 1.3.1.5 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. Welds must be assessed in accordance with ETN-01-06 Weld Quality Management Manual.

### 1.3.2 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).

### 1.3.3 Weld Measurements

#### 1.3.3.1 Vertical Alignment of Weld Collars

Vertical alignment of welds should be checked post-weld see Figure 1.3, to ensure the weld collar is vertically aligned.
Vertical misalignment of the weld collar is due to misaligned moulds which do not allow preheating to occur evenly and it causes poor heat distribution in the weld, which is critical to ensure good fusion across the weld face. Poor alignment can lead to lack of fusion, cold laps, and in extreme cases, shrinkage defects. Figure 1.4 and Figure 1.5 show failed welds as a result of poor alignment of welds on ARTC tracks.
Moulds should be aligned to achieve vertically aligned weld collars that are within a recommended range of ± 2mm perpendicular to the rail. The collar vertical alignment must be measured using either a square and steel rule or weld collar alignment gauge before leaving site.

Vertical misalignment of welds shall not exceed 4mm from vertical. Any new welds exceeding vertical alignment criteria are to be removed within 28 days.

1.3.3.2 Standards of semi-finished rail 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 1.10) 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>
<thead>
<tr>
<th>Factor</th>
<th>Standard for semi-finished state</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak in running surface</td>
<td>+0.8 to +1.2 mm over 1 metre (about 1 mm preferred)</td>
</tr>
<tr>
<td>Dip in running surface</td>
<td>Strictly no dip allowed</td>
</tr>
<tr>
<td>Gauge widening due to change in rail</td>
<td>0.5 mm max (less preferred)</td>
</tr>
<tr>
<td>Gauge narrowing due to change in rail</td>
<td>0.5 mm max (less preferred)</td>
</tr>
<tr>
<td>Vertical deviation in rail running surface (ramp angle)</td>
<td>Approximately 7 milliradians over 50 mm base</td>
</tr>
</tbody>
</table>
1.3.4 Standards of finished rail welds

Minimum standards for rail running surface of new finished welds are given in Table 1.11.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Limits</th>
<th>Method of test</th>
<th>Corrective action to achieve tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak in running surface</td>
<td>+0.0 mm to +0.3 mm over 1m, absolute max peak 0.5mm</td>
<td>1 m reference and height difference measure</td>
<td>Remove or grind</td>
</tr>
<tr>
<td>Dip in running surface</td>
<td>Nil</td>
<td>1 m reference and height difference measure</td>
<td>Remove or lift</td>
</tr>
<tr>
<td>Gauge widening due to change in rail</td>
<td>0.5 mm over 1 m</td>
<td>1 m reference and height difference measure</td>
<td>Remove or bend</td>
</tr>
<tr>
<td>Gauge narrowing due to change in rail</td>
<td>0.5 mm over 1 m</td>
<td>1 m reference and height difference measure</td>
<td>Remove or grind</td>
</tr>
<tr>
<td>Vertical deviation in rail running surface (ramp angle)</td>
<td>7 milliradians or ±0.35 mm over 50 mm</td>
<td>Measured with dipped weld (P1) gauge or electronic straightedge over 1m.</td>
<td>Remove or grind</td>
</tr>
<tr>
<td>Vertical step in rail running surface</td>
<td>±0.15 mm over 100 mm</td>
<td>100 mm reference and height difference measure</td>
<td>Remove or grind</td>
</tr>
<tr>
<td>Horizontal step in rail running surface</td>
<td>±0.15 mm over 100 mm</td>
<td>100 mm reference and height difference measure</td>
<td>Remove or grind</td>
</tr>
<tr>
<td>Vertical alignment (Weld Collar)</td>
<td>Vertical ± 4mm</td>
<td>Square gauge and steel rule or weld collar alignment gauge</td>
<td>Remove</td>
</tr>
</tbody>
</table>

Notes: * Tolerances are applied only to areas of the rail where wheel contact may occur.

* Limit exceedances are to be reported on the relevant form.

1.3.4.1 Straight Track

On completion of grinding, the top and gauge surfaces must be checked.

The welded rail is to be checked for correct surface straightness and proper alignment, using a 1 metre straight edge (see appendix B for details), or an electronic straight edge, or an alternative straightedge or measuring device.

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, this check is not needed if using an electronic straight edge.

Peak, dip and change in weld ramp angle must comply with the standards in Table 1-10 and be checked with the straightedge or other measuring device across the rail head from the gauge corner to the outside edge of the wheel/rail contact band.
1.3.4.2 Curved Track

The top surface is to be checked as for straight track.

The newly welded portion of the gauge face must have a curvature consistent with the curvature of the existing rail, and the gauge face at the weld must be smooth and continuous.

1.3.4.3 Ramp Angle

The critical factor in the rail surface limits is the ramp angle Figure 1.6 measured with a dipped weld gauge (P1) over 50 mm or an electronic straight edge, over the full extent of grinding of the weld.

![Ramp angle equivalence](image)

Figure 1.6: Ramp angle equivalence to 7mr

There may be occasions where peak and dip are within tolerance but the change in ramp angle recorded by a P1 gauge may be outside the permitted tolerance. Such a situation is illustrated in Figure 1.7.

![Vertical deviation in rail running surface](image)

Figure 1.7: Vertical deviation in rail running surface (weld ramp angle)

Changes in the weld ramp angle over a small base length must be assessed with a P1 Gauge or electronic straight edge, to determine whether the weld finish meets the requirements for ramp angle.

1.3.4.4 1-Metre Straight Edge

Required measurements should be taken with a metric taper gauge, feeler gauge or electronic measuring system.

The peak must be checked with the centre of the straightedge positioned at the point of maximum peak. This will usually be at the weld but may be at some point in the area subject to grinding (refer to Figure 1.8 and Figure 1.9).
Both lugs of the ARTC Finishing Straightedge must touch rail

500 mm from point of max. peak

Gap to be between 0 & 0.5 mm

1 m Modified Straight Edge

Figure 1.8: Weld misalignment tolerance in vertical plane (peaking)

500 mm from point of max. peak

No dip permitted

1 m Modified Straight Edge

Figure 1.9: Weld misalignment tolerance in vertical plane (dip)

Note: In some cases, it may be necessary to extend grinding beyond the extent shown on Figure 1.8 and Figure 1.9, when there are nearby variations in rail geometry which are non-compliant with the standards specified in Table 1.11. The standards specified in Table 1.11 must be achieved over the entire area in the vicinity of the weld.

1.3.4.5 Electronic Straight Edges

Electronic straight edge provides a higher level of accuracy and consistent measurements, see Figure 1.10 and Figure 1.11. It also creates records that can be used for traceability. Traditional systems were created as a go or no-go setup where welds either pass or fail. The electronic straight edge can provide feedback on the shape and discover areas for improvement where the compliance could be marginal. In addition to this, the mechanical straight edge and P1 ramp angle gauge requires a large amount of user input where this can cause variability in the results.
1.3.5 Limits on Welds Adjacent to Joints and Other Welds

1.3.5.1 Plain Track:

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.

1.3.5.2 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.

1.3.6 Remediation of rail weld geometry tolerance exceedances

Remedial actions in accordance with Table 1.12 are required for all new field weld alignment defects.

Table 1.12: Remedial actions for rail weld geometry tolerance exceedances

<table>
<thead>
<tr>
<th>Defect type</th>
<th>Defect size</th>
<th>Rectify Heavy Haul &amp; Interstate lines within</th>
<th>Rectify Intrastate &amp; Light Weight lines within</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIP WELDS (WTD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small (WTDS)</td>
<td>Dip is greater than zero but less than 0.5 mm</td>
<td>90 days</td>
<td>180 days</td>
</tr>
<tr>
<td>Medium (WTDM)</td>
<td>Dip is equal to or greater than 0.5 mm but less than 1.0 mm</td>
<td>30 days</td>
<td>60 days</td>
</tr>
<tr>
<td>Large (WRDL)</td>
<td>Dip is equal to greater than 1.0 mm</td>
<td>14 days</td>
<td>28 days</td>
</tr>
<tr>
<td>PEAK WELDS (WTP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small (WTPS)</td>
<td>Peak is greater than 0.5 mm but less than 1 mm</td>
<td>90 days</td>
<td>180 days</td>
</tr>
<tr>
<td>Medium (WTPM)</td>
<td>Peak is equal to or greater than 1 mm but less than 2 mm</td>
<td>30 days</td>
<td>60 days</td>
</tr>
<tr>
<td>Large (WTPL)</td>
<td>Peak is equal to or greater than 2 mm</td>
<td>14 days</td>
<td>14 days</td>
</tr>
<tr>
<td>VERTICAL DEVIATION IN RUNNING SURFACE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>7 to 12 milliradians over 50 mm base</td>
<td>90 days</td>
<td>180 days</td>
</tr>
<tr>
<td>Medium</td>
<td>13 to 18 milliradians over 50 mm base</td>
<td>30 days</td>
<td>60 days</td>
</tr>
<tr>
<td>Large</td>
<td>19 milliradians or greater over 50 mm base</td>
<td>14 days</td>
<td>28 days</td>
</tr>
<tr>
<td>GAUGE NARROW (WTGN) OR GAUGE WIDE (WTGW)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small (WTGNS) or (WTGWS)</td>
<td>Narrowing or widening is greater than 0.5 mm but less than 1 mm</td>
<td>90 days</td>
<td>180 days</td>
</tr>
<tr>
<td>Medium (WTGNM) or (WTGWNL)</td>
<td>Narrowing or widening is equal to or greater than 1 mm but less than 2 mm</td>
<td>30 days</td>
<td>60 days</td>
</tr>
<tr>
<td>Large (WTGNL) or (WTGWNL)</td>
<td>Narrowing or widening is equal to or greater than 2 mm</td>
<td>14 days</td>
<td>28 days</td>
</tr>
</tbody>
</table>
1.4 Inspection and Assessment

1.4.1 Scheduled rail and welded joint inspection

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

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
- 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 visual inspection shall be carried out;

a. for all new welds (see Tables 1.6, 1.7 and 1.8); and
b. where the response following detection of a rail or weld defect is ‘observe’.

1.4.1.3 Detailed inspection

Detailed inspection should be carried out as follows:

a. 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.

b. Manual ultrasonic testing

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

- At new aluminothermic and flash butt welds.
- To confirm suspected defects indicated by the continuous ultrasonic inspection.
- Where there are suspected defects as found by visual inspection.
- When known defects are due to be reinspected and reassessed.

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

- AS 2083 for calibration of equipment.
- AS 1085.15 for weld test procedure

c. 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 1.11.
- Documentation
- The following documentation relating to rail and weld defects shall be maintained:
  - Rail tonnages over nominal track sections.
  - Specifications or work instructions for ultrasonic testing.
  - Defective rail/weld report.
  - Defect listing and status.

1.4.2 Scheduled non-welded joint inspection

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

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:

- Broken, missing or loose bolts.
- Worn, cracked or broken plates.
- Metal flow across joint.
- Vertical deformation or pumping joints.
- Rail end batter.
- Excessive joint gap which may indicate elongated bolt holes or bent bolts.
- Not working as a sliding joint to accommodate designed rail movement
- Insulation breakdown.
- Track circuit bond wire damage.
- 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 'observe'.

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

- Cracked and broken plates.
- Pumping joints.
- Excessive joint gap which may indicate elongated bolt holes or bent bolts.
- Worn fishplates.
- Frozen joints.
- Other defects or missing components.

1.4.2.3 Detailed inspection

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

1.4.3 Scheduled rail wear inspection

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 corrosions during track patrols. The examination should preferably be carried out on a wet day to confirm the location of water ingress into the tunnel.

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

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

Where there is a reduction in rail size in the foot or web measurements should be taken at a maximum spacing of 20 metres with the results reported on the appropriate form. The original and allowable limits for 53kg/m and 60 kg/m are shown on the form. Care should be taken to ensure the worst dimensions in the area are recorded.

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

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

1.4.3.4 Electronic measurement of rail wear

Any electronic measurements must meet the following requirements:

i. Top wear must be measured in the vertical plane in the centre of the head to an accuracy of 0.5mm
ii. Side wear must be measured laterally 16mm from the running surface to an accuracy of 0.5mm

iii. Head loss must be measured as the loss of head area as a percentage of the original area to an accuracy of 2%

iv. 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:

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

ii. Obvious over or under lubrication;
   a. 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).
   b. Combinations of top-lubrication, flange-lubrication and dry rail are variously applied for specific purposes at individual locations.

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

iv. Other obvious unusual conditions.

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

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:

- Carry of lubrication
- Optimisation of rail wear
- Minimisation of wheel squeal
- Obvious damaged or loose components
• Blade height and conditions
• Plunger settings and operation
• Filler valve condition
• Grease leakages
• 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:
• Visual inspection
• Tribometer
• 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 A – Lubricators: Removal, Re-installation and Servicing

1.4.5 Scheduled guard rail inspection
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:
• Missing or ineffective rail/sleeper fastenings.
• Lack of guard rail continuity.
• 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

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

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

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

1.4.7 Rail and welded joint assessment

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

1.4.8 Rail discontinuities assessment

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

i. Running surface discontinuities in welded rails

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

The limits given are recommended limits only for existing welded track and are not recommended for normal track construction and upgrading work (refer to Clause 1.3.4). The limits are not intended to indicate best practice as discontinuities of the magnitude defined in Table 1.15 may lead to a need for a significantly higher maintenance input than track with good rail geometry.

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

Table 1.15 – Welded Rail Discontinuities (Maintenance)

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

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

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

<table>
<thead>
<tr>
<th>Gap</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 30 mm</td>
<td>Train operation at reduced speed appropriate to assessed track conditions.</td>
</tr>
<tr>
<td>&gt; 30 mm and &lt; 100 mm</td>
<td>Pilot trains across the gap</td>
</tr>
<tr>
<td>&gt; 100 mm</td>
<td>Stop traffic</td>
</tr>
</tbody>
</table>

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.
1.4.9 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 1.16. The actions for response codes for A1 to A7 are shown in table 1.16A.

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

<table>
<thead>
<tr>
<th>Component Parameter</th>
<th>Dimension Limit</th>
<th>Track Speed (freight/passenger) km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20/20</td>
</tr>
<tr>
<td><strong>Fishplates</strong> [1]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual cracks</td>
<td>1 or both plates</td>
<td>A6</td>
</tr>
<tr>
<td>Complete failure</td>
<td>1 fishplate</td>
<td>A4</td>
</tr>
<tr>
<td></td>
<td>Both fishplates</td>
<td>A1</td>
</tr>
<tr>
<td><strong>Fishbolts</strong> [2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective</td>
<td>≥ 2 on both rail ends</td>
<td>A7</td>
</tr>
<tr>
<td></td>
<td>1 only on either rail end</td>
<td>A6</td>
</tr>
<tr>
<td></td>
<td>Nil on one rail end [3]</td>
<td>A2</td>
</tr>
<tr>
<td></td>
<td>Nil on both rail ends [3]</td>
<td>A1</td>
</tr>
<tr>
<td><strong>Insulated Joints</strong> [4]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation material</td>
<td>Defective</td>
<td>A6</td>
</tr>
<tr>
<td>Gap between rail ends</td>
<td>≥ 4mm</td>
<td>A7</td>
</tr>
<tr>
<td></td>
<td>&lt; 4mm</td>
<td>A6</td>
</tr>
<tr>
<td><strong>Rail Ends</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batter</td>
<td>&gt; 2mm for over 100mm</td>
<td>A6</td>
</tr>
<tr>
<td></td>
<td>≤ 20mm</td>
<td>A7</td>
</tr>
<tr>
<td></td>
<td>21mm to 30mm</td>
<td>A6</td>
</tr>
<tr>
<td>Rail end mismatch</td>
<td>&gt; 3mm [5]</td>
<td>A2</td>
</tr>
<tr>
<td>misalignment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rail defects</td>
<td>Surface or internal defects</td>
<td>In accordance with Clause 1.4.8</td>
</tr>
</tbody>
</table>

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

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 1.16A is permitted with appropriate documentation and approval by the Civil Engineering Representative or nominate representative.

### 1.4.10 Rail wear assessment

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

#### 1.4.10.1 Rail wear

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

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

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

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

Compulsory actions:

i. 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).

ii. 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:

i. 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.

ii. 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.

iii. 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 Grind Standard for Plain Track.

iv. Apply temporary speed restrictions, depending on operating conditions and other risk factors it may be desirable to introduce a speed restriction to minimise general risks and to reduce ongoing dynamic impact (dip/peaks/corrugation) levels until re-railing occurs. This would be of
particular use in locations where other measures are impractical to achieve at acceptable costs until re-rail can be completed. Note that low legs of curves with heavy wear may not benefit from speed restriction as the wheel loads will be increased due to superelevation.

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

As the rail wear approaches the Re-rail Limit dimensions, clearly the risk levels and associated control actions need to be reviewed and potentially made more stringent. Lines with very high traffic (greater than 20 MGT) rates may need special wear management regimes to give early prediction of risk control or re-rail locations so they are identified in time to enable the specified actions within this clause. Curves with tight radius approximately <300m may also require re-rail planning much earlier than the specified re-rail limits due to very fast rates of wear.

**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.

### 1.4.10.2 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 1.17 until they are removed.
<table>
<thead>
<tr>
<th>Defect Name (Type Code, Position Code)</th>
<th>Response time</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleeper fastenings missing or ineffective [1]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolated (non-effective) fasteners missing or ineffective on either side of the guard rail</td>
<td>—</td>
<td>No action</td>
</tr>
<tr>
<td>2 or more consecutive fasteners missing or ineffective on either side of the guard rail</td>
<td>13 Weeks</td>
<td>Replace or restore to specification</td>
</tr>
<tr>
<td>For splay rails or the ends of guard rails 1 or more fasteners missing or ineffective</td>
<td>13 Weeks</td>
<td>Replace or restore to specification</td>
</tr>
<tr>
<td>Component Damage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any damaged components which may render the guard rail ineffective in the event of a derailment</td>
<td>13 Weeks</td>
<td>Damaged guard rail components should be replaced or restored as necessary.</td>
</tr>
<tr>
<td>Rail joint condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ineffective rail joint</td>
<td>13 Weeks</td>
<td>Ineffective joint components should be replaced or restored as necessary.</td>
</tr>
</tbody>
</table>

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

1.5.1 Components Sorted for Reuse, Quarantine or Disposal

All rails should be quarantined until sorted and classified.

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

1.5.1.1 Reuse

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

i. Rail size and length

ii. Amount of wear

1.5.1.2 Quarantine

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

1.5.1.3 Disposal

All non-reusable rail components should be clearly marked and disposed of as soon as practicable after release from the track. Where practical these rails should be cut into lengths less than 2m.
1.6 Appendix A – 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:

i. Loosen the two-pump casting retaining bolts on each side of the anchor block

ii. Lower plungers below top rail head

iii. 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 A1.

Table A1 – Removal and installation of lubricators

<table>
<thead>
<tr>
<th>P&amp;M type lubricators</th>
<th>For bolt on lubricators:</th>
<th>For clamp on lubricators:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Removal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Loosen grease delivery hose clamps and remove grease delivery hose(s) from blade(s).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Remove blade(s) by loosening blade retaining bolts and rail clamps.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Loosen anchor block retaining clamps and rail clamps and withdraw anchor block and main container.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Note: Main container is still attached to the anchor block.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Remove rail clamps from foot of rail.</td>
<td></td>
</tr>
<tr>
<td><strong>Installation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>After rerailing, determine whether the rail size and lubricator components are compatible.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Determine the correct location to fit the lubricator in relation to the curve tangent point on the correct rail.</td>
<td></td>
</tr>
</tbody>
</table>
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 the lubricator and mark the location of the two holes for the main attachment bolts on the web of the rail. | 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 A2.

**Table A2 – Inspection and maintenance of lubricators**

<table>
<thead>
<tr>
<th>Inspection</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main container</strong></td>
<td></td>
</tr>
<tr>
<td>Check the grease status of the main container. Does it need filling?</td>
<td>Fill main container.</td>
</tr>
<tr>
<td>Check main container for signs of damage especially for cracks around bolts holes in back cover.</td>
<td>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.</td>
</tr>
<tr>
<td>Check that filler valve is clean and has cover fitted.</td>
<td></td>
</tr>
<tr>
<td><strong>Pump assembly</strong></td>
<td></td>
</tr>
</tbody>
</table>
### Inspection

<table>
<thead>
<tr>
<th>Inspection</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check plunger condition</td>
<td>Check plunger condition, replace plungers if necessary; if pump not operating replace assembly with exchange service unit.</td>
</tr>
<tr>
<td>Check plunger height above rail.</td>
<td>Check plunger heights and adjust as required.</td>
</tr>
<tr>
<td></td>
<td>Check height of plungers to establish that passing wheels actuate pumps. If plunger height is too low adjust pump casting to obtain correct height.</td>
</tr>
<tr>
<td>Activate plungers to ensure grease is being delivered to blade.</td>
<td>Activate plungers to ensure grease is delivered to the greasing plate. This may require the pump to be primed to remove air locks.</td>
</tr>
</tbody>
</table>

### Greasing plate assembly

<table>
<thead>
<tr>
<th>Inspection</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check blade for signs of wear</td>
<td>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</td>
</tr>
<tr>
<td>Check blade height below rail head</td>
<td>Adjust blade height and tighten bolts.</td>
</tr>
<tr>
<td>Observe rail around lubricator greasing plate for excessive grease delivery to the rail head and adjacent track structure.</td>
<td>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.</td>
</tr>
<tr>
<td>Observe rail around lubricator greasing plate for insufficient grease delivery.</td>
<td>Adjust greasing plate height as required.</td>
</tr>
</tbody>
</table>

### General

<table>
<thead>
<tr>
<th>Inspection</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check hoses for obvious damage.</td>
<td>Replace any damaged hoses.</td>
</tr>
<tr>
<td>Check all hoses, blade ends and pumps for grease leakages.</td>
<td>Tighten all rail clamps, hose clamps and bolts.</td>
</tr>
<tr>
<td></td>
<td>Clean waste material from rail and rail lubricator. Wash the Greasing Plate, Anchor Block and Pumps and Main Container.</td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>Observe for excessive curve wear; such as shiny wear marks on the gauge face.</td>
<td></td>
</tr>
<tr>
<td>Look for steel shavings along the rail foot.</td>
<td></td>
</tr>
</tbody>
</table>
Plunger and blade settings are given in A3.

**Table A3 – Plunger and blade settings**

<table>
<thead>
<tr>
<th>Setting</th>
<th>P&amp;M</th>
<th>RTE25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plunger height (above top of rail head) (see notes)</td>
<td>1 – 3 mm</td>
<td>2 – 3 mm</td>
</tr>
<tr>
<td>Blade height (below top of rail head)</td>
<td>20 – 23 mm</td>
<td>15 – 20 mm</td>
</tr>
</tbody>
</table>

**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.
1.7 Appendix B – ARTC Finishing Straightedge

ARTC FINISHING STRAIGHTEDGE

NOTES:
1. To be made from 4mm to 6mm steel plate.
2. All gauge faces to be flat to 0.05mm tolerance.

5mm hole locate centrally (Tolerance +/- 0.2)

See Enlargement A for details

(Enlargement A)