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## Preface

This standard was prepared by the Rail management Development Group, overseen by the RISSB Standing Committee.

## Objective

The objective of this Standard is to assist rail infrastructure managers and other entities responsible for the selection, installation, and maintenance of rail by providing fundamental principles for rail management.

It is an overarching document that establishes a roadmap to a suite of other AS standards containing details of various lifecycle stages of rail management.

This standard complements the requirements for designing and manufacturing of steel rails given in AS 1085.1 Railway track materials, Part 1: Steel rails. This standard is also part of the AS 7600 series for rail infrastructure.

## Compliance

There are four types of provisions contained within Australian Standards developed by RISSB:

- (a) Requirements.
- (b) Recommendations.
- (c) Permissions.
- (d) Constraints.

**Requirements** – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term ‘shall’.

**Recommendations** – do not mention or exclude other possibilities but do offer the one that is preferred.

Recommendations are identified within the text by the term ‘should’.

Recommendations recognize that there could be limitations to the universal application of the control, i.e. the identified control is not able to be applied or other controls are more appropriate or better.

**Permissions** – conveys consent by providing an allowable option. Permissions are identified within the text by the term ‘may’.

**Constraints** – provided by an external source such as legislation. Constraints are identified within the text by the term ‘must’.

For compliance purposes, where a recommended control is not applied as written in the standard it could be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities or interfacing organisations where the risk may be shared.

RISSB Standards address known hazards within the railway industry. Hazards, and clauses within this Standard that address those hazards, are listed in Appendix A.

**Appendices** in RISSB Standards may be designated either “normative” or “informative”. A “normative” appendix is an integral part of a Standard and compliance with it is a requirement, whereas an “informative” appendix is only for information and guidance.

## Commentary

### Commentary *C Preface*

This Standard includes a commentary on some of the clauses. The commentary directly follows the relevant clause, is designated by 'C' preceding the clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the Standard.

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## 1 Scope and general

---

### 1.1 Scope

This standard establishes general principles for managing rail throughout its lifecycle in track, excluding design and manufacture.

This standard does not cover:

- (a) non-running rail infrastructure such as check rails and guard rails.
- (b) groove head rail
- (c) turnouts and other special works; or
- (d) cane railway and monorail networks.

### 1.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

- AS 1085.1 Railway track materials, Part 1: Steel rails
- AS 1085.2 Railway track material, Part 2: Fishplates
- AS 1085.13 Railway track materials, Part 13: Spring fastening spikes for sleeper plates
- AS 1085.20 Railway track materials, Part 20: Welding of steel rails
- AS 7639 Track structure and support
- AS 7641 Rail gauge corner lubrication management – for friction levels and measurement
- AS 7643 Track stability
- AS 7715 Train detection
- RISSB Wheel rail profile development guideline

NOTE: Documents for informative purposes are listed in a Bibliography at the back of the Standard.

### 1.3 Terms and definitions

For the purposes of this document, the following terms and definitions apply:

#### 1.1.1

##### **rolled rail**

rail that is cooled off in the mill without accelerated cooling and is not subsequently heat treated

#### 1.1.2

##### **foul joint**

misalignment of the running edge or top of rail at a joint

#### 1.1.3

##### **head-hardened rail**

rolled rail in which the head has a hardened zone extending inwards from its top and side surfaces

#### 1.1.4

##### **hardened rail**

rolled rail that has been head-hardened or full section hardened by in-line or offline processes

**1.1.5****insulated rail joint**

a rail joint manufactured from components and assembled such that the joined rails are electrically insulated from each other. An Insulated rail joint is also known as a glued rail joint (GIJ) or insulated joint

**1.1.6****junction rail**

a manufactured or forged closure rail made from at least two rails of differing size for use to join rails of differing size

**1.1.7****rail**

the rolled steel section used to guide wheelsets of rolling stock. The most common rails are vignole head which is the Australian Standard. Rail is described by weight per unit length, i.e. kilograms/metre (kg/m) commonly reduced to kg and pounds per yard (lb/yd) commonly reduced to lb

**1.1.8****rail, control cooled**

the process of controlling the cooling rate of rolled rail to eliminate hydrogen inclusions

**1.1.9****rail integrity**

the requirements that shall be met for rail to be deemed to be fit for purpose and suitable for the railway

**1.1.10****transition rail**

a closure rail used to join two rails usually of the same nominal size but with differing wear profiles

**1.1.11****rail head profile**

the designated cross-sectional dimensions for a given section of rail that is shaped based on its application

**1.1.12****stress free temperature**

the temperature at which the rail in CWR is stress free. If the rail were to be cut, the gap created would remain constant. It would neither close nor would it widen unless the rail temperature was to change. Also referred to as neutral temperature stress

**1.1.13****design neutral temperature**

stress free temperature to which CWR is to be adjusted during stressing. Also referred to as design stress free temperature (DSFT)

General rail industry terms and definitions are maintained in the RISSB Glossary:

<https://www.rissb.com.au/products/glossary/>

**1.4****Abbreviations****1.1.14****RIM**

railway infrastructure manager

**1.1.15**

**RVD**

rail vehicle detection

**1.1.16**

**TSR**

track speed restriction

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## Section 1 Fundamentals of rail management

---

### 1.1 General

The purpose of rail management is to ensure rail integrity throughout the stages of the asset's lifecycle.

Safe and cost-effective rail management considers:

- (a) The longer-term requirements when selecting rail
  - (i) The type, size, bending rail strength
- (b) Mechanical joints
  - (i) Keeping mechanical joints at a minimum and defect free
- (c) The wheel rail interface
  - (i) Wear, rolling contact fatigue, profiles and grinding strategy
- (d) NOTE: Refer to the Wheel and Rail Profile Guideline
- (e) Friction management
- (f) Surface condition
- (g) Internal defect management
  - (i) Maintain head profile by maintenance grinding.
- (h) Head profile maintenance grinding regime shall be determined by the RIM
  - (i) Handling of rail
- (i) Efficient and effective handling of rail to minimize handling defects

### 1.2 Rail management plan

A whole of life rail management plan should be established specifying rail characteristics approved for the railway, including:

- (a) rail head profiles (appropriate for the interfacing rolling stock wheel profiles);
- (b) rail cross-section;
- (c) metallurgical properties of the steel;
- (d) rail wear limits and tolerances;
- (e) defect tolerances and repair priorities; and
- (f) monitoring and maintenance methodologies (including management of rail stress due to temperatures and track creep).

### 1.3 Recommended practices

#### 1.3.1 General

The following practices should not be carried out for serviceable rail:

- (a) Flame cutting:
  - (i) Permanent bolt holes; or
  - (ii) Rail ends that are not welded by mobile flash butt or aluminothermic welding processes within the stipulated timeframes.

- (b) Drilling holes anywhere other than the neutral axis of the rail.
- (c) Installing short lengths of rail as set out in clause 5.3.
- (d) Placing rail welds less than as set out in clause 5.3.
- (e) Carry out any work that results in fatigue initiating points in the foot of the rail.
- (f) Allow rolling stock to travel over field welds before they have cooled, been trimmed and ground to profile.

### 1.3.2 Mechanically joined rail

The threshold between jointed track and welded rail and where mechanically jointed rail is acceptable shall be defined.

The criteria for determining where mechanically jointed rail is acceptable includes;

- (a) axle loads;
- (b) gross tonnage;
- (c) rollingstock type;
- (d) train speeds;
- (e) rail size;
- (f) rail fasteners and sleeper type;
- (g) environmental factors (noise); and
- (h) operational risk management.

Mechanical joints shall have in place a maintenance regime to ensure that the;

- (i) thermal forces can be accommodated without causing excessive compressive force in the rail; and
- (j) integrity of the joint.

The location, length of rail for mechanical jointed track should be documented.

### 1.3.3 Welded rail

Welded rail includes long welded rail and continuous welded rail. Long welded rail is nominally up to 180 metres in length.

For welded rail, the following shall be defined:

- (a) The neutral temperature.
- (b) The installation methods.
- (c) Monitoring and maintenance methods.
- (d) Ballast shoulder widths.
- (e) Permitted sleeper types.

## Section 2 Selection of rail

---

### 2.1 General

The selection of rail is a risk-based decision.

When selecting rail, the following items should be reviewed:

- (a) Railway network operating conditions:
  - (i) Annual gross tonnage.
  - (ii) Track classification.
  - (iii) Curves.
  - (iv) Maximum speed.
  - (v) Traffic frequency.
  - (vi) NOTE: Considering both traffic density and maintenance opportunities.
  - (vii) Line criticality.
- (b) Rolling stock characteristics including but not limited to:
  - (i) axle load;
  - (ii) wheel diameter;
  - (iii) wheel profile;
  - (iv) suspension; and
  - (v) bogie configuration.
- (c) Track system compatibility, such as:
  - (i) rail fastening system;
  - (ii) sleeper type and distribution;
  - (iii) other ancillary equipment; and
  - (iv) the type, size and wear of adjoining rail.
- (d) Maintenance and lifecycle cost.
  - (i) Maintenance availability.
- (e) Use of new or serviceable rail.
- (f) Rail characteristics, including:
  - (i) rail section and rail head profile;
  - (ii) rail metallurgy includes existing steel in use;
  - (iii) corrugations in the rail head;
  - (iv) internal rail defects;
  - (v) condition of bolt holes; and
  - (vi) state of any corrosion.

New rail selected for use in main lines and yards shall comply with the requirements in AS 1085.1  
Railway track materials - Steel rails or other standard as may be nominated.

## 2.2 Fit for purpose

Rail shall be selected with sufficient strength, shape stability and wear resistance for use in its intended application.

At a minimum, rail serviceability requirements shall include:

- (a) track geometry;
- (b) rail section and rail head profile;
- (c) rail ends;
- (d) rail wear limits are within tolerances;



- (e) managing risks associated with wheel / rail profiles;
- (f) steel manufacturing process; and
- (g) any other additional requirements.

### 2.3 Serviceable rail

Rail that has been previously used or has been stored trackside for an extended period shall be assessed for serviceability before re-use. Serviceable rail may be re-installed, cascaded or transposed.

The selection criteria shall check for:

- (a) any internal or surface defects by non-destructive testing methods;
- (b) any welds within the section are of suitable condition (not dipped, battered, etc);
- (c) rail within the acceptable wear limits as per the rim requirements;
- (d) rail section, grade and size is suitable for use in the chosen location;
- (e) rail of sufficient length for re-use;
- (f) rail free of corrosion defects (including the foot);
- (g) the rail worn profile suitably matches the adjoining rail;
- (h) joint bolt holes should be cropped if there is evidence of cracking or elongation of bolt holes;
- (i) rail end straightness, twist and other rail distortions (battered, crippled or deformed) meets the requirements for installation of aluminothermic welds or mechanical joints and should be cropped if necessary;
- (j) rail does not contain any condition or defect that is deemed to be unsafe; and
- (k) all serviceable rail shall be non-destructively tested post installation as specified.

#### 2.3.1 Transposing rail

Transposing of rails may be permitted where rails are curve worn or have exceeded a wear angle as determined by the RIM and the other rail face (field side) is in an as new condition.

The new gauge face should be reprofiled to the RIMs specification and remove any lip that can have developed. Rail that is not suitably re-profiled can suffer damage rapidly and cause damage to wheels and rails.

For rail transposed from curves to straight track, the rail shall meet acceptance wear limits as determined by the RIM.

### 2.4 Head hardened rail

Selection of head hardened rail or alternative strength rail is a decision based on the overall rail management strategy.

Head hardened rail should only be selected where suitable maintenance practices (including grinding and friction management) are in place. Head hardened rail may be used:

- (a) to control wear in sharp curves of radii less than 600 m;
- (b) in difficult to relay locations such as tunnels and long bridges, provided that realistic grinding strategies are factored into the long-term maintenance and management plans; and

- (c) areas where there is high tonnage and or high frequency of traffic.

NOTE: Head hardened rail can develop running surface cracking in tangents and large radius curves (>1200 m radius) that is not subsequently worn away if the rail traffic has predominantly low to intermediate axle loads. This can develop into severe cracking that can require re-railing significantly earlier than if standard carbon rail was used at the same location.

## **Section 3 Handling, transport, and storage**

---

### **3.1 General**

Methods of storing, handling, transporting, and laying rail to avoid damage or deformation shall be prescribed.

Rails shall be stored in such a manner that prevents rail crippling, corrosion, and impact damage.

Rails shall be handled and stored in such a manner that does not cause damage to the rail. The follow shall be implemented when handling and storing rail:

- (a) When lifting long lengths rail consideration should be taken to apply multiple lifting points.
- (b) When dragging rail, rollers or other approved methods should be used to avoid damage to the rail. Rail shall be dragged in an upright orientation.
- (c) Where rail is stacked, rails shall be stacked on suitable dunnage with all tiers separated in the same manner. The rail shall be supported to ensure integrity and avoid damage.

## **Section 4 Installation and commissioning**

---

### **4.1 General**

The process shall be documented in the rail management strategy and shall include methods for the installation and commissioning of rail in track including the records and documentation required.

Configuration records for the installation and commissioning including weld returns, stressing of rail, and type of rail installed and any other requirements the RIM has requested shall be recorded and documented.

### **4.2 Joining rails**

#### **4.2.1 General**

When joining rail, the running surface and the gauge face shall align at the joint to provide a safe and smooth transition from one rail to another.

Rails shall have saw cut ends and shall be joined mechanically or by welding.

#### **4.2.2 Differential rail wear**

When welding rail of similar section and differing amount of wear of more than 3 mm, a step weld or machined transition rail should be used.

#### **4.2.3 Differing rail sections**

Rails of different sections may be joined using:

- (a) junction plates;
- (b) a junction weld; or
- (c) a junction rail.

The outer ends of the junction rail should be of the same section as the rail into which it is being welded.

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

- (a) 60 kg to 53 kg
- (b) 53 kg to 50 kg
- (c) 53 kg to 47 kg
- (d) 50 kg to 47kg
- (e) 47 kg to 41 kg.

#### 4.2.4 Location of joints

The position of aluminothermic welds, mechanical joints, and insulated joints shall be placed midway between adjacent sleepers.

Flashbutt welds may be positioned at any location along the track, provided that the underfoot shear is less than 1 mm proud of the base of the rail

The minimum permissible distance shall be documented between;

- (a) aluminothermic welds;
- (b) aluminothermic welds and mechanical joints;
- (c) aluminothermic welds and insulated joints;
- (d) mechanical joints; and
- (e) mechanical joints and insulated joints.

The minimum distance may be common to all combinations.

Mechanical and insulated joints should be staggered on adjacent rails.

The RIM shall determine and document the minimum permissible stagger between mechanical joints, and mechanical joints and insulated joints.

#### 4.2.5 Mechanical joints

The RIM shall assemble mechanical joints using:

- (a) fishplates that meet the requirements of AS 1085.2 Railway Track Materials – fishplates;
- (b) fishbolts, and nuts that meet the requirements of AS 1085.4 Railway Track Materials – fishbolts, and nuts, and swage fasteners;
- (c) spring-washers that meet the requirement of AS 1085.7;
- (d) fishplates that are the correct size for the rail sections;
- (e) fishbolts that are the correct type and size for the fishplates; and
- (f) fishplates, fishbolts and nuts that are in a serviceable condition.

The RIM shall develop and document a process for;

- (g) determining that fishplates and fishbolts are serviceable;
- (h) the management of serviceable and non-serviceable fishplates and fishbolts;  
and
- (i) the construction rail gap between rail ends at design neutral temperature.

#### 4.2.6 Insulated rail joints

Insulated rails shall comply with AS 1085.12 insulated joints assembly or an approved alternative as determined by the RIM.

Insulated rail joints should be centrally suspended between sleepers and located within 700mm of its designed position. When placed on curves, pre-assembled IRJ's may be pre-curved to suit the radius of the track and length of insulated rail joint to be installed or as determined by the RIM.

For insulated joints in turnouts or special track works, the minimum distance from the rail end post to weld should not be less than 1.2 m.

Location of insulated joints is determined by the signaling design.

Joints on opposite legs may be adjacent to each other (i.e. square). Where staggered joints are used the effect on the vehicle resonances should be taken into consideration.

Insulated joints should be installed at the minimum acceptable length for the first installation to allow subsequent replacement without the use of closure rail.

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

#### 4.2.7 Cutting of rails

Rails installed into track should be cut with a low heat method such as a friction or hacksaw removing at least 100 mm from any oxy cut regions, and at least 500 mm from the end of the rail if it has been removed from track using a rail breaker.

The first cut (to release stresses) in installed CWR shall be a flame cut.

The variation of the alignment at the rail end following cutting should be within,

- (a) 1.0 mm of vertical perpendicular from the head to the foot; and
- (b) 0.7 mm of horizontal perpendicular from one toe to the other toe at the foot.

#### 4.2.8 Drilling of rails

When drilling holes for plated rail, the location of the holes in the web of the rail are determined by the section of rail as per AS 1085:2 fishplates.

When drilling rails for fishplates the appropriate template shall be used for the section of rail.

Holes shall be drilled square to the web.

Drilling of the rail for track bonding shall be defined by the RIM. However, drilling of holes in the rail shall be minimized.

Drilling into the foot and head of the rail is prohibited.

Drilling of rail shall be undertaken by an approved drilling process including the use of lubricant.

Flame cutting holes and velocity punching holes in rail is prohibited.

Cold bolt holes expansion of rail may be used to manage the asperities (burrs) generated from the drilling process.

#### 4.2.9 Welding rails

The RIM shall develop a rail welding standard and rail welding procedure/s.

The RIM shall also develop a rail welding register documenting;

- (a) weld returns;
- (b) time, date, temperature;
- (c) type of weld;
- (d) the welder who performed the weld;
- (e) the welder's competency; and
- (f) the testing of the welds.

The rail welding standard and procedure shall be documented in the RIM's SMS (Safety Management Systems) and should align with the AS 1085.20 Welding of Steel Rails. The rail welding standard and procedure/s should define;

- (g) what rails can be welded;
  - (i) rail sizes; and
  - (ii) rail metallurgy; and
- (h) the methods and products permitted for these rail welding tasks;
- (i) the tracking of rail welds; and
- (j) the testing/inspection of rail welds.

The RIM's rail welding standard should define:

- (k) limits on the proximity of welds to holes in the rail;
- (l) If heat affected metal from a previous weld is acceptable in or adjacent to a new weld; and
- (m) tolerances for finished welds (horizontal and vertical rail alignment through the weld).

The RIM should only use type approved welding methods and products.

The RIM shall only permit competent Rail Welders that hold national competency to weld rail and should track the competencies of the Rail Welders permitted to weld on the RIM's network. The Rail Welders should hold the national competencies for rail welding and should be competent in the use of the type approved welding methods and products.

Accepted rail welding methods typically used in Australia include Aluminothermic Welding (Thermite Welding), and Flashbutt Welding.

There are other rail welding methods that may be used such as gas pressure welding and electric arc welding. It is recommended that electric arc welding only be used for joining rail sections that are smaller than 41 kg.

When new rail is welded into long welded rail and continuous welded rail the neutral temperature should be set. The stressing of rail should be done in accordance with section 5.4.

### 4.3 Closure rails

Closure rails should be serviceable rail as set out in clause 3.3, should match or exceed the current head height and the same width.

The minimum distance between welds should be 6 m in plain line track.

Closure rails shall be joined mechanically or welded to adjoining rails in accordance with section 5.2. Any rail ends which have been left in track and battered by traffic should be re-cut prior to welding, removing a minimum of 25 mm.

For curves of 500 m radius or less, the closure may be pre-curved to the radius of the track curve.

Where it is necessary to grind the closure to match the existing rail, the maximum allowable rate of change of rail head sections should be 1 in 500 vertically and horizontally.

NOTE: The characteristics of closure rails used in turnouts and other special track work are given in AS 7642.

### 4.4 Rail adjustment

Rail adjustment is the process of adjusting rail to the design rail neutral temperature.

The RIM shall establish the neutral temperature in newly installed rail.

Rail adjustment shall be managed in accordance with AS 7643.

Track geometry shall be managed in accordance with AS 7635

### 4.5 Rail head profile

The rail head profile shall be established to the specifications determined by the RIM. The measured head dimension shall be discounted for any metal flow outside the original rail profile. Recommended limits are shown in Appendix B4.

Considerations should be given to the combined effects of rail side wear and track gauge widening in the determination of rail head wear limits.

The limits should apply to the worst location, and not the average rail wear, for the segment of track being considered (such as a curve).

Individual limits should not apply to combinations of wear and defects as it can be necessary to adopt a lower limit.

When approaching the rail wear limits, factors such as defect types, defect density and defect history should be considered.

Where combined wear and defects occur, detailed assessment by qualified personnel is required.

Where the prescribed wear limits are exceeded, operating restrictions can need to be imposed.

Note that temporary speed restrictions can lead to an increase in rail stress in the low leg of curves.

#### 4.5.1 Alternative rail wear strategy

Rail wear limits in all dimensions may be determined from the relationship between rail stress and its fatigue stress limit.

The charts in Appendix C show the relationship between the amount of wear in the rail head and the stress at the rail foot.

The prescribed wear limits may be reassessed using a risk-based approach if the factors in the table in Appendix Care mitigated.

#### **4.5.2 Gauge face angle**

To prevent wheel climb, the gauge face angle of rails should not exceed 26° perpendicular from the horizontal plane of the track as shown in Appendix B5. Methods of assessment for gauge face angle may be engaged subject to RIM's approval.

Where the prescribed gauge face angle limits are exceeded, operational restrictions could possibly be required.

The timeframe and requirements for establishment grinds shall be nominated by the RIM.

RIMs may specify that an establishment grind is to be carried out prior to commissioning.

NOTE: Additional guidance on the wheel rail interface is given in the Wheel and Rail Profile Development Guideline.

#### **4.5.3 Rail cleaning**

Any new rail installed in the network within RVD territory shall have the head of the rail cleaned to achieve a suitable wheel to rail interface to correctly operate the required track circuitry according to AS 7715. This includes turnouts, catch points and bonded insulated rail joints.

NOTE: Rail surface condition can affect adhesion, track circuit detection and testing effectiveness.

#### **4.6 Lubricators**

Rail friction levels for lubricated rail curves shall be established according with AS 7641.

#### **4.7 Rail connected equipment**

When installing and commissioning new rail, correct fitment of wayside interfacing equipment shall be included for the type and size of the rail.

Wayside interfacing equipment includes:

- (a) track bonding;
- (b) axle counters;
- (c) point motors;
- (d) buffer stops;
- (e) ballises; and
- (f) lubricators.

Installation of equipment connected to the rail shall be undertaken in accordance with section 5.2.8

#### **4.8 Electrified network**

##### **4.8.1 Traction return bonding**

The rail, fasteners, plates and bonding in an electrified network forms part of the electrical traction return system. Whenever installing rail in an electrified network, traction return power shall be reviewed including power bonding and the insulations that form electrical isolation from other wayside equipment.



Any electrolysis equipment bonding shall be connected to the new rail and provide a solid connection to the electrolysis attachment point.

Any direct connections to rail shall comply with 5.2.3

#### **4.8.2 Rail vehicle detection territory**

When installing rail in RVD territory electrical insulation between rails shall be consistent with the requirements of AS 7715.

### **Section 5 Commissioning**

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#### **5.1 General**

The RIM shall specify requirements for commissioning new rail into service.

Commissioning of new rail should include the following;

- (a) Check for no mechanical damage to the rail.
- (b) Check for any defects in the installed rail.
- (c) Cleaning for the correct operation of track circuits.
- (d) QA documentation completed for all flashbutt and aluminothermic welds including:
  - (i) Weld records including UT (Ultrasonic Testing) tests; and
  - (ii) Weld alignments checks.

### **Section 6 Rail maintenance and monitoring**

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#### **6.1 General**

The RIM shall specify requirements for monitoring, documenting, and maintaining rail integrity throughout its operational life.

##### **6.1.1 Patrol inspections**

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

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

##### **6.1.2 General inspections**

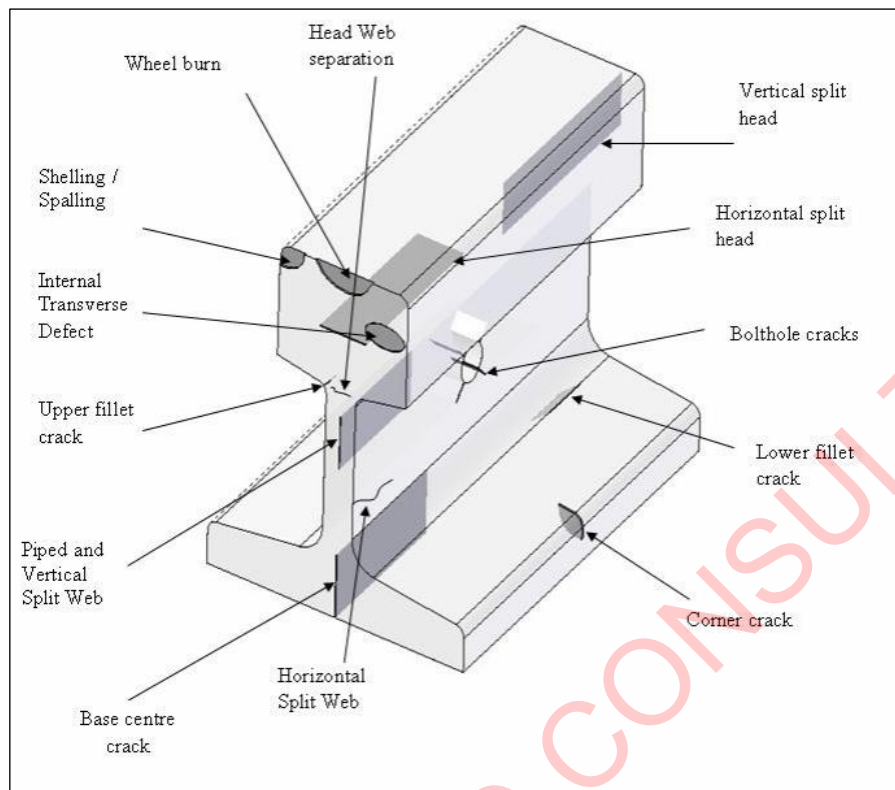
A general visual inspection should be carried out for all new welds and new mechanical joints; or where the response following detection of a rail or weld defect is noted for further observation.

#### **6.2 Rail defect identification**

The RIM shall have a system and process in place to consistently identify, categorize, prioritize and manage rail defects.

The image below illustrates some of the most common defects.





*Figure 1 Common rail defects*

Figure 1 shows typical internal and external rail defects.

RIMs shall determine rail performance criteria for defects, including:

- (a) defect type;
- (b) size; and
- (c) rectification timeframes.

### 6.3 Monitoring

Rail integrity can be monitored through:

- (a) Track test vehicle-based measurements.
- (b) Manual non-destructive testing.
- (c) Remote condition monitoring.
- (d) Visual inspections.
- (e) Manual measurements.
- (f) Incident reporting.

#### 6.3.1 Track test vehicle

Track test vehicles are used to identify rail defects using specific measuring tools.

Track test vehicles may inspect one or more of the following;

- (a) Rail defects.
- (b) Rail head profile.

- (c) Rail surface condition.
- (d) Corrugation and impact data.
- (e) Missing components of the rail.

### **6.3.2 Non-destructive testing**

#### **6.3.2.1 Ultrasonic non-destructive testing**

Ultrasonic non-destructive testing identifies defined rail defects, typically in the head and the web.

The RIM shall specify the requirement for ultrasonic rail testing including frequencies, methods and classification of defects.

NOTE: Testing might not be effective after rail grinding or extended periods without traffic. Surface roughness or rust on the rail head can affect the quality of the test. Sufficient rail traffic dependant on frequency and tonnage is require before an accurate test can be achieved.

Identification of defects should be carried out via manual ultrasonic testing in the following situations:

- (a) At new aluminothermic and flashbutt welds.
- (b) To confirm suspected defects indicated as part of the continuous ultrasonic inspection.
- (c) Where there are suspected defects found by visual inspection.
- (d) When known defects are due to be reinspected and reassessed.

### 6.3.2.2 Other non-destructive testing

Other methods of non-destructive testing can also be used to identify rail defects.

Techniques commonly used are magnetic particle, dye penetrant, eddy current, electromagnetic array, and magnetic remanence.

*Table 6-1 Non-destructive testing of rail defects*

Technique	Suited to	Steel type	Test location	Ideal use case	Speed	Limitations
Magnetic particle inspection	Checking weld collars	Magnetic	Specific locations, can be performed around entire rail	Detection of surface connected cracks from the head due to rolling contact fatigue. Detection of surface connected cracks at ground web and upper foot surfaces of flashbutt welds.	Very slow, manual process	Highly localized due to manual nature of the process
Dye penetrant inspection	Verify defect removals on welded repairs	Magnetic and non-magnetic	Specific locations, generally used at AMS crossings	Detection of surface connected cracks from the head due to rolling contact fatigue in Austenitic Manganese steel crossings. As an alternative to MPI where power is not available.	Very slow, manual process	Highly localized due to manual nature of the process
Eddy current	Running surface	Magnetic	Running surface, all track locations	Identify the presence and some information on the lateral extent of rolling contact fatigue cracks at the running surface. Depth information is not reliable.	Can be performed at speed	Process varies from one provider to another
Electromagnetic array	Running surface	Magnetic	Running surface, all locations	Identify the presence and more precise lateral extent of rolling contact fatigue cracks at the running surface. Can resolve position of cracks across head (gauge corner, crown, field side). However, depth information is only indicative.	Can be performed at speed	Process varies from one provider to another

Magnetic Flux leakage	Running surface	Magnetic	Running surface, all locations, can provide RCF crack depth information	Has been considered for better defining the depth of rolling contact fatigue cracks to determine required depth of grinding to remove cracks. The method is still gaining recognition.	Generally performed at walking speed	Niche technique, precision of crack depth measurements is not always validated in physical assessments.
Gamma ray		Magnetic and non-magnetic	Aluminothermic welds	Identify internal casting (volumetric) defects such as shrinkage or porosity in aluminothermic welds.	Extremely slow, radiation hazard	Not effective at flashbutt welds as these generally only have planar defects.

### 6.3.3 Remote condition monitoring for rail

Remote condition monitoring for rail can be used in addition to other methods and processes of rail condition monitoring.

Remote condition monitoring systems are being developed to aid rail infrastructure maintainers to monitor rail conditions such as, broken rail, and lubrication. For temperature fluctuation and rail stress refer to AS 7643.

### 6.3.4 Visual inspections

Visual inspections are undertaken as part of the asset management of the rail or when the test track vehicle has found a defect.

Visual inspections may be undertaken from a road rail vehicle or by walking the track. This can also include using applicable manual portable devices.

Visual inspections might find the following defects.

- (e) Running surface defects such as
  - (i) contact patch irregularities;
    - a. spalling;
    - b. wheel burn;
    - c. scuffing & cracking; and
    - d. hunting related wear.
- (f) Corrosion.
- (g) Broken rail.
- (h) Any missing rail components.
- (i) Deficient or excessive carry of lubricant.
- (j) Damaged rail joints.

#### 6.3.4.2 Manual measurements

Any equipment used for manual visual inspections should be validated and have a system documenting its calibration and asset condition.

#### 6.3.4.3 Incident reporting

The RIM should investigate and analyze any reports of rough rides, or any other abnormalities reported on the network.

## 6.4 Maintenance

The RIM shall specify requirements for rail maintenance in accordance with their asset management plan.

Maintenance shall be undertaken on:

- (k) rail profile management;
- (l) rail surface condition;
- (m) friction management;
- (n) rail internal defect management;

- (o) rail head wear limits;
- (p) missing rail components; and
- (q) rail adjustments in accordance with AS 7643.

#### **6.4.1 Rail profile management**

The RIM shall establish a rail profile management regime in accordance with their asset management plan to optimise the wheel/rail interaction characteristics. The rail profile should also consider any requirements for wheel to rail interfacing and rail vehicle detection.

The rail head profile should be maintained through preventive and corrective maintenance.

Preventive action such as a cyclic grinding should be carried out to re-establish the design or the required rail head profile.

Corrective grinding or milling may be used to rectify defects or to establish or maintain rail profile.

The rail profiles should be determined for tangent and curved track (including high and low rails) up to the last of the canted sleeper plates before and after turnouts.

The same basic profiles should be applied to all rail sizes and types.

The main rail profiles should be designed to suit current wheel profiles in both the new and acceptable worn conditions.

Rail profiles should be compatible with the traffic travelling over them.

More information is provided in the RISSB Wheel to Rail Profile Development guideline.

#### **6.4.2 Rail surface condition**

The grinding process can remove longitudinal rail surface defects such as corrugations, dipped or peaked welds, wheel burns, flaking, shelling, and bruising, etc.

Depending on the severity, some larger defects cannot be removed by grinding.

There should be no sharp ridges especially at the corners of the head of the rail.

There should be no excessive gouging on the rail surface or sharp grinding marks.

There should be no indentations in the running surface or the running edge.

There should be no continuous indication of overheating (bluing) of the rail.

The ground rail surface should be no rougher than an average of 10 mR, within 5 km of any dwelling, and 15 mR elsewhere.

Short pitch surface irregularities (30 mm to 150 mm in wavelength) should be removed.

The RIM shall specify requirements for rail grinding including frequency, metal removal rates, profile and quality.

The RIM can specify requirements on intervention strategies for surface conditions such as contamination, rust, surface damage.

#### **6.4.3 Friction management**

Gauge face rail lubrication should be considered at locations where there is potential for wear beyond acceptable levels as established by the RIM, and/or flanging noise is a problem.

The RIM shall specify friction management requirements for their network. Recommended practices for the requirements and use of rail lubrication are described in AS 7641 and Appendix D.

Top of Rail Friction Management (TORFM) to improve steering and reduce lateral forces on the head of the rail may be considered to reduce corrugation growth and rail head wear whilst also providing significant noise reduction.

#### **6.4.4 Rail internal defect management**

The RIM shall specify the requirements for monitoring and the removal of known rail internal defects.

Protection requirement should be appropriate for the type of defect and risk. For example, a single fishplate could not suitably protect longitudinal defects in the event of failure.

#### **6.4.5 Rail head wear limits**

The RIM shall establish rail wear limits for all rail sizes within their network. See Appendix B4.

Rail wear measurements shall be taken at specified intervals at marked locations to ensure the effective monitoring of percentage head loss, side wear (distance and angle), and total wear.

Rails should be replaced prior to the rail wear tolerances being exceeded or other controls implemented on a risk-based approach.

#### **6.4.6 Missing rail components**

The RIM shall inspect and replace any missing rail components such as bolts and fishplates in accordance with their defect management requirements.

#### **6.4.7 Rail adjustments**

Rail adjustments shall be undertaken in accordance with AS 7643.

### **6.5 Management of rail defects**

#### **6.5.1 General**

Identified defects shall be repaired or removed in accordance with the RIMs specifications and standards. Examples of common rail defects are shown in Appendix E.

The RIM shall determine the action required to manage the defect until it is repaired or removed. Management of a defect should include controls which can include operational restrictions such as a temporary speed restriction.

Below is a table of common defects, their description and codes as well as typical failure mode and detectability type.

Table 6-2 Common defects, codes description typical failure modes

Internal/ External	Type of defect	Code	Description	Typical Failure Mode	Detectability
Internal	Transvers defect	TD	A single, isolated defect growing in the transverse and vertical planes. May be located in the head web or foot.	Head: Will often result in a straight break. Web or foot: Often result in 'S' break	Head: UT Detectable by 70. Web: UT Limited detectability with 38 Foot: Detection unlikely, can be possible with 38
Internal	Transverse defect - Multiple	TDX	When 2 or more transverse defects are closer than 2.2m apart.	Initial break will trigger additional breaks, resulting in total loss of rail.	Same as TD
Internal	Shatter crack	SC	A defect originating as a series of small hydrogen inclusions or cracks in the head of a rail and occurring as a transverse defect.	Develops into TD or TDM	Detected by 38 and 70 probes
Internal	Weld Defect Flashbutt	WF	Defects originating from imperfections within flashbutt weld zones (e.g., inclusions, fusion defects). If internal flaw shows signs of growth, should be re-classified at TD	Often develop into transverse defects	Detected by 0, 38 and 70 probes. Can be visible at surface
Internal	Weld Defect Aluminothermic	WT	Defects originating from imperfections within aluminothermic weld zones (e.g., inclusions, fusion defects). If internal flaw shows signs of growth, should be re-classified at TD	Often develop into transverse defects	Detected by 0, 38 and 70 probes. Can be visible at surface
Internal	Weld Defect arc repair	WR	Can be inclusions introduced during the arc welding process, and/or excessive or insufficient hardness in the weld or heat affected zone of the underlying rail	Can lead to internal defects, eventual near surface cracking	



Internal/ External	Type of defect	Code	Description	Typical Failure Mode	Detectability
				and loss of welded region, or transverse defect	
External	Weld Defect Arc Repair	WC	Defect developing from a local weld between a stud with an external thread (cad weld) to the web at the neutral axis used to connect signal wires to the rail.	May lead to transfer defect in the web	Detected by 0, 38 probes
Internal	Horizontal split web	HSW	A progressive longitudinal fracture in the web of rail, oriented horizontally along the length of the rail.	Upwards or downwards curve, resulting in S break. Can develop into head / web separation.	Limited detectability, possible with 0
Internal	Horizontal split head	HSB	A progressive longitudinal fracture in the head of a rail, where separation along a seam spreads horizontally through the head, parallel to the running surface	Upwards or downwards curve, resulting in loss of rail head.	Detected by 0, 38 and 70 probes
Internal	Head Web separation	HW	A crack that generally occurs in the rail end and separates the head from the web.	Can lead to collapse of rail head or complete break	Detected by 0, 38 probes
Internal	Vertical Split Head	VSH	A progressive vertical fracture in the rail, where separation along a seam spreads vertically through the head, along the length of the rail.	Failure of rail head, resulting in loss of section	Detected by 38 and 70 probes
Internal	Vertical Split Web	VSW	A progressive vertical fracture in the rail, where separation along a seam spreads vertically through the web, along the length of the rail.	Can develop into piped rail or HSW	Limited detectability
Internal	Piped rail	PR	A vertically orientated defect resulting in opening of a cavity and a bulge in the web (i.e. a pipe).	Can lead to collapse of rail or complete break	Detected by 0, 38
Internal	Bolt hole crack	BHC	A progressive fracture that originates at a bolt hole and progresses radially away from the hole.	Upon failure, the rail can break into several pieces.	Visual Can be detected with MPI. Can be detected by 38 probe

Internal/ External	Type of defect	Code	Description	Typical Failure Mode	Detectability
Internal	Bolt hole elongation	BHE	A mechanical deformation of bolt hole, arising from interaction with a bolt.	Can progress to form an internal defect (bolt hole crack or horizontal split head)	Visual
Internal	Bolt hole non-conforming	BHN	A bolt hole with incorrect size, location or method of formation	Can progress to form an internal defect (bolt hole crack or horizontal split head)	Visual
External	Squat - Thermal	SQT	A type of squat normally associated with traction issues, typically forms in on the crown.	Often results in a breakout at the surface of up to ~5 mm. Resulting in impact forces and ballast deterioration.	Visual
External	Squat - Mechanical	SQM	A type of squat normally associated with RCF and initiate from a gauge corner crack to the middle of the head.	Can develop into Transverse defect	Visual
External	Wheel Burn	EB	A scar on the running surface of the rail caused by intense friction heating from slipping driving wheels.	Can develop into Transverse defect	Visual
External	Rolling Contact Fatigue	RCF	Rolling contact fatigue is generic in nature and used to describe a range of defects, that are due to the development of excessive shear stresses at the wheel/rail contact interface.	Can resulting is loss of ultrasonic signal, masking internal defects	Eddy Current. Visual
External	Gauge corner cracking	GC	Surface cracking in the vicinity if the gauge corner in the high leg of a curve, with an appearance like fish scales.	Can develop into Transverse defect	Visual
External	Shelling	SH	Small fractures commence at the surface of the rail and extend into the head and quite often small pieces break out completely. This mostly occurs on the gauge corner and crown, and they are readily detected by the appearance of dark spots on the running surface.	Can develop into Transverse defect	Visual

Internal/ External	Type of defect	Code	Description	Typical Failure Mode	Detectability
External	Corrugations	CG	Wave-like irregularities in the running surface, generally with a wavelength of 30-90 mm and a depth of up to 0.5 mm	Will lead to increased noise and impact loads, can eventually form cracks and transverse defect	Visual
External	Corroded rail	CR	Corrosion of the metal on the foot or web of the rail which results in pits or cavities, or loss of section thickness.	Can create stress concentrators for rail breaks.	Visual
External	Crippled rail	RC	A permanent vertical or horizontal plastic deformation of rail (a short abrupt kink)	Can lead to high impact loads and/or cracking, eventually transverse defect	Visual
External	Defective Joint	MJ	Damage to mechanical or insulated joint, including surface batter, flow, broken or damaged fishplates or missing bolts.	Loss of track circuits. Can fail similar to rail break.	Visual
External	Damaged Rail	DR	Rail damage such as wheel marks, scrapes, anchor strike, dog spike strike arising from derailed running of rolling stock or from other mechanical means. (Often referred to as notches)	Can create a stress concentration for future rail break.	Visual
External	Weld alignment	WAH	Non-compliance to the required vertical and/or lateral tolerances for welds, found in AS1085.20	Can lead to high impact loads and/or cracking, eventually transverse defect	Visual
Internal	Foot Web Separation	FW	A progressive crack along the foot/web fillet area	Can lead to collapse of rail or complete break	Visual
External	Broken Rail	BR	A transverse separation of rail. Includes failures of joints and welds.	Simple breaks can see passage of a train. Complex breaks likely to result in derailment.	Visual
External	Broken foot	BF	The separation is longitudinal but usually turns out to the edge of the foot. These separations are often called half-moon breaks	Will lead to complete rail break from the foot, cannot be detected via ultrasonics prior to rail break.	Visual

Internal/ External	Type of defect	Code	Description	Typical Failure Mode	Detectability
NOTE: 0 = 0 degree ultrasonic probe, 38 = 38 degree ultrasonic probe, 70 = 70 degree ultrasonic prob					

## Section 7 Defect repair

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### 7.1 General

Identified defects shall be repaired or removed in accordance with the RIMs specifications and standards.

Defects shall be managed until they are repaired or removed. Response time to the defect should be risked based.

The RIM shall determine the management of a defect until it is repaired or removed. Management of a defect should include controls which can include operational restrictions such as TSR (Temporary Speed Restrictions).

### 7.2 Defect corrective repair and removal

The RIM shall determine the type and method of the corrective repair.

A typical rail defect management regime is shown in Appendix F.

Corrective actions and priorities shall be determined based on the severity of the defect, the time to planned repair completion, whether and under what circumstances trains can operate over the defect and what arrangements for regular retesting and increased surveillance are to be made.

Repairs include grinding/milling of the rail, removal of the defect from the track or using an approved method of repair by the RIM such as rail head repair.

Internal rail defective sections should be replaced in accordance with the RIM's rail management requirements.

### 7.3 Temporary defect repairs

Temporary repairs shall be made permanent in a timeframe as specified by the RIM.

When repairing defects, the longitudinal adjacent rail should also be inspected for any unknown defects.

All temporary repairs shall be managed until permanent repair can be carried out.

Rail clamps shall be installed as per the manufacturer's specifications. Clamps shall be inspected on a risk based approach at intervals as determined by the RIM to ensure that they are fit for purpose.

Fishplates should be the correct size and type for the rail section and defect, are sufficient strength and approved in accordance with AS 1085.2. Fishplates can be clamped or bolted. Bolts holes shall be drilled.

When permanent repairs are completed, any remaining bolt holes should be removed.

### 7.4 Permanent defect repairs

The RIM shall determine the type and method of the permanent repair.

Repairs include grinding/milling of the rail, de-stressing, removal of the defect from the track or using an approved method of repair by the RIM such as rail head repair. When repairing defects adjacent rail should also be inspected for any defects.

## Section 8 Renewal

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### 8.1 General

Rail renewal shall be carried out in accordance with the installation and commissioning requirements in section 5.

Rail that is being renewed can also provide information on the wear rates and characteristics which can inform on the correct selection of rail to replace it with.

When removing rail from service, there should be consideration to the serviceability. Care should be taken not to cripple the rail and it should be stored correctly and not buried as per section 3.3.

## **Section 9    Decommissioning and disposal**

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### **9.1            General**

When rail is removed from track, it should be managed to ensure that it does not get placed back in track unless it has been tested or approved by the RIM.

Unserviceable rail should be clearly marked as unserviceable as determined by the RIM.

Any unserviceable rail shall be decommissioned in a manner to ensure that it cannot be re-commissioned.

## Appendix A Hazardous register (Informative)

Hazard number	Hazard
6.14.1.3	Track irregularity
6.14.1.4	Derailment at turnouts
6.14.1.5	Derailment at curve transitions
6.14.1.8	Cant ramp being too steep or through excessive superimposed dip
6.14.1.21	Horizontal or vertical track curvature being too sharp
6.15.1.1	Track failure
6.15.1.7	Cracked broken or bent rails
6.15.1.28	Previous derailment causing failed or cracked, broken, or bent rails
6.15.1.32	Excessive applied cant
6.15.1.59	Excessive rail side wear
6.15.1.60	Rail neutral temperatures being too low
6.28.1.1	Inappropriate track structure configuration selection
6.28.1.2	Inappropriate track alignment selection
6.28.1.4	Inappropriate selection of structural components
6.28.1.5	Work not being carried out as per design specifications
6.28.1.7	Commissioning excesses failing to detect unacceptable risk situations

## Appendix B New rail selection chart (Informative)

### B.1 New rail selection chart

Speed Limit Axle Load (tonnes)	10	20	25	30	40	50	60	70	80	90	100	110	115	120	130	140	150	160
<11	31																	
12																		
13																		
14				41														
15																		
16	41																	
17																		
18				50														
19																		
20																		
21	50																	
22																		
23																		
24																		
25																		
26																		
27																		
28																		
29																		
30																		
31																		
32																		
33	136RE, 141 RE & 68			136RE, 141RE & 68														
34																		
35																		
36																		
37																		
38																		
39																		
40																		

Figure 2 New Rail Selection Chart

NOTE: Figure 3 should be read in conjunction with AS 7630 Track Classification



## B.2 Equivalent rail sizes In Australia

Nominal Rail Size	Actual Rail Size
20 kg/m	41¼ lb/yd
	42 lb/yd
	20 kg/m
	45 lb/yd
	46¼ lb/yd
31 kg/m	58 lb/yd
	60 lb/yd
	61 lb/yd
	63 lb/yd
	31 kg/m
	66 lb/yd
	70 lb/yd
	71¼ lb/yd
41 kg/m	75 lb/yd
	78 lb/yd
	80 lb/yd
	83 lb/yd
	41 kg/m
50 kg/m	DKA 42 kg/m
	90 lb/yd
	94 lb/yd
	47 kg/m
60 kg/m	50 kg/m
	100 lb/yd
	103 lb/yd
	107 lb/yd
	53 kg/m
	110 lb/yd
68 kg/m	119 lb/yd (AREA)
	60 kg/m
	66 kg/m (AREA)
	68 kg/m
71 kg/m	136RE or 136RE-10 (AREAMA)
	141RE OR 141AB (AREAMA)

### B.3 Rail wear measurement

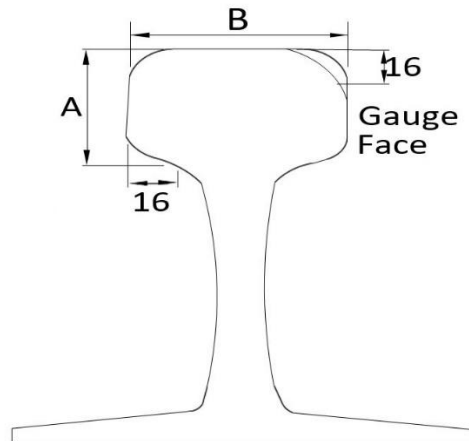


Figure 3 Rail wear measurement

### B.4 Rail wear limits

Rail Size kg/m	New Rail Head height mm	New Rail Head Width mm	Max. Head Loss Limit	
			R<600	R≥600
31	30	64	20%	38%
41	35	64	29%	46%
47	37	70	33%	50%
50	40	70	35%	53%
53	40	70	34%	51%
60SC	44	70	38%	51%
60HH	44	70	39%	54%
68	44	74	35%	45%
71	47	76	35%	45%

NOTE: Table B4 shows a table of suggested rail wear limits. The Track Manager should assess the appropriate wear limits for the respective track classification.

## B.5 Gauge face angle

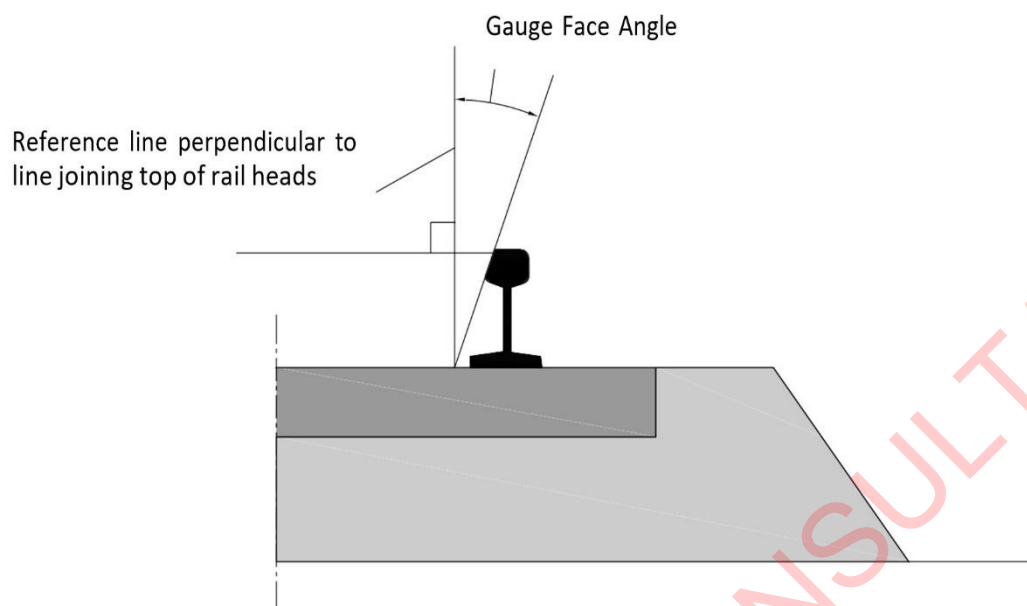
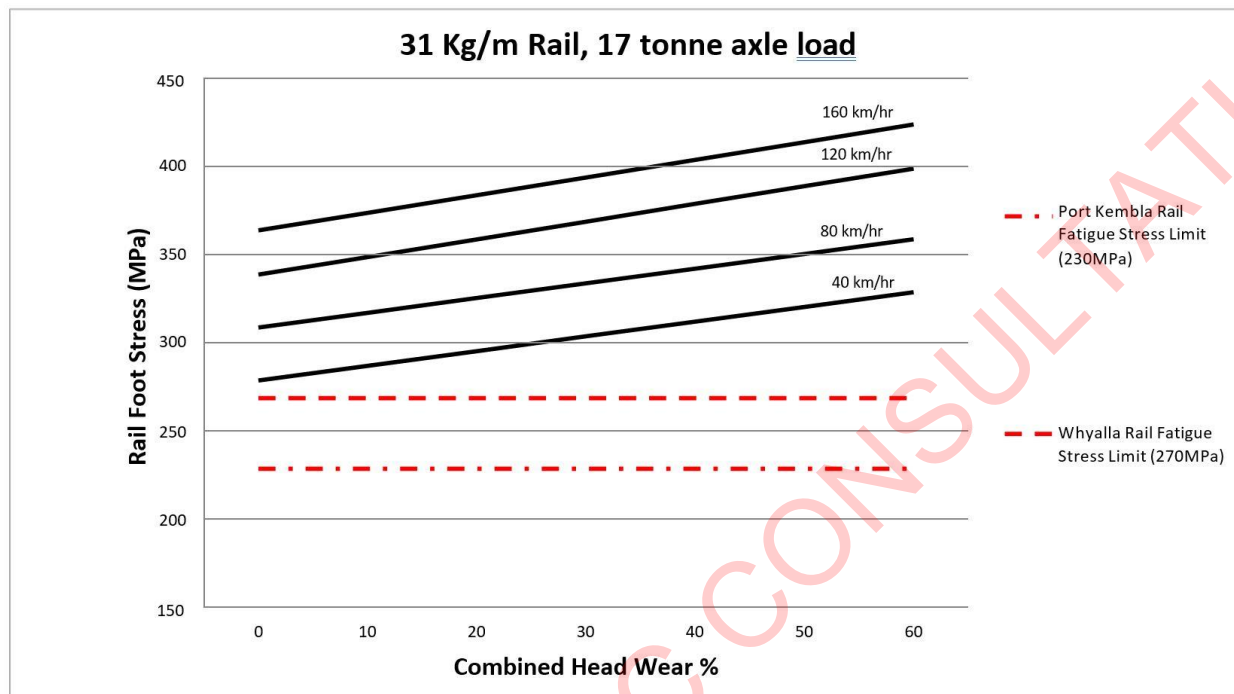


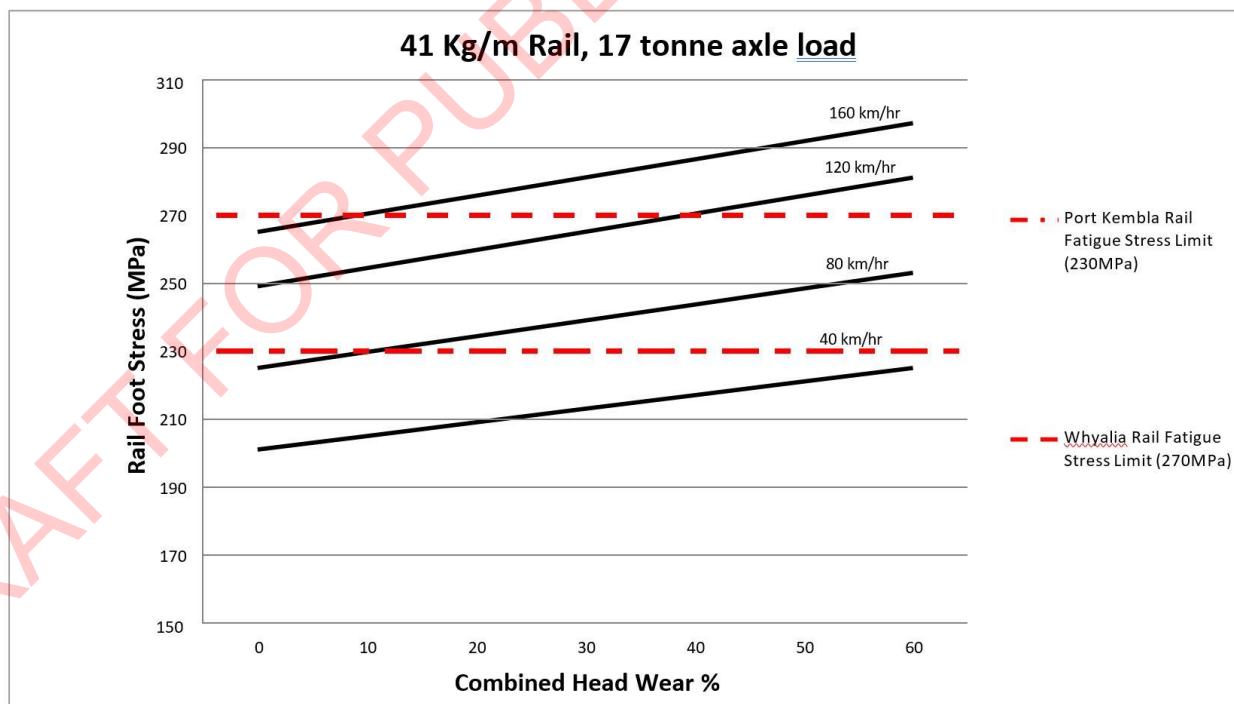
Figure 4 Gauge face angle

## Appendix C Rail foot stress versus combined head wear (informative)

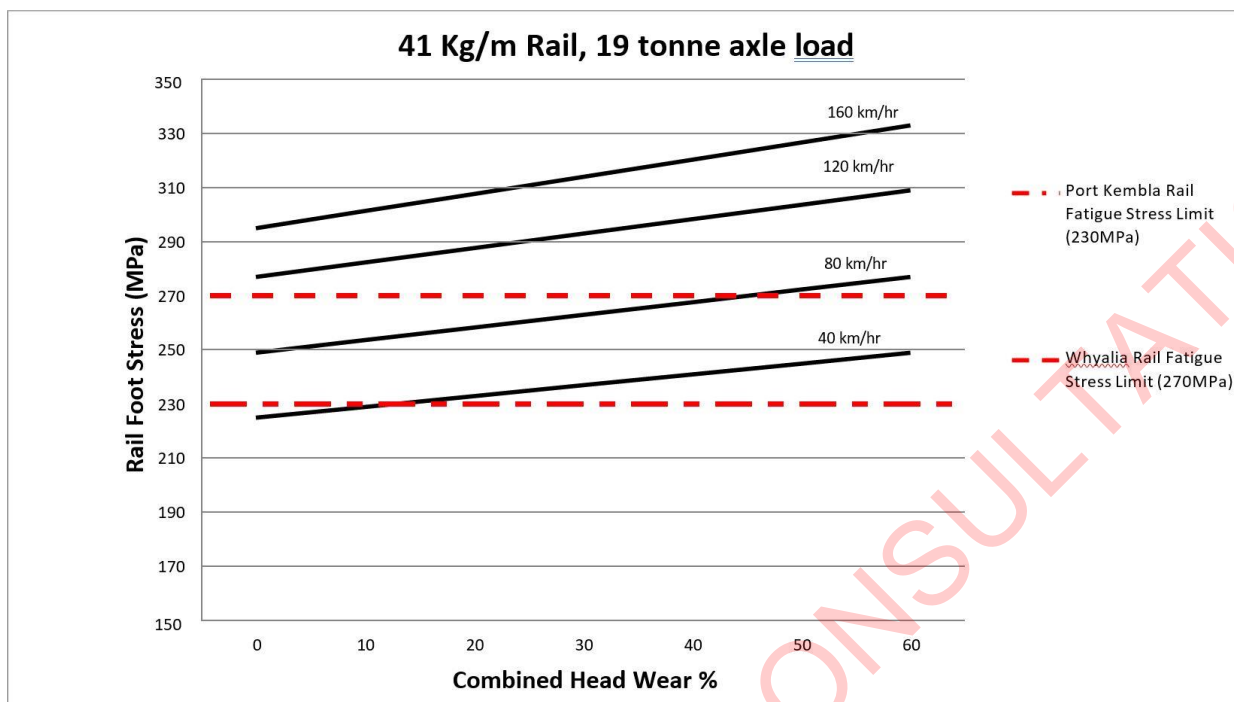
### C.1 31 Kg/m rail, 17 tonne axle load



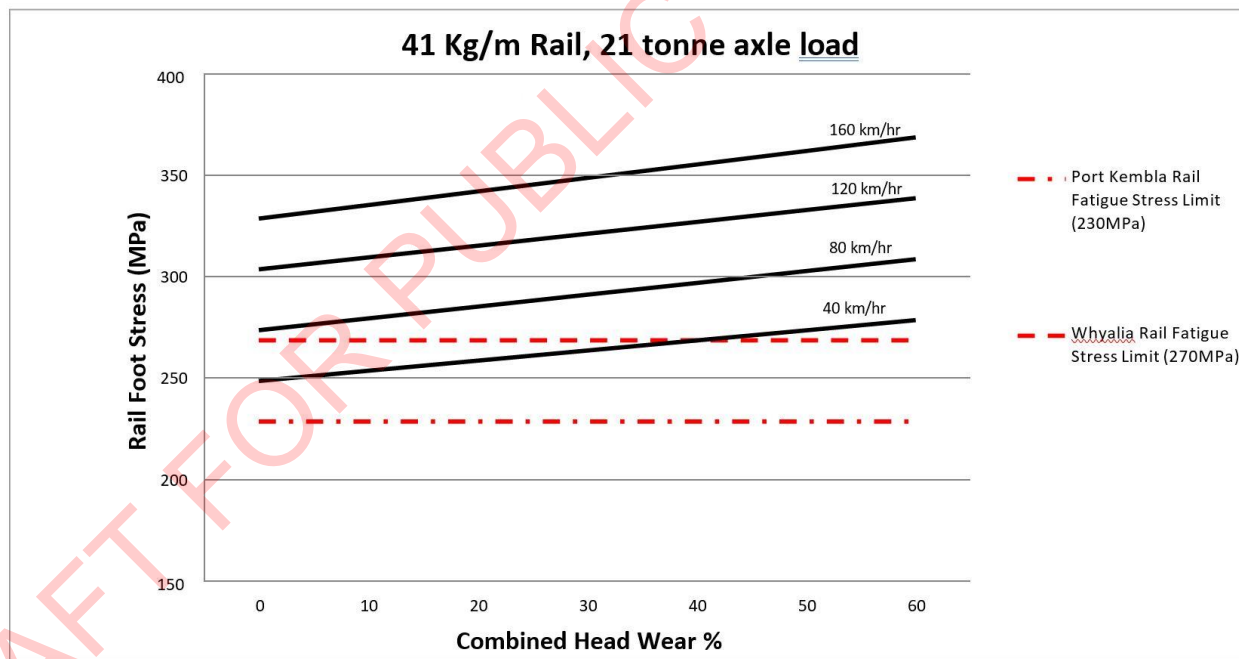
### C.2 41 Kg/m rail, 17 tonne axle load



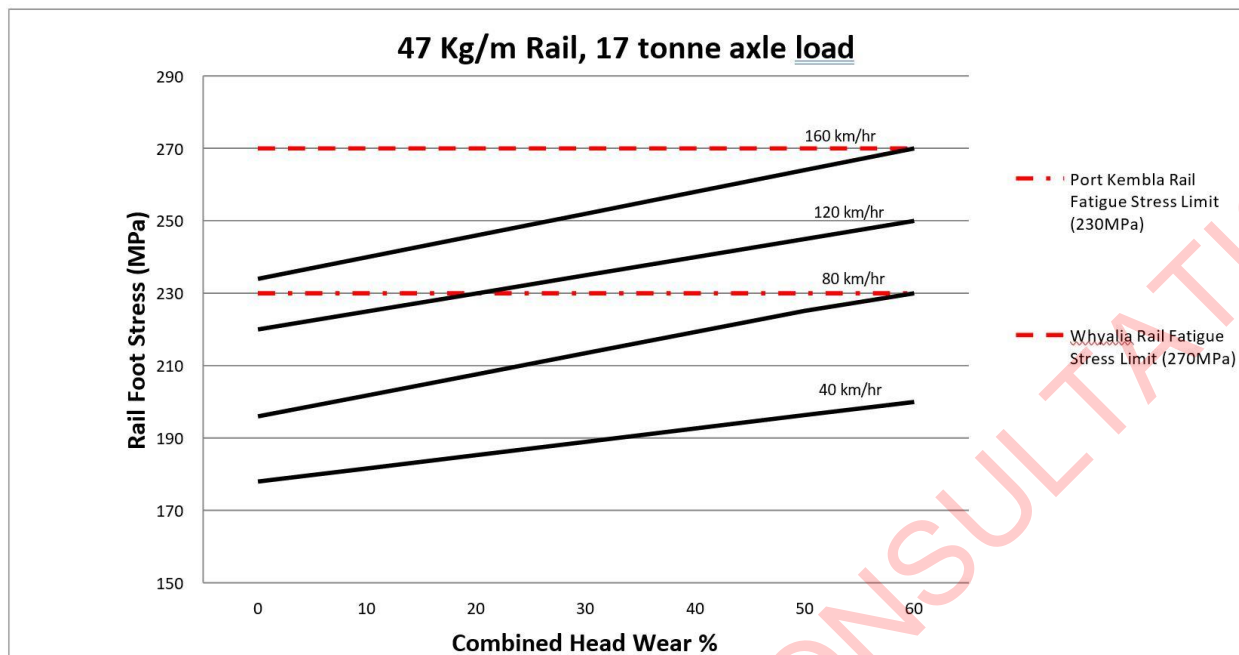
### C.3 41 Kg/m rail, 19 tonne axle load



### C.4 41 Kg/m rail, 21 tonne axle load



### C.5 47 Kg/m rail, 17 tonne axle load



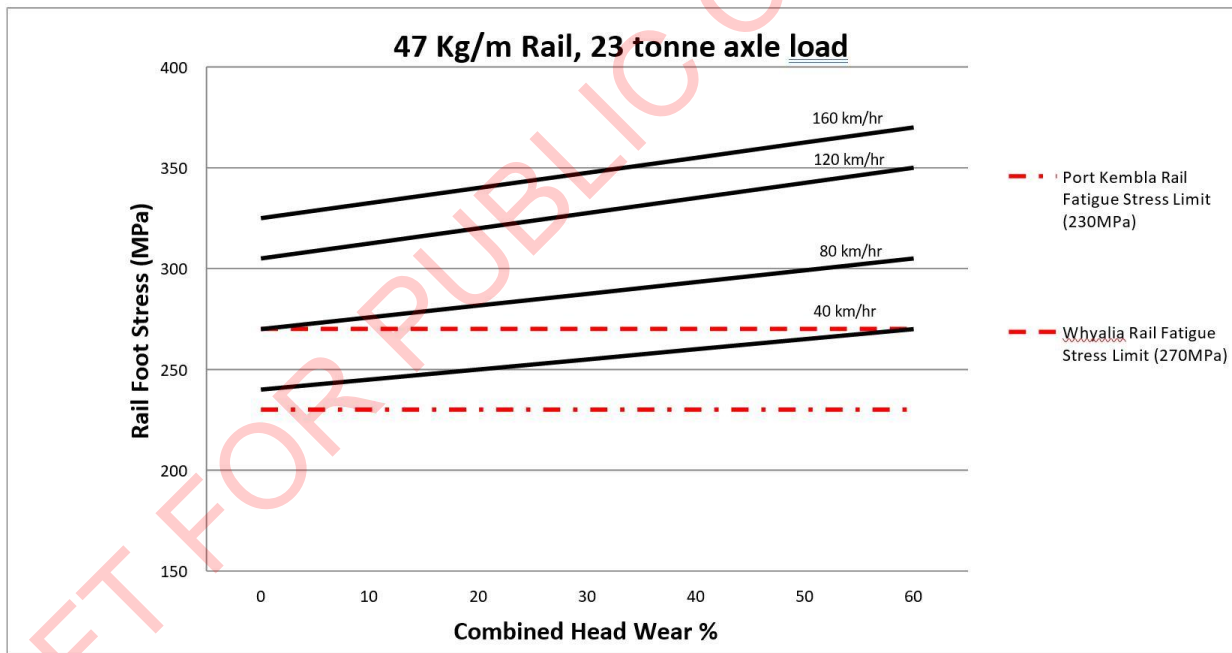
### C.6 47 Kg/m rail, 19 tonne axle load



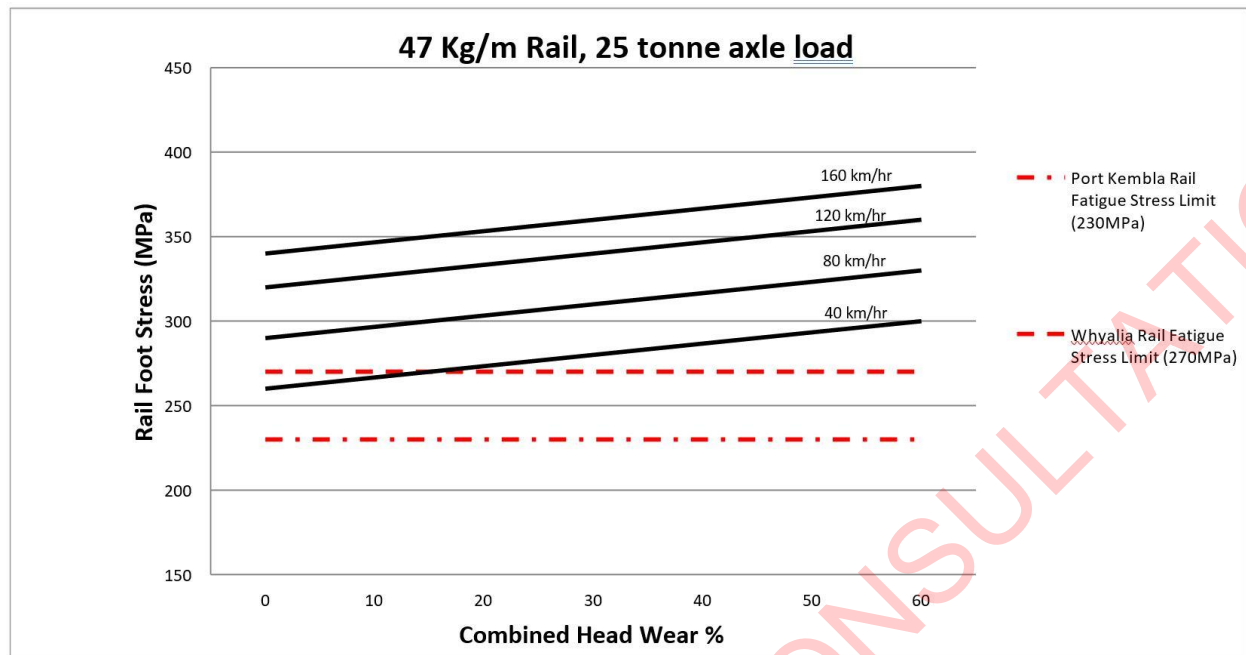
### C.7 47 Kg/m rail, 21 tonne axle load



### C.8 47 Kg/m rail, 23 tonne axle load

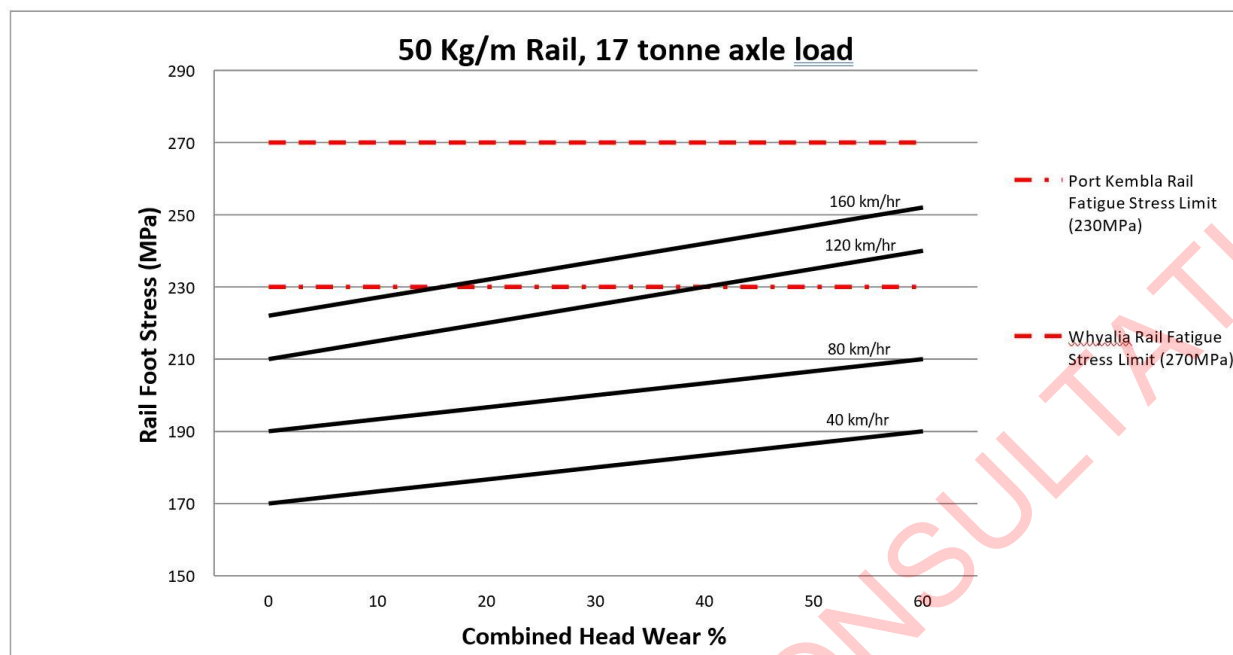


### C.9 47 Kg/m rail, 25 tonne axle load

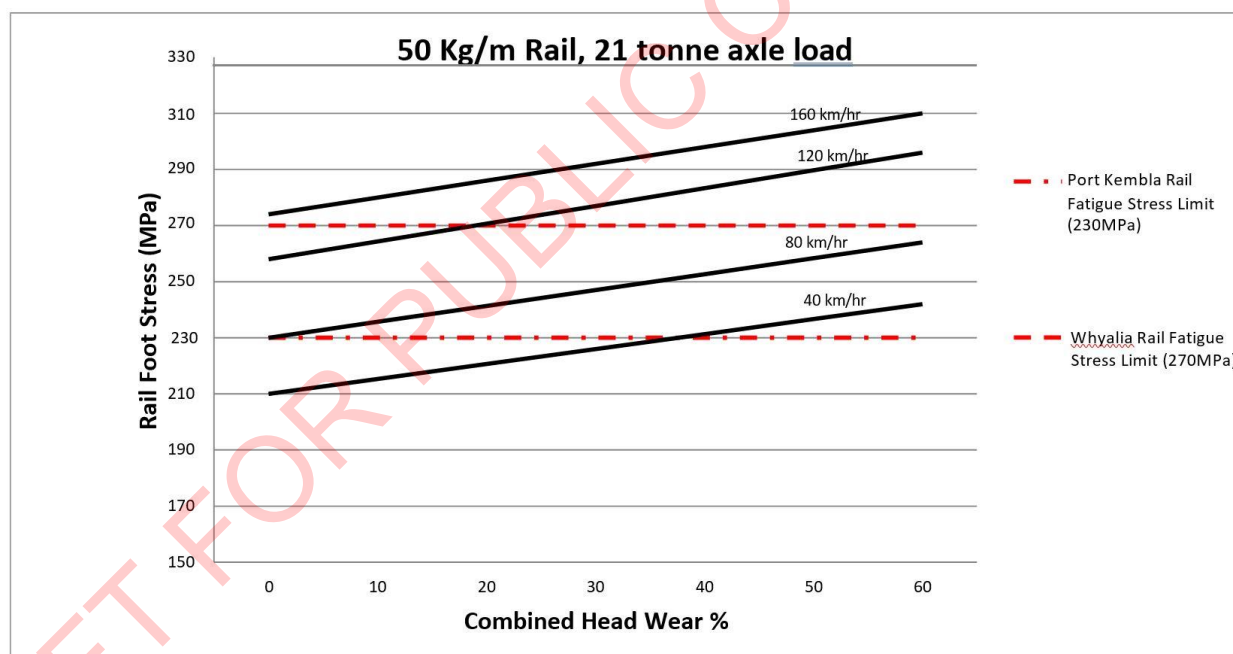




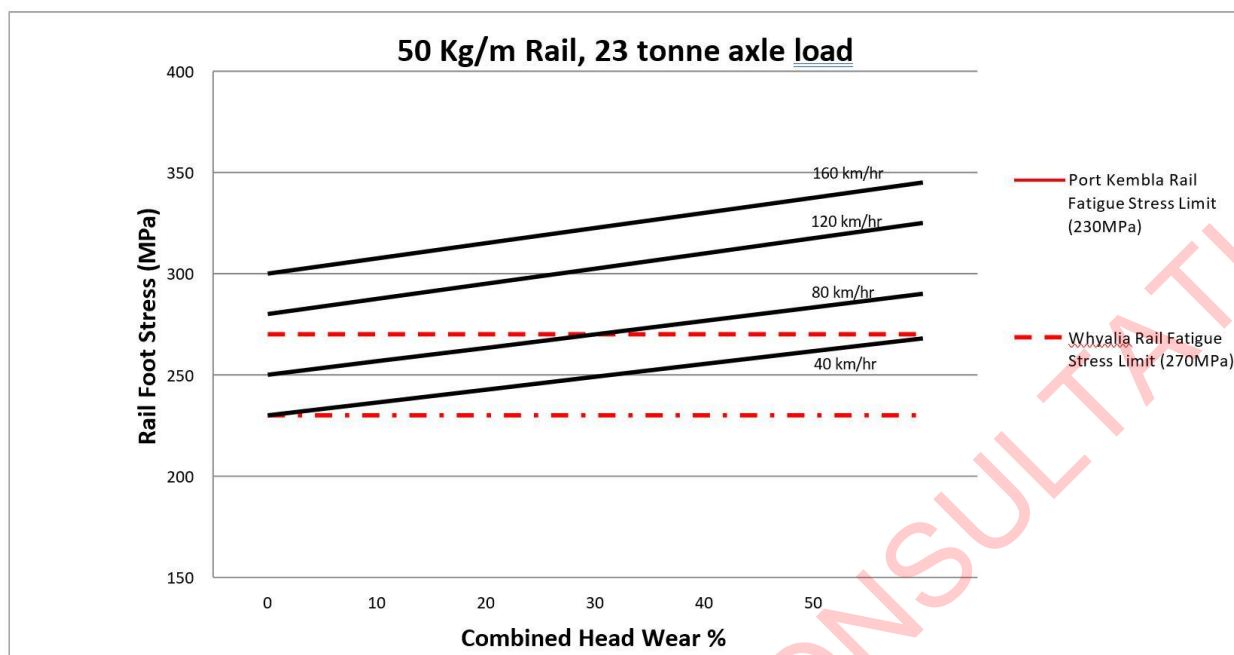
### C.10 50 Kg/m rail, 17 tonne axle load



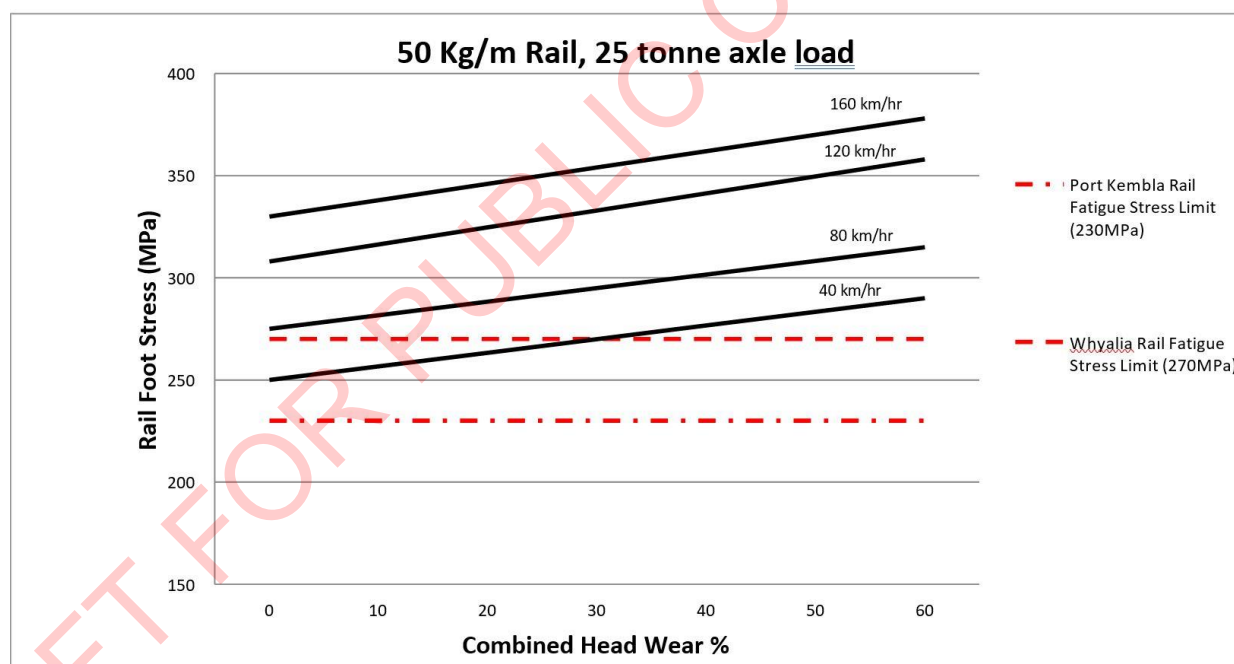
### C.11 50 Kg/m rail, 21 tonne axle load



**C.12 50 Kg/m rail, 23 tonne axle load**



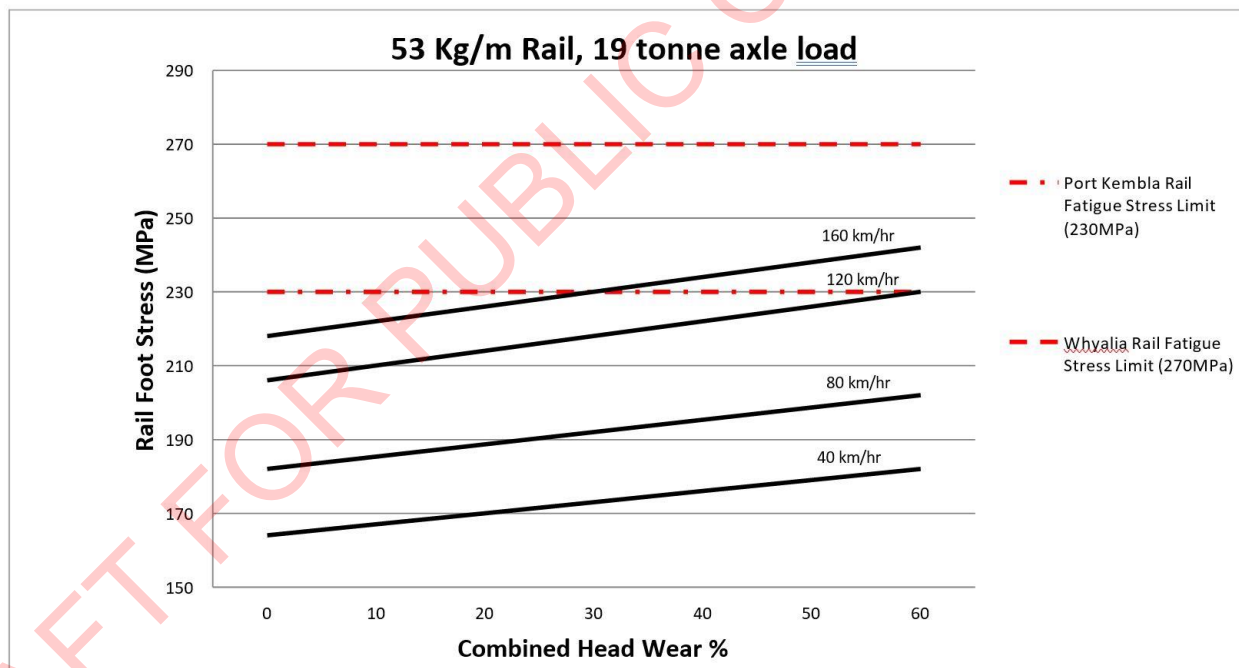
**C.13 50 Kg/m rail, 25 tonne axle load**



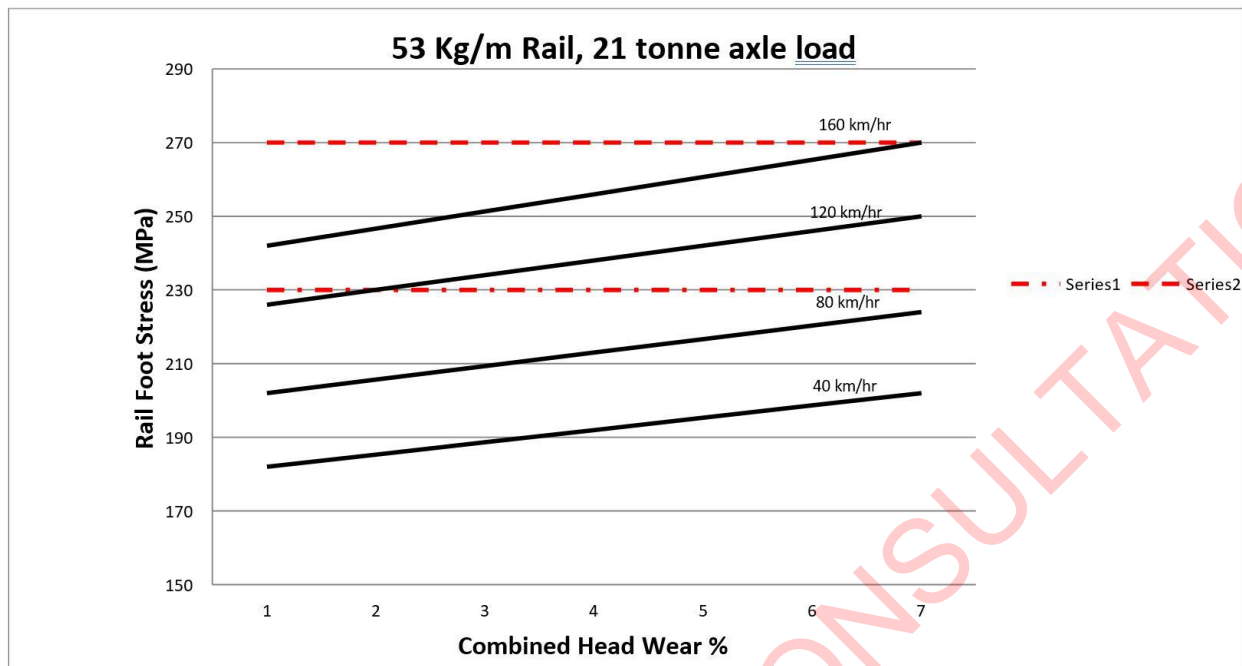
C.14 53 Kg/m rail, 17 tonne axle load



C.15 53 Kg/m rail, 19 tonne axle load



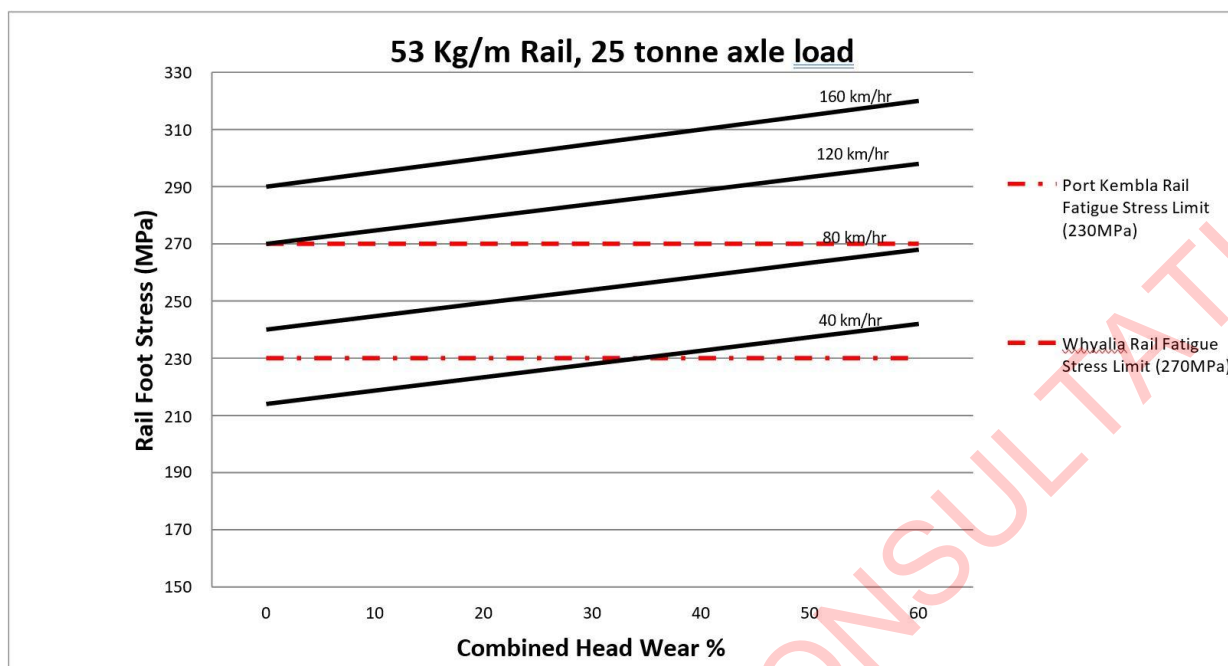
C.16 53 Kg/m rail, 21 tonne axle load



C.17 53 Kg/m rail, 23 tonne axle load



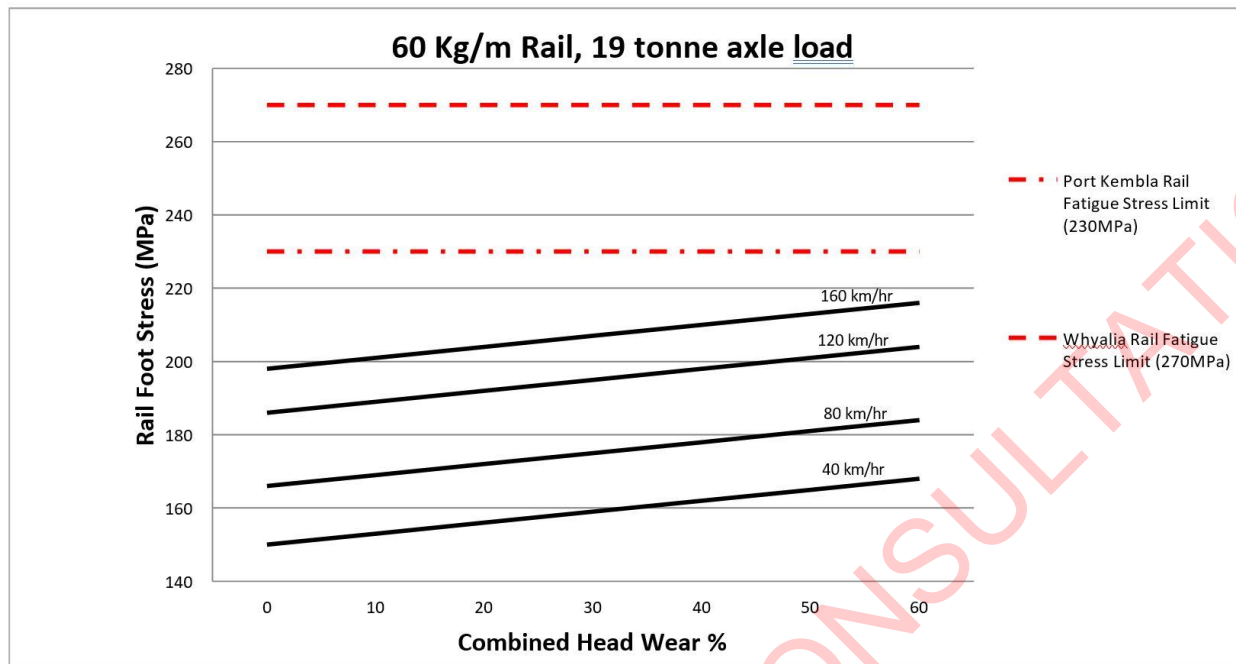
C.18 53 Kg/m rail, 25 tonne axle load



C.19 53 Kg/m rail, 25 tonne axle load



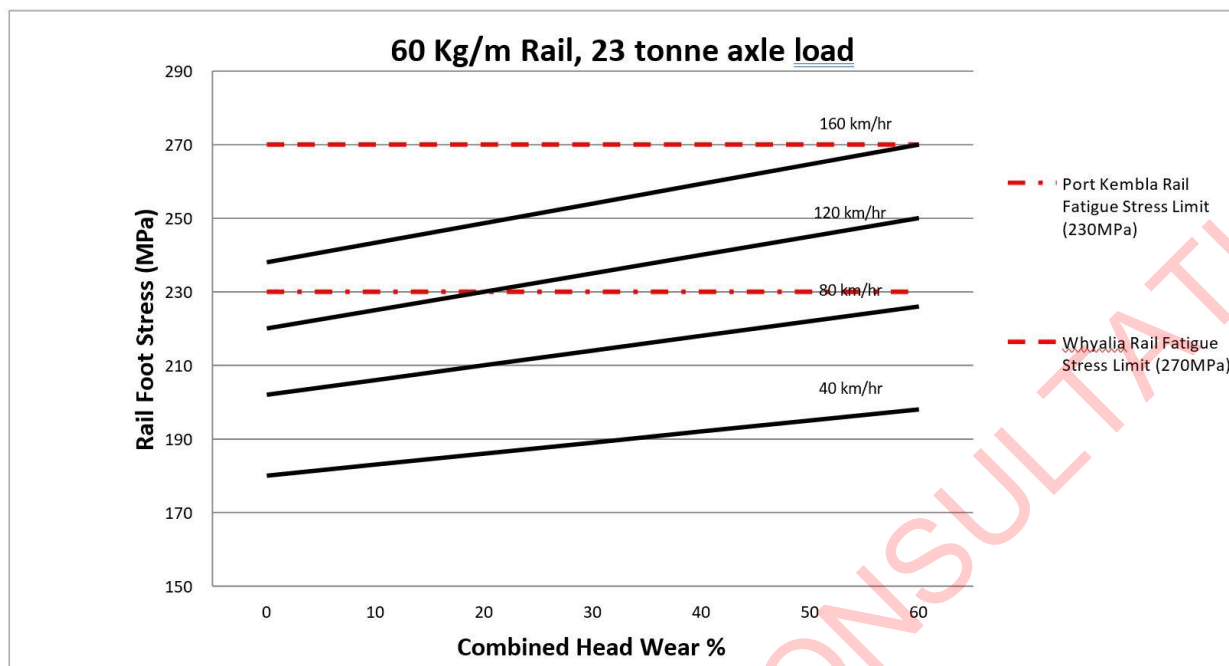
### C.20 60 Kg/m rail, 19tonne axle load



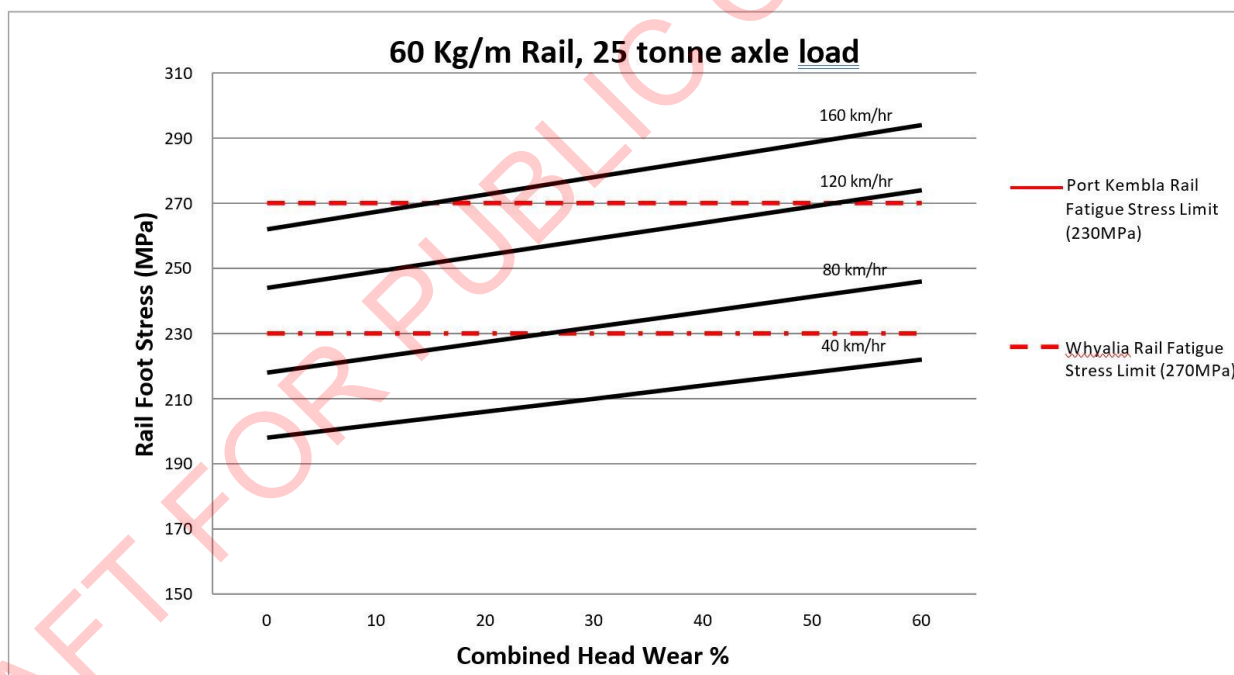
### C.21 60 Kg/m rail, 21 tonne axle load



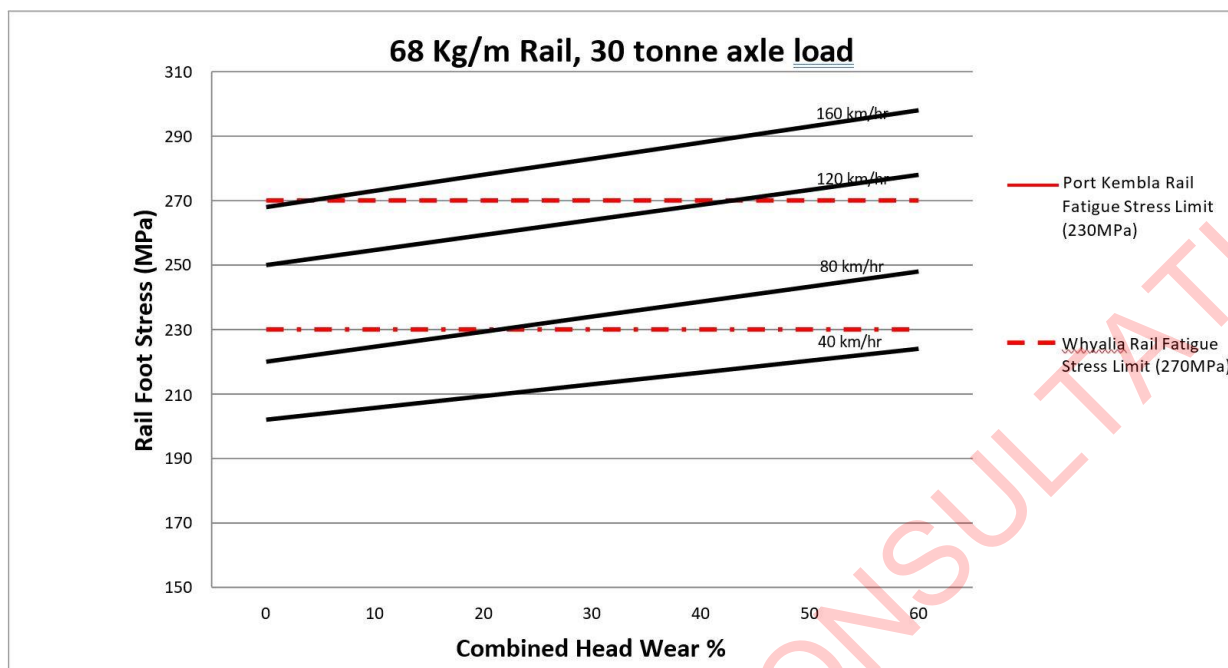
## C.22 60 Kg/m rail, 23 tonne axle load



## C.23 60 Kg/m rail, 25 tonne axle load



**C.24 68 Kg/m rail, 30 tonne axle load**

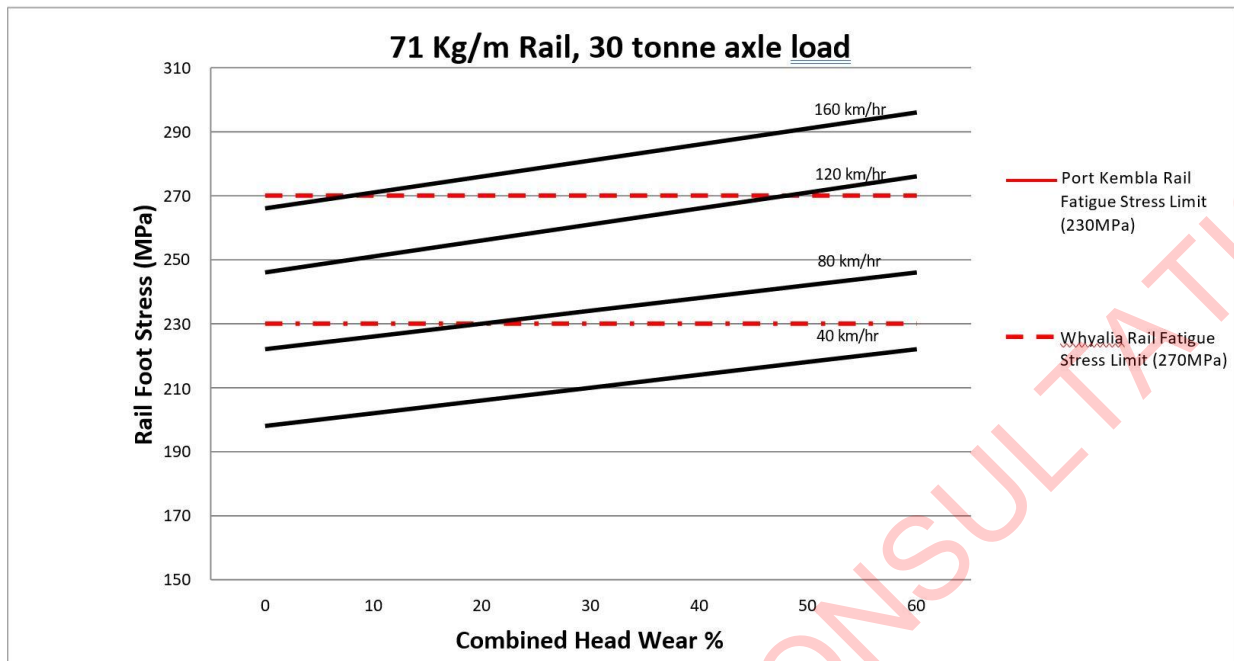


**C.25 68 Kg/m rail, 33 tonne axle load**





**C.26 71 Kg/m rail, 30 tonne axle load**



**C.27 71 Kg/m rail, 33 tonne axle load**



## Appendix D Use of rail lubrication and friction modification (Normative)

Rail lubrication is applied to control friction at the rail/wheel interface and consequential rail/wheel wear, noise, and train energy consumption.

### D.1 System design

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

- (r) The friction coefficient on the gauge face of the outer rails on curves should be  $< 0.30$  and preferably  $< 0.25$  if metropolitan passenger trains are involved.
- (s) The friction coefficient on the contact surfaces of both rails should be  $> 0.35$  ( $> 0.40$  preferred) and  $> 0.40$  on grades steeper than 1 in 50.
- (t) A lower friction level may be acceptable on the contact surface in the immediate area of the lubricator (within 50 m).
- (u) It is also desirable that the difference in the running surface friction coefficients between the high and low rails should be  $< 0.15$ .

### D.2 Placement

Lubrication should be considered:

- (v) on curves of 800 m radius or sharper depending on track design, wheel and rail profiles and train operations.
- (w) on other curves exhibiting, or with a history of, gauge face wear on the high rail; and
- (x) where flanging noise is a problem.

The factors to be considered in the placement of lubrication should include:

- (y) minimal effect on traction and braking.
- (z) at the start or approach of a curve where wheel flange contact would normally commence.
- (aa) lubricant spread on a rail on balloon loops and bi-directional tracks; and
- (bb) clearances to low lying items such as check rails and trackside equipment.

Lubrication should not be placed:

- (cc) in the body of a sharp curve;
- (dd) where there could be a tripping hazard for train crews or shunting personnel;
- (ee) where there is an unacceptable risk that lubricant splatter onto the head of the rail could cause trains to overrun signals or platforms;
- (ff) in front of a platform face; or
- (gg) where heavy sanding for locomotive traction is common.

In locations where lubrication is required on both rails, maintaining adequate tractive and braking forces needs to be considered.

Under severe grade conditions (steeper than 1:50), lubricators on opposite rails should not be positioned within 500 m of each other.

Where there is a change in operating condition or environment, the locations of lubricators should be reviewed.

### **D.3 Installation**

Where fixed lubricators are used, they shall be installed in accordance with the manufacturer's instructions.

All trackside lubricators shall be fixed by clamping to the rail.

New installations should not be fixed by bolting through the rail.

Lubricators shall be made clearly visible to train crews, operators of on-track equipment, track maintenance and lubricator servicing personnel by painting or other appropriate marking or signage.

In areas where vandalism is of concern, action should be taken to minimize the effect of tampering.

### **D.4 Lubricator performance**

The factors affecting the performance of lubricators include:

- (hh) the type of lubricant;
- (ii) wheel contact;
- (jj) rate of feed;
- (kk) servicing; and
- (ll) condition of unit.

### **D.5 Lubricant**

Environmental factors shall be considered in the selection of lubricant.

If standard lubricant is used, an appropriate mat should be placed to prevent contamination of the ballast and the environment.

### **D.6 Inspection and maintenance**

#### **D.6.1 Inspection**

Inspection of rail lubricators should be carried out in accordance with the manufacturers' requirements.

#### **D.6.2 Maintenance**

Lubricators removed for maintenance from the track for any reason should be reinstated as quickly as possible to ensure that any unavoidable wheel and rail wear is minimized.

Maintenance of lubricators should consider the adjustments required for seasonal average ambient temperature variation, to compensate for changes in lubricant viscosity.

#### **D.6.3 Alternative lubrication strategy**

Manual placement of lubricant on the gauge face is permissible, however lubricant should not be placed on the top of the rail.

Alternative lubrication strategies, e.g., top of the rail friction modifiers, should be periodically reviewed.

#### **D.6.4 Friction modification**

Prior to implementing top of rail lubrication for the purpose of noise mitigation, the following issues should be considered:

- (mm) Signal Locations.
- (nn) Rail head roll due to changed friction characteristics.

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## Appendix E Common rail defects examples (Informative)

### E.1 Internal defects

#### E.1.1 Bolt hole crack

A progressive fracture that originates at a bolt hole and progresses radially away from the hole (Figure 5).

The origin is usually stresses along the edge of the bolt hole. The stresses can be the result of vertical or horizontal rail movement, improper drilling, a burr on the edge of the bolt hole, or rollingstock impacts. Growth can be erratic and accelerated when subjected to additional stresses. Upon service failure the rail can fracture into several pieces.

As bolt holes are normally associated with fishplated joints, visual detection can only be possible after removal of plates. The crack can be accentuated by the effects of oxidation (bleeding).



Figure 5 Bolt hole crack

#### E.1.2 Bolt hole elongation

Mechanical compression or damage at a bolt hole arising from interaction with the bolt. The hole becomes oval (Figure 6) with the resultant metal flow concentrating stress. This defect can progress to a bolt hole crack. A horizontal split web can develop in a welded rail if the defect is not removed.

As bolt hole defects are normally associated with fishplated joints, visual detection can only be possible after removal of plates.



*Figure 6 Bolt hole elongation*

#### **E.1.3 Bolt hole, non-conforming**

This defect can result in additional stresses in bolt holes.

As bolt hole defects are normally associated with fishplated joints, visual detection can only be possible after removal of plates.

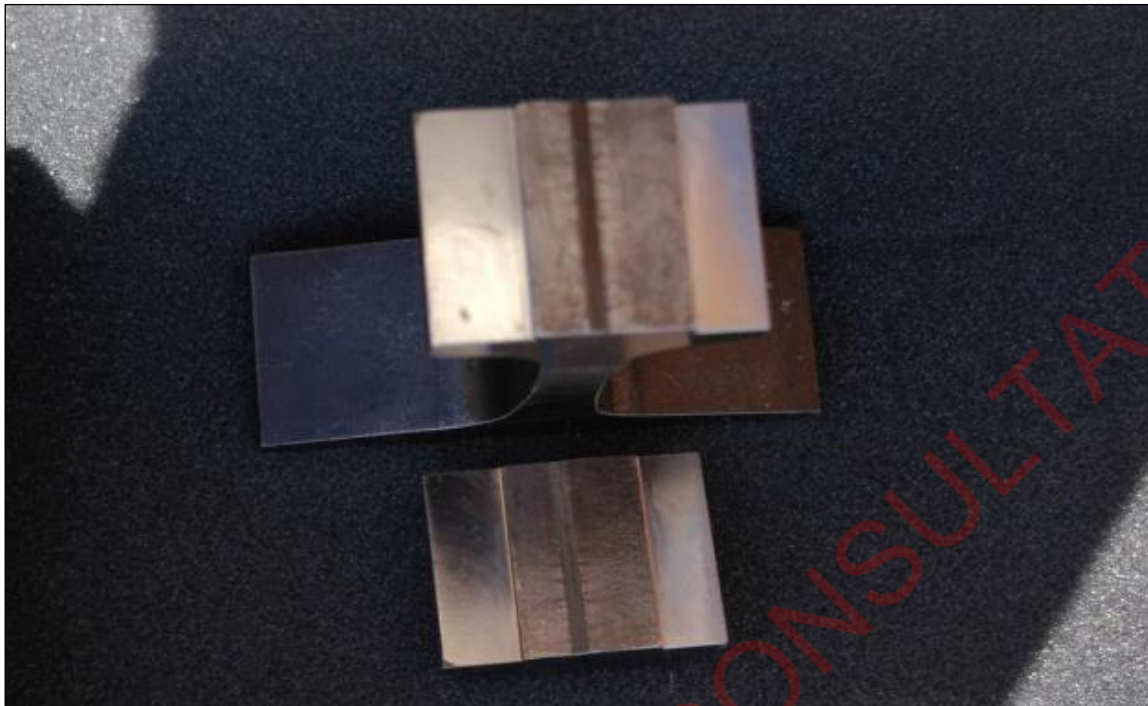
#### **E.1.4 Horizontal split head**

An internal defect that occurs within the head of rail. It is a progressive longitudinal fracture in the rail, where separation along a seam spread horizontally through the head (Figure 7), parallel to the running surface. It can curve upwards or downwards before breaking.

The origin of this defect is an internal longitudinal seam, segregation or inclusion. This can be seen by a widening in the top of the rail head. A horizontal crack will eventually start to form on the sides of the rail head.

This defect can result in a long section of the rail head falling out and can occur throughout the rail and therefore result in multiple breaks.





*Figure 7 Horizontal split head*

#### **E.1.5 Horizontal split web**

A defect that occurs within the web of the rail and can start from a weld. As it grows it can curve downwards or upwards or simultaneously in both directions.

This defect is fast growing and can result in a long section of the rail head and web falling out.

Detection is by visual observation of a horizontal crack forming on the sides of the rail web, which can be noticed by rust marks.

#### **E.1.6 Longitudinal vertical split web (VSW)**

It is a progressive vertical fracture in the rail, where separation along a seam spreads vertically through the web (Figure 8) parallel to the web of the rail.

In itself a VSW is not a serious defect. However, it can develop into a serious defect, for example piped rail or horizontal split web. It can occur throughout the rail.



*Figure 8 Longitudinal vertical split web*

#### **E.1.7 Mill defect**

Deformations, cavities, seams, or foreign material found in the head, web, or foot of a rail. They are formed during rail manufacture.

Progression depends on the type of defect, its position within the rail, and stresses within the rail.

Surface defects can be visible, but the defect is too small to detect visually.

#### **E.1.8 Multiple transverse defects**

Defects where there is more than one transverse defect in the same rail.

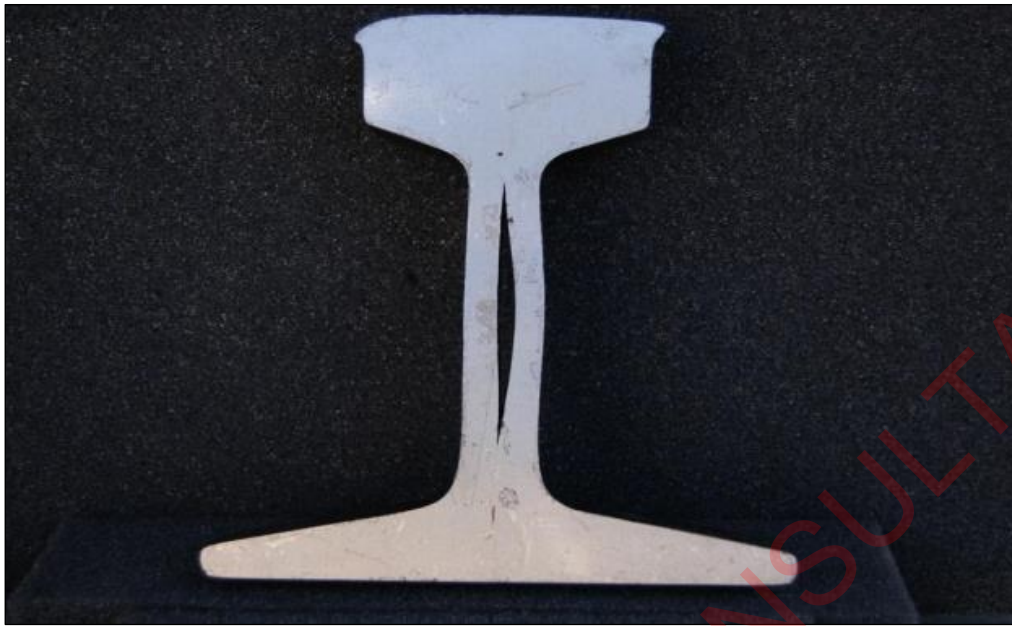
#### **E.1.9 Piped rail**

A longitudinal internal defect that occurs within the web or head of the rail. The development of a vertical split due to heavy loads can lead to an opening of a cavity and a bulge in the web. The pipe can originate from a mill defect and can contain inclusions.

Shallow cracks due to distortion can be found in the bulging surface, and a slight depression above the pipe. Cracking can also develop at the edge of the bulge.

Upon service failure the rail can break into several pieces.





*Figure 9 Piped rail*

#### **E.1.10 Shatter crack**

A defect originating as a series of small hydrogen inclusions or cracks in the head of a rail. This defect is likely to exist throughout that piece of the rail and is characterised by a series of closely spaced internal defects that occur within the head of the rail.

Shatter cracks are likely to progress to transverse defects.



*Figure 10 Shatter crack*

### E.1.11 Transverse defect

A single isolated transverse internal defect that occurs within the head of rail. The remainder of that piece of rail between adjacent welds should be checked ultrasonically for other transverse defects. If present, then the defect should be treated as a multiple transverse defect (TM).

The origin of this defect is an imperfection in the steel, e.g., a shatter crack, minute inclusion, or an internal longitudinal seam or segregation. Impact of the wheels and stress reversals in the rail start the growth of a transverse separation around the imperfection. Visual detection is only possible after the defect has reached the surface. Rail breakage often occurs before the defect becomes visible.



*Figure 11 Transverse defect*

### E.1.12 Transverse defect from impact

A transverse defect propagated from an impact (e.g., derailment) on the rail foot. The origin of this defect is high stresses below the rail surface that grow from a nick or bruise mark on the rail, (e.g., an anchor strike).

### E.1.13 Transverse defect from shelling

A transverse defect propagated from shelling. This defect originates below the rail surface usually at the gauge corner on high legs of curves and can mask a transverse defect that grows into the rail head.

The origin of this defect is high stresses below the rail surface that grow from an imperfection in the steel, for example a minute inclusion.



*Figure 12 Transverse defect from shelling*

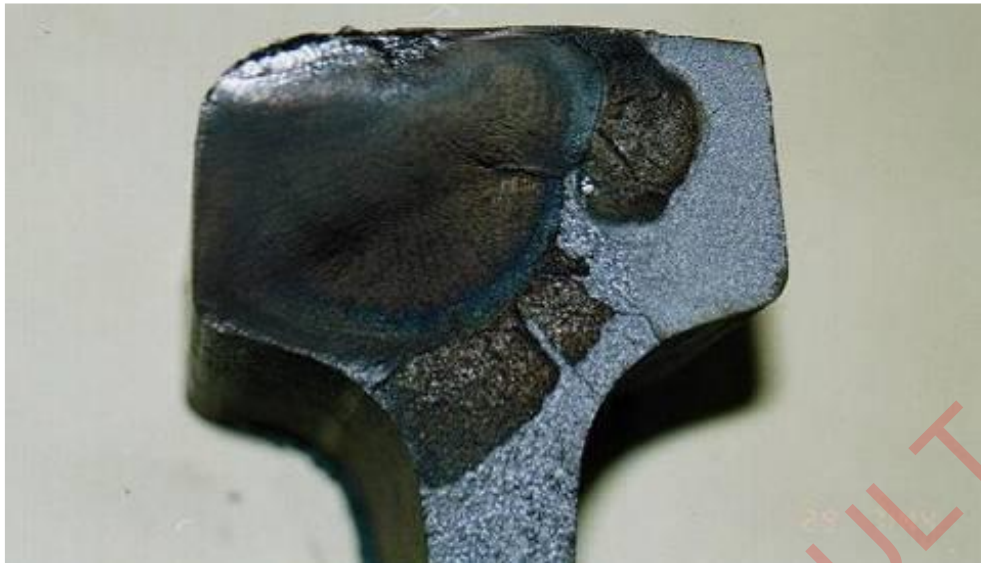
#### **E.1.14 Transverse defect from wheel burn**

A transverse defect propagated from a wheel burn.

A slipping wheel heats the rail surface and can flow the metal. Rapid cooling forms thermal cracks and wheel pounding starts

horizontal separations.

Visual detection of such cracks or separations is usually not possible due to masking by the wheel burn.



*Figure 13 Transverse defect from shelling*

#### **E.1.15 Transverse vertical split web**

An internal defect that occurs within the web of the rail. It is a progressive vertical fracture in the rail where separation across the web of the rail will eventually lead to complete rail failure.

#### **E.1.16 Vertical split head**

An internal defect that occurs within the head of rail.

It is a progressive vertical fracture in the rail, where separation along a seam spread vertically through the head, parallel to the side of the rail.

This is a serious defect because it can:

- (oo) result in a long section of the rail head falling out; and
- (pp) occur throughout the remainder of that piece of rail and therefore result in multiple breaks.

Detection is by visual observation of widening in the top of the rail head, or the dipping of one side of the rail head.



*Figure 14 Vertical split head*

#### **E.1.17 Weld defect**

Internal defects that occur within the head, web, or foot of a rail at welds joining rails. They usually start from incorrect welding procedures or imperfections (e.g., inclusions from the welding process) within the weld zone. The weld zone extends 100mm each side of the weld. Any rail or weld defect of internal origin occurring in this zone shall be classified as a welding defect.

Visual detection is only possible after the defect has reached a surface.





*Figure 15 Weld defect*

## **E.2 External defects**

### **E.2.1 Broken foot**

A progressive fracture in the foot of the rail with a vertical split. The separation is longitudinal but usually turns out to the edge of the foot. These separations are often called half-moon breaks.

The cause is usually uneven bearing on plates, damage to rail foot or a seam, segregation or inclusion. The crack is usually visible and can be accentuated by the effects of oxidation (bleeding).



*Figure 16 Broken foot*

### **E.2.2 Broken rail**

A square or angular sudden rupture, transverse separation of the head, web, and foot of the rail. This type of failure usually occurs in very cold weather and is often caused by concentrated loadings (overstressing) from rollingstock or track maintenance operations.

### **E.2.3 Corroded rail**

Corrosion of the metal on the foot or web of the rail which results in pits or cavities. Corrosion occurs in wet or damp areas and is usually a slow process. However, the process will be accelerated in situations where electric current passes through the rail due to electrolysis, or where chemicals, for example, sea water in coastal environment, acidic ground water or fertilisers are concentrated.

Points of high stress from corrosion pitting or severe reduction in cross-section may cause sudden failure.



*Figure 17 Corroded rail*

#### **E.2.4 Corrugation**

Rail corrugations are cyclic (wave like), vertical, irregularities on the running surface of the rail.

Corrugations are of two main types:

(a) Short pitch corrugations develop under lighter nominal axle load (<20 tonnes) passenger operations.

This corrugation usually has a depth of less than 0.2 mm - 0.3 mm and a wavelength from about 30 mm to 90 mm.

(b) Long pitch corrugations develop under higher nominal axle load (>20 tonnes) mixed freight and unit train operations.

This corrugation usually has a depth range from 0.1 mm to above 2.0 mm and a wavelength above about 300 mm.





*Figure 18 Corrugation*

#### **E.2.5 Derailment damage**

Rail damage such as wheel marks, dents, scrapes, anchor strike or dogspike strike arising from running of derailed rollingstock.



*Figure 19 Derailment damage*

#### **E.2.6 Flaking**

A defect that appears as a mosaic or snakeskin like pattern on the running surface of the rail. In the latter stages of growth, the cracks produce "spalls" that can be up to about 10 mm to 15 mm wide, up to 3 mm deep, and can be continuous along the rail length.



*Figure 20 Flaking*

#### **E.2.7 Foot web separation**

A crack that occurs in the foot and web fillet area. It is a progressive crack along the fillet. Visual detection is by inspection of the foot/web fillet.



*Figure 21 Foot web separation*

#### **E.2.8 Gauge corner cracking**

Multiple surface cracks running across the gauge corner, which left untreated will result in gauge corner cracking out.





*Figure 22 Gauge corner cracking*

### **E.2.9 Head shelling**

Small fractures commence at the surface of the rail and extend into the head and quite often small pieces break out completely. This mostly occurs on the gauge corner and crown, and they are readily detected by the appearance of dark spots on the running surface.



*Figure 23 Head shelling*

### **E.2.10 Head web separation**

A crack that occurs in the rail end where the head and the web separates. It starts developing parallel to the head/web fillet and may, as it develops, curve either upwards or downwards, or in both directions simultaneously.

It is a progressive crack along the fillet. This is a serious defect because it can:

- (a) result in a long section of the rail head falling out; and
- (b) occur throughout the remainder of that piece of rail and therefore result in multiple breaks along the rail. Detection is by inspection of any crack or rust running along the head/web fillet.

Detection is by inspection of any crack or rust running along the head/web fillet.



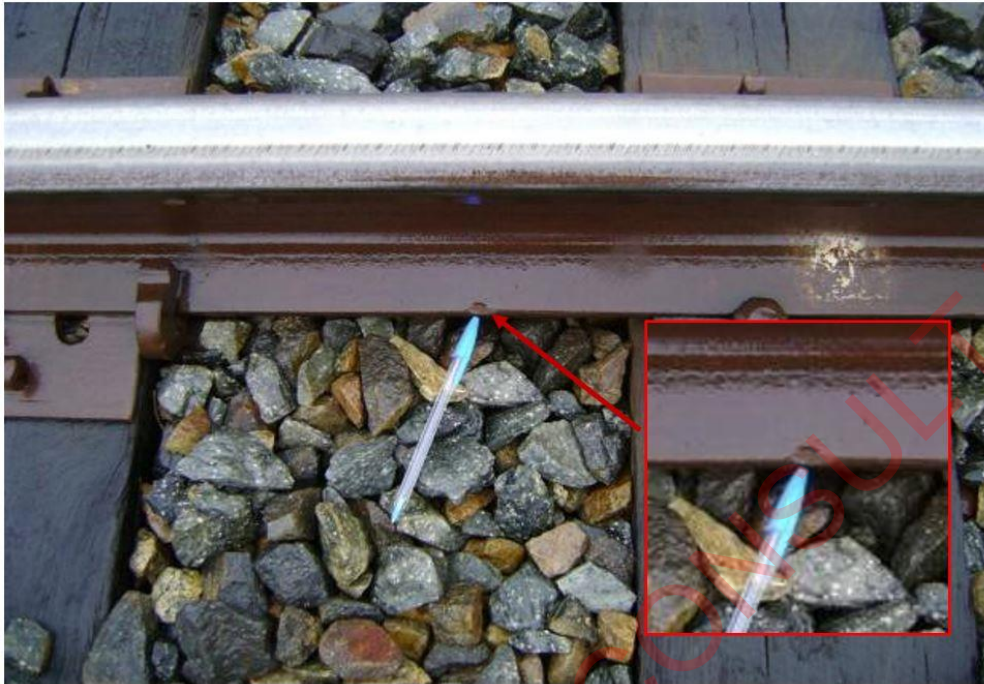
*Figure 24 Head web separation*

#### **E.2.11 Mechanical joint suspect**

Rail damage on the surface of the rail head from the action of the wheels battering the rail ends. This creates an area of metal flow and dipping of the rail end. In severe cases it can lead to total rail failure.

#### **E.2.12 Notches**

Mechanical damage to the head, web or foot of the rail that results in a point of stress concentration. It can be caused by careless handling of rail, hammer blows, equipment contact, damaged wheels, overdriven fastenings, local corrosion, wear from plates or fastenings, saw cutting or gas cutting. Defects are visible.



*Figure 25 Notch in foot of rail*

### **E.2.13 Squat**

Squats are surface or near-surface initiated defects, which can be of two types, 1. the more common type of squats, which are initiated on the crown or ball of the rail head, or, 2. those that are initiated from the gauge corner checking cracks. These are easily identified visually, as they appear as dark spots or “bruises” on the running surface of the rails. The defective area seems darkened because of the sub-surface cracking which occurs typically on a horizontal plane, approximately 3 mm to 5 mm below the rail surface, and which causes a depression on the rail surface.





*Figure 26 Squat*

**E.2.14 Weld defect alignment**

Any deviation from set rail end alignment tolerances.

**E.2.15 Weld defect visual**

Any visual defect on the surface of the weld such as a hole, crack or porosity.

**E.2.16 Wheel burn**

A scar on the running surface of the rail caused by intense friction heating from driving wheel slippage. The flowed metal can chip out and thermal cracks can develop into a transverse defect.



*Figure 27 Wheel burn*

## Appendix F Defect sizing and response guidelines (Normative)

### F.1 Defect treatment for tracks of various classification

Table F1 below shows a defect treatment regime for an organization with tracks of various classification. The Track Manager should develop a similar defect treatment management methodology in accordance with AS 7630 Track classification.

#### F.1.1 Defects and actions

Defect	Comment on actions
Bolt hole (crack, elongation, or non-conforming)	Defects should be cut out and replaced by a closure rail. The closure rail may be welded at both ends provided specified rail lengths are not exceeded.
Broken foot	Defects should be cut out and replaced by a closure rail.
Broken rail	Defects should be cut out and the rail welded (subject to compliance with guidelines for distances to bolt holes) or replaced by a closure rail.
Corroded rail	The defective portion of rail should be replaced.
Foot/web separation arc head web separation	Repairs should 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.
Horizontal split (head or web)	Repairs should 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.
Mechanical joint	The necessary repair should be determined by a competent worker,
Mill defect	Repair is not normally required until growth is detected. The defect should then be reclassified according to the nature of propagation or failure.
Multiple transverse defects	Repairs should be carried out by replacing the complete rail between welds. unless the rail has been inspected in detail by manual ultrasonic examination. The rail removed should be immediately rendered unsuitable for reuse.
Notches	Defects should be cut out and the rail welded or replaced by a closure rail.
Unclassified Defect	The necessary repair should be determined by a competent worker.
Piped Rail	Repairs should be carried out by replacing the complete rail between welds. unless the rail has been examined in detail by manual ultrasonic examination. The rail removed should be immediately rendered unsuitable for reuse.
Rail surface (e.g., rolling contact fatigue)	The necessary repair should 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.

Vertical Split (head or web)	Repairs should be carried out by replacing the complete rail between welds. unless the rail has been examined in detail by manual ultrasonic examination. The rail should be immediately rendered unsuitable for reuse
Weld defect (head, web or foot)	Repairs should be done by removing the weld and replacing it with a closure rail, or by using wide gap welds if no bolt holes exist.

## F.2 Rail and rail welded joint assessment responses

### F.2.1 Standard track types for determining assessment responses

Assessment responses are based on two representative track types, Type A and Type B, which are defined in the table in appendix F.2.2.

For track where all factors fall within the definition of Type A track, then the response times and action regimes for Type A track shall apply.

For track where all factors fall within the definition of Type B track, then the response time and action regimes for Type B track shall apply.

Where the factors vary between those of Type A and Type B track an assessment shall be performed to determine the appropriate response times and action regimes. Type A track represents a higher risk situation requiring more stringent responses. Type B track is the base case track type. Responses (and inspection frequency) should be adjusted to suit local conditions and special situations of risk hazards (e.g., high embankments, very tight curvature, bridges), and should include consideration of the actual operating regime.

Assessment and actions Defects detected from inspections should be assessed and reported in accordance with the classification, position and sizing codes as specified in actions for each defect and the response time to carry out such actions accordingly.

Rail support system	A sleeper and fastening system that supplies longitudinal lateral and vertical restraint to the rail equivalent to dog spiked and rail anchored track	A sleeper and fastening system that supplies longitudinal lateral and vertical restraint to the rail equivalent to concrete, steel or timber sleepers track with resilient fastenings
Passenger volumes	Over an average of 1000 passengers per day	Up to an average of 1000 passengers per day

### F.2.2 Rail and rail welded joint assessment responses tables

Factor	Type A Track	Type B Track
Line Type	Multiple Main Lines	Single Main line
Track Alignment	Track alignments with curve radii less than or equal to 600 m	Track alignments with curve radii greater than 600 m or straight

Note: Table applies to 47 kg rail or greater.

Table does not apply to local areas of higher risk, for example at bridges or track on high embankments. The criteria that divides each factor between Type A or B tracks are indicative and not absolute.



Type of defect	Defect size	Type A track		Type B track	
		Response time	Action	Response time	Action
Shatter crack	<5% (<10 mm)	90 Days	Reassess or remove	360 Days	Reassess or remove
	<5%		Treat as a Multiple transverse defect		Treat as a Multiple transverse defect
Transverse defect	5-7% (10-15 mm)	7 days	Reassess or plate or remove	90 days	Reassess or plate or remove
	7-10% (18-20 mm)	7 days	Reassess or plate or remove	30 days	Reassess or plate or remove
	10-30% (21 mm to 30 mm)	day	Speed restrict and reassess, or plate or remove	14 days	Reassess or plate or remove
	>30% (>30 mm)	2 hours	Pilot or plate or remove	1 day	Speed restrict and reassess, or plate or remove
	>30% and surface cracking on rail head	Prior to the passage of the next train	Pilot or plate or remove	Prior to the passage of the next train	Speed restrict and visually inspect every day. or plate or remove
	Broken rail (ref BR defect)	Prior to the passage of the next train	Pilot or plate or remove	Prior to the passage of the next train	Pilot or plate or remove
Multiple transverse defects	5-7% (10 mm to 15 mm)	7 days	Reassess or remove	60 days	Reassess or remove
	7-10% (16 mm to 20 mm)	7 days	Reassess or remove	14 days	Reassess or remove
	10-30% (21 mm to 30 mm)	1 day	Speed restrict and reassess every day or remove	1 day	Speed restrict and reassess or remove

Type of defect	Defect size	Type A track		Type B track	
		Response time	Action	Response time	Action
	>30% (>30 mm)	Prior to the passage of the next train	Pilot or remove	Prior to the passage of the next train	Speed restrict or remove
	>30% and surface cracking on rail head	Prior to the passage of the next train	Pilot or remove	Prior to the passage of the next train	Pilot or remove
<b>Transverse defects from wheel burn</b>	Any		Treat as Transverse Defect or Multiple Transverse defect as appropriate.	Treat as Transverse Defect or Multiple Transverse defect as appropriate.	Transverse defects from wheel burn
<b>Transverse defects from shelling</b>	Any		Treat as Transverse Defect or Multiple Transverse defect as appropriate.	Treat as Transverse Defect or Multiple Transverse defect as appropriate	Transverse defects from shelling
<b>Horizontal split head</b>	25 mm to 100 mm	35 days	Reassess or remove	90 days	Reassess or remove
	101 mm to 200 mm	7 days	Reassess or remove	30 days	Reassess or remove
	>200 mm	Prior to the passage of the next train	Speed restrict and visually inspect every day or remove	14 days	Reassess or remove
	>200 mm and with severe bleeding or head flow	Prior to the passage of the next train	Speed restrict and visually; inspect every day or remove	Prior to the passage of the next train	Speed restrict and visually inspect every day or remove
	Broken Rail (refer BR defect)	Prior to the passage of the next train	Pilot or remove	Prior to the passage of the next train	Pilot or remove
<b>Horizontal split web</b>	40 mm to 75 mm	2 days	Speed restrict or remove	7 days	Reassess or remove

Type of defect	Defect size	Type A track		Type B track	
		Response time	Action	Response time	Action
	->75 n-m	Prior to the passage of the next train	Pilot or remove	Prior to the passage of the next train	Pilot or remove
	Broken Rail	Prior to the passage of the next train	Pilot or remove	Prior to the passage of the next train	Pilot or remove
	40 mm to 75 mm	2 days	Speed restrict or remove	7 days	Reassess or remove
<b>Vertical split head</b> <b>NOTE: Check for piped rail and transverse or horizontal spirt web</b>	25 mm to 130 mm	35 days	Reassess or remove	90 days	Reassess or remove
	101 mm to 200 mm	35 days	Reassess or remove	45 days	Reassess or remove
	201 mm to 400 mm	7 days	Reassess or remove	7 days	Reassess or remove
	>400 mm	Prior to the passage of the next train	Speed restrict and visually inspect every day or remove	Prior to the passage of the next train	Speed restrict and visually inspect every day or remove
	Broken Rail	Prior to the passage of the next train	Pilot or remove	Prior to the passage of the next train	Pilot or remove
<b>Vertical split web</b> <b>NOTE: Check for piped rail and transverse or horizontal spirt web</b>	= IZ <sup>as</sup>	180 days	Reassess or remove	180 days	Reassess or remove
<b>Piped Rail web</b>	25 mm to 150 mm	35 days	Reassess or remove	60 days	Reassess or remove
	151 mm to 300 mm	7 days	Reassess or remove	14 days	Reassess or remove
	>300 mm	Prior to the passage of the next train	Speed Restrict and reassess every day or remove	1 day	Speed restrict or remove

Type of defect	Defect size	Type A track		Type B track	
		Response time	Action	Response time	Action
	Visible cracking	Prior to the passage of the next train	Speed Restrict and reassess every day or remove	Prior to the passage of the next train	Speed restrict and reassess every day, or remove
	Broken rail	Prior to the passage of the next train	Pilot or remove	Prior to the passage of the next train	Pilot or remove
<b>Transverse split web</b>	20 mm to 40 mm	7 days	Reassess, plate or remove	7 days	Reassess, plate or remove
	41 mm to 75 mm	2 days	Reassess, plate or remove	2 days	Reassess, plate or remove
	>75 mm	Prior to the passage of the next train	Speed restrict, plate or remove	Prior to the passage of the next train	Speed restrict, plate or remove
	Broken rail	Prior to the passage of the next train	Pilot or remove	Prior to the passage of the next train	Pilot or remove
<b>Head web separation</b>	20 mm to 75 mm	7 days	Reassess or remove	7 days	Reassess or remove
	78 mm to 200 mm	2 days	Speed restrict and reassess every day, or remove	2 days	Speed restrict and reassess every day, or remove
	> 200 mm	Prior to the passage of the next train	Speed restrict and reassess every day, or remove	Prior to the passage of the next train	Speed restrict and reassess every day, or remove
	Broken rail	Prior to the passage of the next train	Pilot or remove	Prior to the passage of the next train	Pilot or remove
<b>Bolt hole crack NOTE: For bolt hole cracks less than 20mm refer engineering instruction ETI-01-05 dated Oct 2008</b>	20 mm to 40 mm	7 days	Reassess or remove	30 days	Reassess or remove.
	41 mm to 75 mm	2 days	Speed restrict and reassess every day, or remove	7 days	Reassess or remove

Type of defect	Defect size	Type A track		Type B track	
		Response time	Action	Response time	Action
	>75 mm	Prior to the passage of the next train	Speed restrict and reassess every day, or remove	Prior to the passage of the next train	Speed restrict and reassess every day, or remove
	Broken rail	Prior to the passage of the next train	Pilot or remove	Prior to the passage of the next train	Pilot or remove
<b>Bolt hole elongation</b>	To be determined				
<b>Bolt hole non-conforming</b>	To be determined				
<b>Weld defect head</b>	5 to 10% (10 mm to 20 mm)	7 days	Reassess, plate, repair or	180 days	Reassess, plate, repair or remove
	10 to 30% (21 mm to 30 mm)	1 day	Reassess, plate, repair or remove	90 days	Reassess, plate, repair or remove
	30 to 70% (31 mm to 40 mm)	2 hours	Speed restrict and reassess every day, or plate, or remove	30 days	Reassess, plate, or remove
	>70% (>40 mm)	Prior to the passage of the next train	Speed restrict and reassess every day, or plate, or remove	Prior to the passage of the next train	Speed restrict or remove
	Surface cracking on rail head (visual- not confirmed)	Prior to the passage of the next train	Speed restrict and reassess every day, or plate, or remove	7 days	Speed restrict and reassess every day, or remove
		By ultrasonic examination		NOTE: Surface cracking can sometimes not be very deep, but this can only be confirmed by manual ultrasonics.	
	Broken weld	Prior to the passage of the next train	Pilot, or plate, or remove	Prior to the passage of the next train	Pilot or plate, or remove

Type of defect	Defect size	Type A track		Type B track	
		Response time	Action	Response time	Action
<b>Weld defect web</b>	<15 mm width and full height of rail foot	14 days	Reassess or plate or remove	30 days	Monitor Removal is optional
	51 mm to 75 mm	1 day	Speed restrict and reassess daily, or plate, or remove	30 days	Reassess, plate or remove
	>75 mm	2 hours	Speed restrict and reassess daily, or plate, or remove	1 day	Speed restrict and reassess daily. or plate. or remove
	Broken weld	Prior to the passage of the next train	Pilot or plate or remove	Prior to the passage of the next train	Pilot or plate or remove
<b>Weld defect foot</b>	<15 mm width and full height of rail foot	14 days	Reassess or plate or remove	30 days	Monitor Removal is optional
	15 mm to 35 mm width (if on edge use 10 mm to 35 mm)	1 day	Speed restrict and reassess every day, or remove	1 day	Speed restrict and reassess every day, or remove
	>35 mm width	Prior to the passage of the next train	Speed restrict and reassess every day, or remove	Prior to the passage of the next train	Speed restrict and reassess every day, or remove
	Broken Weld	Prior to the passage of the next train	Pilot or plate or remove	Prior to the passage of the next train	Pilot or plate or remove
<b>Weld defect surface</b>	3% to 7% (10 mm to 15 mm)	7 days	Reassess, plate, repair or remove	90 days	Reassess, plate, repair or remove
	7% to 10% (18 mm to 20 mm)	7 days	Reassess, plate, repair or remove	30 days	Reassess, plate, repair or remove

Type of defect	Defect size	Type A track		Type B track	
		Response time	Action	Response time	Action
	10% to 20% (21 mm to 30 mm)	1 day	Speed restrict, plate. repair or remove	14 days	Reassess, plate, repair or remove
	>20% (>30 mm)	Prior to the passage of the next train	Speed restrict, plate. repair or remove	1 day	Reassess, speed restrict, plate. repair or remove
	>20% and surface cracking on rail head	Prior to the passage of the next train	Speed restrict, plate. repair or remove	Prior to the passage of the next train	Speed restrict, plate, repair or remove
	Broken weld	Prior to the passage of the next train	Pilot or plate, or remove	Prior to the passage of the next train	Pilot or plate, or remove
<b>Mill defect</b>	NOTE: The necessary action should be assessed by a competent worker				
<b>Corroded rail</b> NOTE: The necessary action should be assessed by a competent worker and include consideration of the location, extent and geometry of the corrosion Refer also to Rail Surface below where corrosion impacts on the running surface of the rail.	>3 mm section loss in web or foot	7 days	Speed restrict, until removed	7 days	Speed restrict until removed
<b>Mechanical joint</b>	Any	14 days	Remove plates and assess	14 days	Remove plates and assess

Type of defect	Defect size	Type A track		Type B track	
		Response time	Action	Response time	Action
<p><b>Rail Surface: e.g., rolling contact fatigue</b></p> <p><b>NOTE:</b> The necessary action should be assessed 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.</p> <p>Rolling contact point fatigue is a known phenomenon and owners are referred to current literature on the topic.</p>		To be determined			



Type of defect	Defect size	Type A track		Type B track	
		Response time	Action	Response time	Action
<b>Wheel Burn</b>  <b>NOTE: Wheel burns should be removed by grinding and/or surface repair welding and in severe cases by removal of the rail and insertion of a closure rail. Grinding should remove all heat affected rail steel. Wheel burns can vary significantly in severity. The severity will determine the response time and actions necessary. The geometry of the wheel burn can result in severe dynamic loading of the track and a resulting increased rate of deterioration of the track structure in general. Where defects are not removed from track, a defect management plan should be put in place to monitor the wheel burn for TWH defects and general track deterioration</b>	Any	[1]	Check for Transverse defect from wheel burn	[1]	Check for Transverse defect from wheel burn
<b>Notches</b>	<b>NOTE: The necessary action should be assessed by a competent worker and include consideration of the location, extent and geometry of the notch or cut. isolated dented or bruised rail, for example due to a hammer blow can possibly not require removal.</b>				

Type of defect	Defect size	Type A track		Type B track	
		Response time	Action	Response time	Action
<b>Broken foot</b>	All	Prior to the passage of the next train	(Pilot) or (Speed restrict, plate and reassess daily) or (Remove)	Prior to the passage of the next train	(Pilot) or (Speed restrict, plate and reassess daily) or (Remove)
<b>Broken rail</b>	All	Prior to the passage of the next train	(Pilot) or (Speed restrict, plate and reassess) or (Remove)	(Pilot) or (Speed restrict, plate and reassess) or (Remove)	Broken rail

NOTE 1: If not otherwise specified "reassess" requires defects that have not been corrected to be re-examined ultrasonically (\* or by visual or other means if ultrasonic methods are not appropriate). If not otherwise specified, the frequency of reassessment is to be the same as the nominated response time.

NOTE 2: Time periods used in the previous table are based on the assessment of the rate of propagation of rail defects. Where a defect cannot be actioned in accordance with the table an assessment of the track condition is to be undertaken. This should be based on the severity of the defect, the time to planned repair completion, whether and under what circumstances trains can operated over the defect and what arrangements for regular retesting and increased surveillance are to be made.

## Appendix G Bibliography (Informative)

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The following referenced documents are used by this Standard for information only:

- (a) AS 7642 - Turnouts and Other Special Trackwork
- (b) Guideline - Wheel and Rail Profile Development