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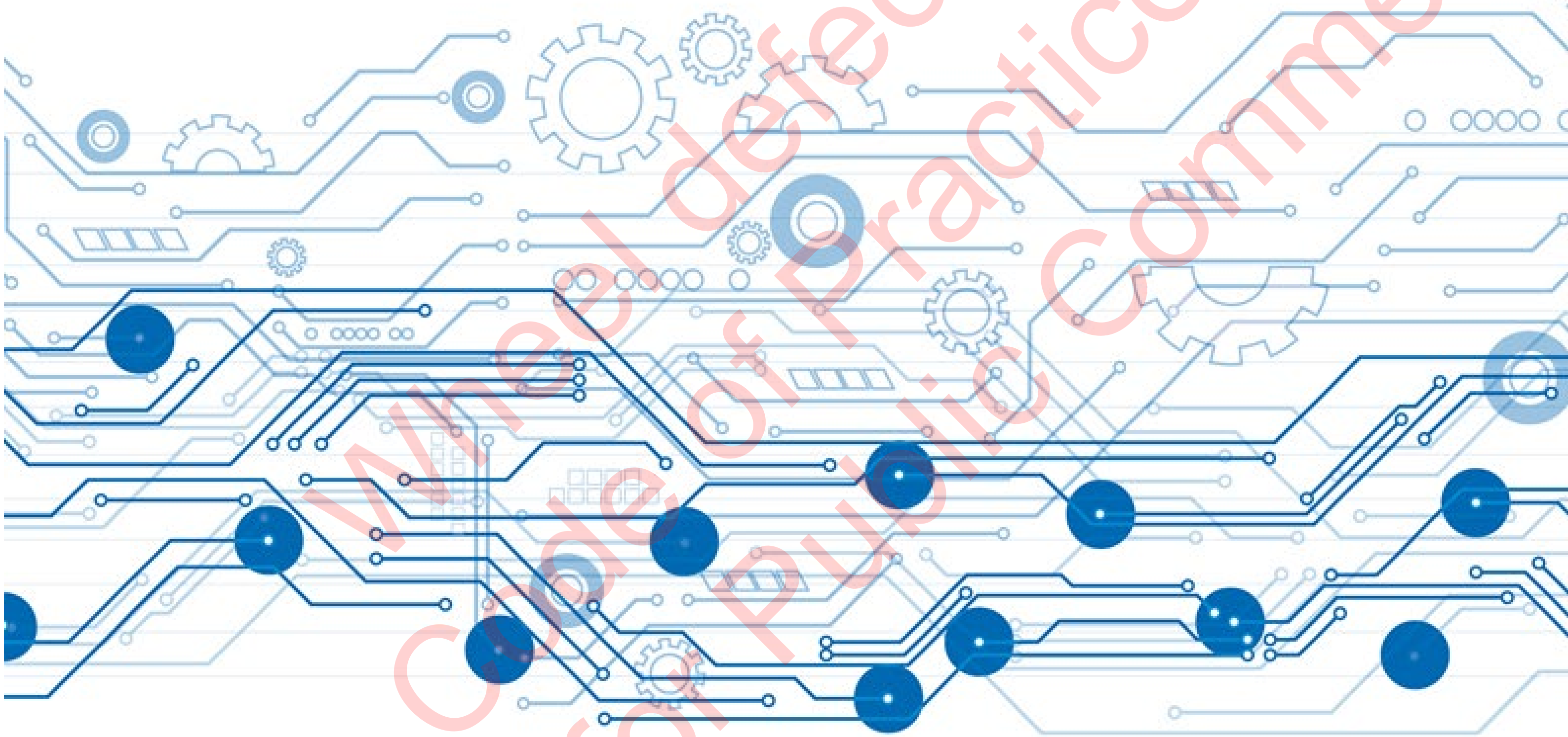
RAIL INDUSTRY SAFETY AND STANDARDS BOARD



Wheel defects
Code of Practice

This Rail Industry Safety and Standards Board (RISSB) product has been developed using input from rail experts from across the Rail Industry. RISSB wishes to acknowledge the positive contribution of all subject matter experts and DG representatives who participated in the development of this product.

The RISSB Development Group for this Code of Practice consisted of representatives from the following organisations:

John Holland	Metro Trains	PTA
ATRC	Queensland Rail	Aurizon
DPTI	TfNSW	Pacific National

Development of this Code of Practice was undertaken in accordance with RISSB's accredited processes. It was approved by the Development Group, endorsed by the Standing Committee, and approved for publication by the RISSB Board.

I commend this Code of Practice to the Australasian rail industry as part of the suite of RISSB products assisting the rail industry to manage rail safety, improve efficiency and achieve safety outcomes through interoperability and harmonisation.

Deborah Spring
Chief Executive Officer | Executive Chair
Rail Industry Safety and Standards Board

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RISSB welcomes suggestions for improvements and asks readers to notify us immediately of any apparent inaccuracies or ambiguities, please contact us via email at info@rissb.com.au or write to Rail Industry Safety and Standards Board, PO Box 518, Spring Hill, QLD 4004, Australia.

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Document Control

Identification

Document Title	Version	Date
Wheel defects	2.0	29 July 2020

Document History

Publication Version	Effective date	Page(s) Affected	Reason for and extent of changes
2.0		All	New edition (CoP reviewed and updated)
1.2	2 August 2013		Clarifications and correction of minor errors
1.1	15 Jul 2013		Errata – missing Appendix A Wheel measuring points inserted, and old Appendix A & B become B & C
1.0	3 December 2012	All	First Publication

Approval

Name	Date
Rail Industry Safety and Standards Board	

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Contents

1 Introduction

1.1 Purpose

This document describes requirements for the inspection and repair of freight, passenger, and infrastructure maintenance rolling stock wheels, providing definitions and illustrations of wheel faults and defects. Each defect category has a severity and corresponding action.

The main purposes of the requirements are to:

- reduce the risk of derailment arising from wheel failure;
- reduce the risk of damage to infrastructure caused by wheel defects;
- minimise hunting/maintaining good vehicle stability; and
- minimise wheel/rail contact stresses in order to prevent rolling contact fatigue in wheels and rails.

1.2 Scope

This Code is supplementary to AS 7514 and applies to new and existing locomotive, freight, passenger and infrastructure maintenance rolling stock.

This Code is not specifically intended to cover rolling stock used on light rail, cane railway and monorail networks, but items from this Code may be applied to such systems as deemed appropriate by the relevant Railway Infrastructure Manager (RIM).

Dimensions and limit values given in this Code are primarily for wheels over 700 mm diameter. Where smaller wheels are used, suitable adjustments to the wear and defect limits may be made by the RTO.

The defect levels given in this Code are for operation at speeds below 200 km/h. For operational speeds above 200 km/h the defect levels given in this Code may be reassessed by the RTO / RIM based upon the risk.

This Code prescribes a system of classification for several common defects and includes representative photographs and/or figures. There are also instructions relating to the appropriate action to be taken in the case of each defect. Where this Code prescribes a restricted speed for a defective vehicle the maximum permitted speed over any track section is the lower of the speed prescribed by this Code and the maximum permissible track speed for that section.

For operations with axle loads exceeding 30 t the specific wheel defect limits and their requirements for qualifying wheelsets for service, including their methods of measure, are not included in this Code. Likewise, the specific methods of repair, actions to be taken and permitted speeds may not be applicable or acceptable to axle loads exceeding 30 t.

When moving rolling stock between differing networks e.g. DIRN and Pilbara networks, or between Queensland, South Australia, Tasmania and Western Australia narrow gauge networks, the differing wheelset back-to-back dimensions, wheel cross-sections and profiles applicable to each network shall be taken into account.

Application of this standard to infrastructure maintenance rolling stock that operate at speeds below 15 km/h or at rail wheel axle loads below 5 t needs to be assessed on an individual basis and RTOs should develop specific wheel defect criteria where necessary.

Significant technical changes from the previous revision of this Code include:

(a) section and clause numbering from section 4 onwards to support relocation of the following content to appendices:
   i. inspection technologies;
   ii. types of gauges; and
   iii. repair guidance.

(b) section based numbering applied to tables (previously referred to as charts) and figures throughout;

(c) removal of a measurement method for gauging rim thickness previously known as alternative 2 and the associated figures;

(d) updates to figure 3:1 – Location of limiting dimensions (previously referred to as figure 2) and associated notes to:
   i. indicate a range of values for the flange angle secondary measurement point;
   ii. note known variations for flange thickness limits in use by RTOs.

1.1 Normative references

The following reference documents are indispensable for the application of this Code of Practice:

(a) AS 7514 – Wheels.

(b) AS 7517 – Wheelsets.

1.2 Definitions

For the purposes of this Code of Practice the definitions given in the RISSB glossary of terms shall apply. The following definitions are specific to this Code:

(a) ***arris***
raised lip near the flange tip caused by metal flow under load

(b) ***back***
face of a wheel on the flange side

(c) ***class***
grade of wheel defect severity

(d) ***competent person***
person who carries out assessment and has suitable or sufficient skill, knowledge, experience and qualifications as determined by their organization

(e) ***cutter block***
special brake block (or cutting shoe) that is utilised for the purpose of reconditioning a wheel tread

(f) ***flange***
protruding portion of a wheel profile, the function of which is to provide lateral restraint and guidance by making contact with the gauge face of the rail head

(g) ***front***
face of a wheel on the non-flange side

(h) ***heat check***
wheel tread surface checking (a network of fine cracks) caused by heat input from tread braking that is not cause for wheel removal

(i) ***hub***
central portion of a wheel that interfaces with the axle. Also known as the boss

(j) ***infrastructure maintenance rolling stock***
track machines and road-rail vehicles used for infrastructure maintenance, construction, or inspection

(k) ***maintenance officer***
person with experience identifying wheel defects

(l) ***out-of-round wheel***
wheel that exhibits rim radial run out that exceeds the maximum permissible. Includes wheel tread corrugation

(m) ***overheated wheel***
wheel that has been subjected to potentially damaging thermal input, typically as a result of heavy braking or sticking brakes

(n) ***remove from service***
removal of vehicle from service within the specified time until the damaged wheelset is replaced by a serviceable wheelset or where appropriate, machined on an underfloor lathe

(o) ***rim***
outer portion of a wheel that interfaces with the rail

(p) ***rim face***
vertical front (outer) or back (inner) surface of the rim

(q) ***rim width***
distance between the faces of the rim

(r) ***rolled edge***
lip overhanging the rim face formed by metal under load flowing from the tread, typically occurring fully around the circumference of the wheel

(s) ***rolling-contact fatigue***
mechanism of crack generation and propagation caused by the near surface alternating stress field that exists within rolling-contact bodies, which eventually leads to loss of material

(t) ***scaled wheel***
wheel that has a build-up of metallic scale on the surface of the tread. Also known as metal build up

(u) ***shelling***
circumferential metal loss (breakout) from a wheel tread due to rolling-contact fatigue. Also known as shelled tread

(v) ***skidded wheel***
wheel that has experienced a skid/slide after a "lock-up" under braking

(w) ***shattered rim***
defect initiated at a sub-surface defect within the wheel rim, resulting in loss of a segment of the wheel tread. Also known as deep shelling

(x) ***spalling***
localised loss (breakout) of metal from a wheel tread due to (brittle) martensite formation at the tread surface as a result of wheel skid/slide

(y) ***spread rim***
localised form of rolled edge generally caused by out-of-round wheel impacts or local fatigue cracking (a sub-set of the shattered rim defect)

(z) ***thermal crack***
transverse crack in the tread resulting from alternate heating and cooling of the wheel tread and rim

(aa) ***tread***
portion of a wheel profile that makes contact with the upper surface of the rail head

(bb) ***tread checking***
series of fine linear ridges in a wheel tread, often inclined, that could result from high wheel-to-rail contact stresses. Also known as stress checking

(cc) ***tread line***
datum line drawn on a wheel profile to indicate the position at which wheel diameter should be measured. Also known as the taping line. The position of the tread line may be approximately that of the circle of contact of a new wheel and unworn rail (mean position), subject to wheel profile and rail head contour and the position will vary, depending on which standard has been adopted for the wheel profile

(dd) ***web***
section between the wheel hub and the wheel rim. Also known as the plate

(ee) ***wheel flat***
flattened zone on the tread of a skidded wheel

(ff) ***wheelset***
assembly consisting of axle, wheels and bearings, and where applicable brake discs, traction gears, traction motor support bearings or gearbox

(gg) ***work out of service***
arrange for a defective vehicle to be removed from service for repair upon reaching its current allocated destination or on-route if reasonable to do so

2 General requirements

2.1 General

Wheel defects are classified according to their severity. A Class 1 defect is the least severe and a Class 5 defect is the most severe. Table 2:1 summarises the definitions that should be implemented in respect of each defect classification.

Table 2:1 - Wheel defect classification and definitions

Wheel defect classification	Definition
Class 1	Visual damage which does not impact rolling stock operation.
Class 2	Minor damage which requires reporting ongoing monitoring.
Class 3	Damage which requires ongoing management to assess the operational risk to rolling stock.
Class 4	Damage which requires ongoing management to assess impact to the operation risk to infrastructure.
Class 5	Severe damage. Vehicle not to run until defect rectified or wheel removed.

NOTE 1. An RTO should categorise and record the reasons for the removal of wheels from service.
NOTE 2. Moving a vehicle with Class 3 or greater defects presents operational risks to the RTO and or RIM. This Code does not specify operational outcomes for these defects, as this risk is managed at an organizational level.

2.2 Wheel defect categories

The following are the principal types of defect and unacceptable wheel condition:

(a) Rolling contact/thermal fatigue defects Initiated from surface or near surface:
  i. Thermal cracks - see Section 5.
  ii. Shelling - see Section 6.
  iii. Tread checks - see Section 13.

(b) Defects caused by heat generation from sliding:
  i. Spalling - see Section 6.
  ii. Wheel Flats - see Section 7.
  iii. Scaled wheels - see Section 8.

(c) Defects caused by wear, flow, and improperly steering bogies:
  i. Arrises & flange defects - see Section 9.
  ii. Steep flanges - see Section 10.2.1.
  iii. High flanges - see Section 10.2.2.
  iv. Hollow tread - see Section 10.2.3
  v. Rolled edges / spread rim - see Section 10.2.4.
  vi. Flange Plastic Flow - see Section 10.2.5.

(d) Fatigue defects originated below the surface:
  i. Cracked or broken web / plate - see Section 11.2.
  ii. Shattered rim - see Section 11.3.
  iii. Cracked or broken wheel rim - see Section 11.4.
  iv. Cracked or broken flange - see Section 11.5.

(e) Defects that cause or result from impacts:
  i. Dented flange - see Section 11.6.
  ii. Wheel distortion - see Section 11.6.
  iii. Out of round wheels - see Section 15.

(f) Defects associated with braking:

i. Overheated wheels - see Section 12.

ii. Misaligned brake gear - see Section 14.

2.3 Wheel features

Figures 2:1, 2:2 & 2:3 identify common important wheel features. Refer to Figure 3:1 and Appendix A for diagrams indicating common defining points as to where to measure critical parameters.

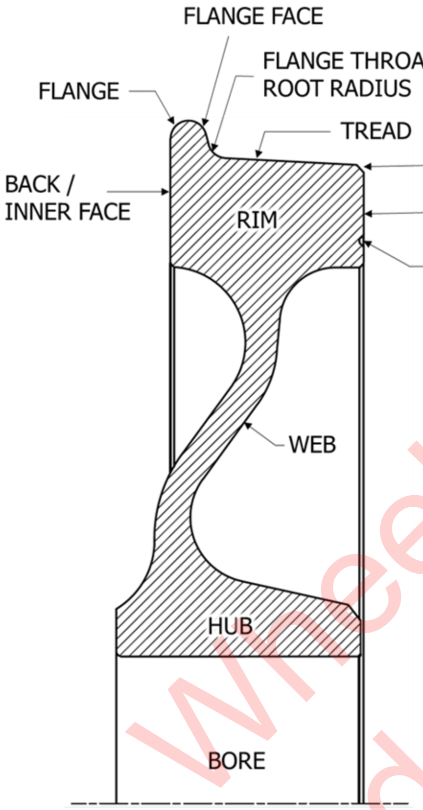


Figure 2:1 - Wheel disc terminology

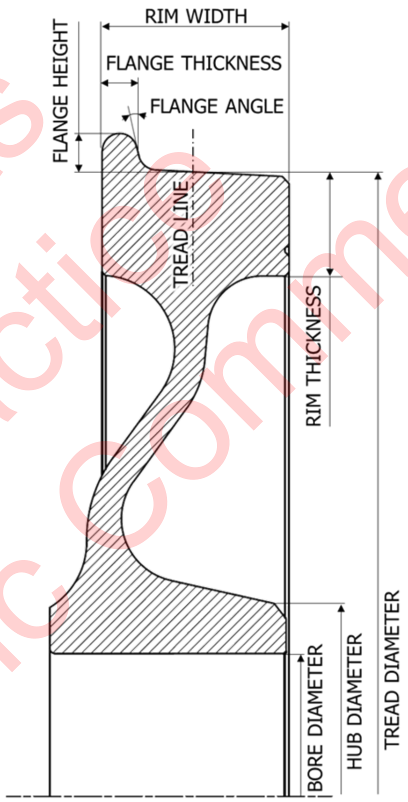


Figure 2:2 - Location of wheel limiting dimensions

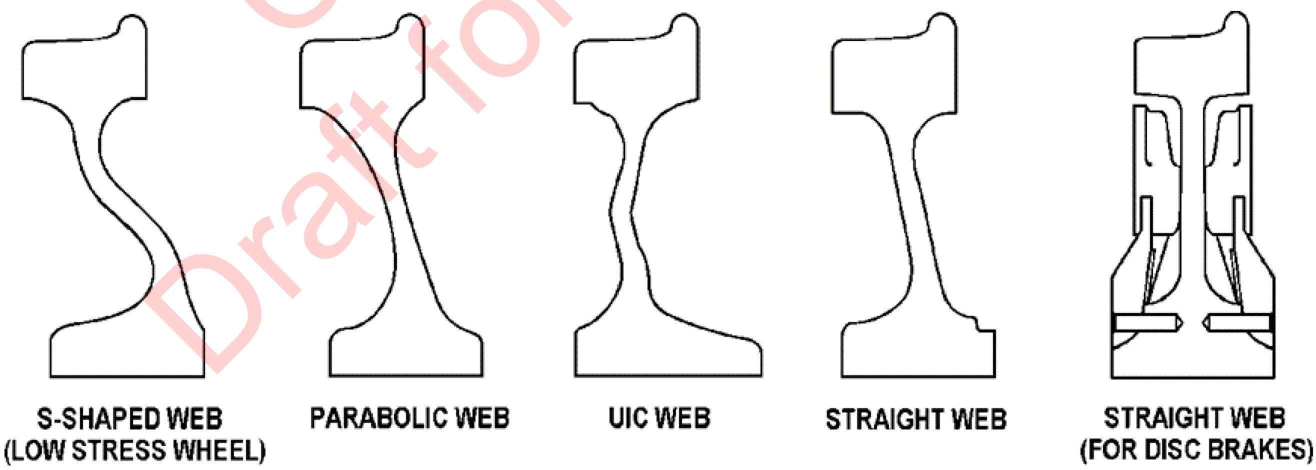


Figure 2:3 – Wheel shape definition

3 Wheel inspection

Wheels shall be inspected for profile, flange, tread, rim and general physical condition. A wheel can be condemned because of:

(a) thin flange;

(b) steep flange;

(c) high flange;

(d) thin rim;

(e) hollow tread;

(f) flange defects;

(g) tread defects;

(h) irregularities in contour including grooving;

(i) wheel out-of-roundness; or

(j) fractures and overheating.

This document generally describes the visual and manual methods of wheel inspection. However, Appendix C provides guidance for more modern inspection technologies available that can also be used.

Wheels should be inspected, and action taken in accordance with Tables 5:1 to 13:1 of this Code. Rolling stock shall be repaired or removed from service if wheels or wheelsets exceed the limits imposed by the relevant wheel gauges which represent the limiting parameters as shown in Tables 4:1 and 4:2.

See Figure 3:1 for locations of limiting dimensions. The figure shows new profiles, but the definitions also apply to worn profiles.

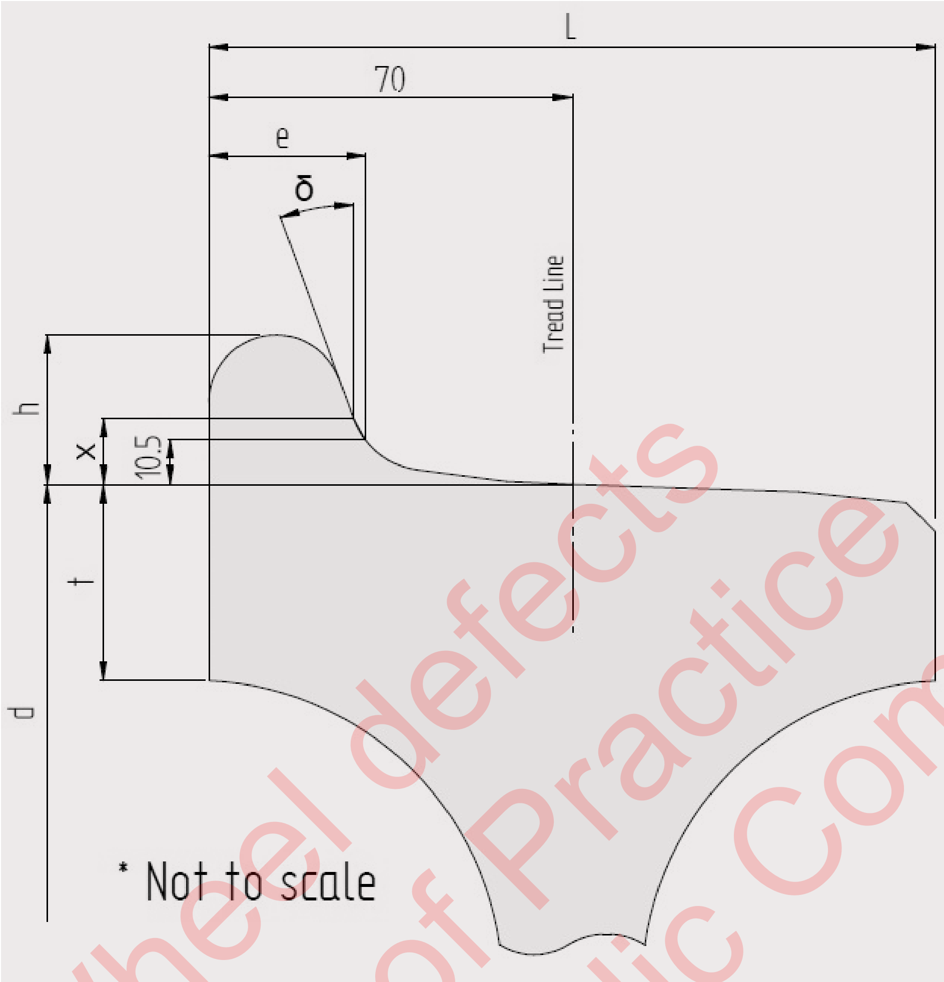


Figure 3:1 – Location of limiting dimensions

d: Wheel diameter
l: Rim width
e: Flange thickness[1]
h: Flange height
δ: Flange angle[2]
t: Rim thickness[3]
x: Flange angle secondary measurement point[2]

Note 1. Currently there is no consistent standard for measurement of flange thickness in Australia as the flange thickness is associated with the particular gauges being used by the RTOs. For the purpose of this Code, flange thickness limits will be related to the gauges presently in use and varies slightly between gauges used, at a height between 10.5 mm ±0.5 mm above the tread line point, except for Queensland Rail who measure the flange thickness between 16 mm ±0.5 mm above the tread line point.

Note 2. Flange angle is measured at any point between 13 - 18 mm above the tread line point.

4 Limiting dimensions

4.1 General

The accuracy of gauges used for checking limiting dimensions shall regularly be verified against approved standards.

4.2 Wheel rim thickness

Table 4:1 - Summary of limiting rim thickness

Limiting dimension	
Tread-braked wheels – Low stress design (S-shaped web)	
Up to 25 tonnes axle load	20 mm
Over 25 tonnes axle load	22 mm
Tread-braked wheels - Traditional	
Operations up to 80 km/h	20 mm
Operations over 80 km/h	25 mm
Locomotives	25 mm
Disc-braked wheels	
Locomotives	22 mm
Passenger vehicles	20 mm

Note 1. Traditional wheels refers to wheels that have no low stress design, e.g. wheels with UIC web or straight web.

Note 2. The values in 4:1 shall be applied regardless of rim thickness definition. Allowable rim thickness definitions are defined in Figure 3:1.

Note 3. Special consideration may be required for wheels of less than 700 mm diameter.

Note 4. If the wheels have a condemning groove, the rim thickness can be checked visually. The requirement for continued service then is that the condemning groove is fully visible and unaffected by wear.

Note 5. Wheels with rim thickness less than the limiting dimensions in Table 4:1 shall be worked out of service within 14 days.

4.3 Permissible variation in wheel diameter

Maximum variation in wheel tread diameter on a wheelset shall be as specified in AS 7517.

Note**:** Normally wheel diameters are only checked at wheelset exchange or at wheel reprofiling.

4.4 Limiting tread and flange dimensions

Maximum permissible tread and flange parameters shall be as per Table 4:2.

Table 4:2 - Summary of limiting wheel parameters (in train inspections)

Limiting dimensions	
Maximum permissible flange height	
All vehicles	35 mm
Maximum permissible tread hollowing	
All vehicles	3 mm
Minimum permissible flange thickness	
Using gauges 307 0030, 17-4-1, 207-661 (see note 1) or equivalent	19 mm
Queensland Rail Narrow gauge network	22 mm

NOTE 1. Gauge 207-661 is to be used for indication only. Gauges 307-030 and 17-4-1 are the definitive condemning gauges.

4.5 Movement of a wheel on axle

Any wheel that exhibits movement relative to its axle shall be immediately removed from service. Symptoms of wheel movement are wheel seat becoming visible or back-to-back measurement getting out of tolerance.

4.6 Tyred wheels

Tyred rail wheels shall be inspected either before each trip or at intervals less than 1000 km.

Tyred wheels shall be removed from service if identified with any of the following criteria:

(a) Loose tyre rotation around the wheel centre.

(b) Detachment of retaining ring.

(c) Cracked spokes.

(d) Cracks or flaws on any wheel disc or centre.

5 Thermal cracks

Thermal cracks are the result of alternate heating and cooling of the wheel tread and rim area, and are a severe form of wheel defect, see Figures 5:1 to 5:4. These cracks originate from areas of metallurgical change which occur in the wheel material during thermal cycling.

Heating from braking produces a network of fine, shallow, superficial lines or "heat checks" running in many different directions on the wheel tread surface. Because of its similarity to the type of fine cracks found in pottery glazes, it is sometimes referred to as surface crazing. This should not be confused with true thermal cracking, and if found on its own causes no problems.

Thermal cracks are generally transverse (across the tread) and if allowed to grow without corrective action can quickly lead to brittle failure and the wheel will fracture.

If there is any doubt as to the severity of the thermal crack, the higher classification shall be reported.

Refer to Table 5:1 for description of the defect and actions to be taken.

If a vehicle is detected with thermal cracks, the brake system shall be checked for correct operation and correct type of brake blocks. Where cracks are found outside the shaded area according to Table 5:1, brake alignment with the tread (i.e. no brake show over hanging the rim edge) shall be checked.

Lateral and longitudinal surface traction forces can also produce a series of fine checks on the wheel tread caused by rolling contact fatigue (not to be confused with thermal cracks). These are generally inclined at a 45-degree angle and most commonly occur near the front face of the wheel and flange where the wear rate is low (see Section 13).

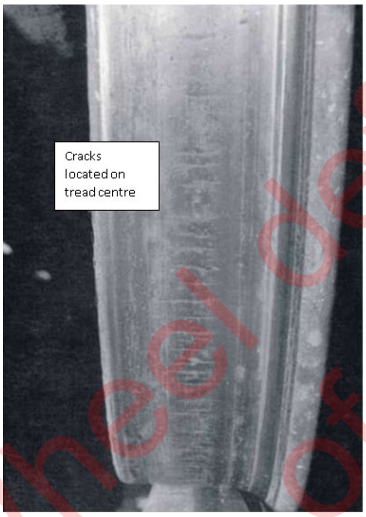


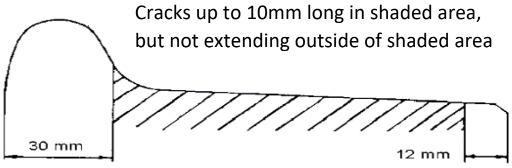
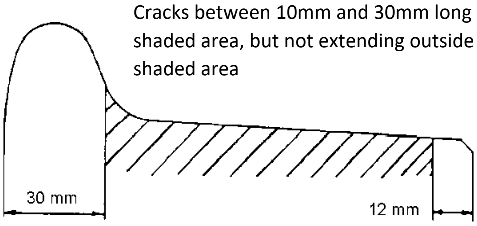
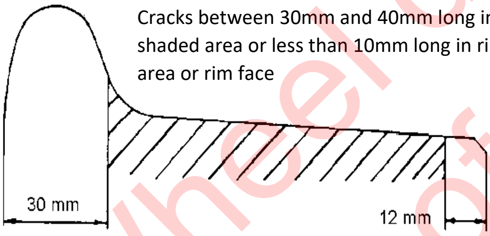
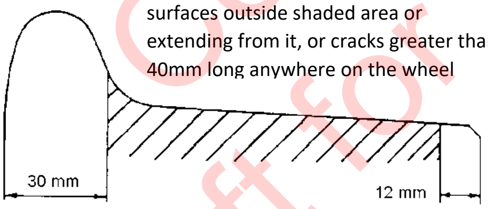
Figure 5:1 – Class 2 Thermal crack

Figure 5:2 – Class 3 Thermal crack

Figure 5:3 – Class 4 thermal crack

Figure 5:4 – Class 5 Thermal crack

Table 5:1 - Thermal cracks

Class	Description of defect	Action required	Speed restriction
1	 Cracks up to 10mm long in shaded area, but not extending outside of shaded area	No action required	Normal speed
2	 Cracks between 10mm and 30mm long in shaded area, but not extending outside of shaded area	Wagons & infrastructure maintenance Re-examine carefully to ensure that no Class 3 Thermal cracks exist. Defects shall be reported. Passenger and locomotives: Defects shall be reported and scheduled for re-examination at the next general inspection or at no greater than 10,000 km.	Normal speed
3	 Cracks between 30mm and 40mm long in shaded area or less than 10mm long in rim area or rim face	If wheel is approaching condemning diameter, treat as Class 4 defect. Wagons & infrastructure maintenance: Work out of service. Passenger & locomotives: Defects shall be reported and scheduled for turning within 14 days.	Normal speed
4	 Any visible cracks in the flange surface outside the shaded area, or cracks greater than 10mm long the rim surfaces outside shaded area or extending from it, or cracks greater than 40mm long anywhere on the wheel	If found pre-trip or at a depot, the wheel shall not enter service. If found en-route continue at reduced speed with the brakes cut out. Locomotives: The use of the independent brakes should be kept to a minimum.	Speed 40 km/h maximum
5	Fractured wheel Any crack running though the rim, web or hub of wheel	Examine defect in the section before movement to the nearest siding at the speed nominated by the attending maintenance officer.	NOT TO RUN Until wheel inspected

6 Spalling and shelling

Spalling occurs when pieces of metal break out of the tread surface in one or several places, see Figures 6:1 to 6:4. This defect can be caused by thermal damage, skidding or over-stressing at the wheel-rail contact point. It is usually attributed to a combination of two or more of the following factors: poor track and excessive speed resulting in high impact loads, excessive vertical loads, excessive braking (thermal damage and/or skidding) or the use of wheels of insufficient hardness or metallurgical quality.

Spalling and shelling can have a similar appearance, but their generation mechanisms are different. The appearance of spalls or shelling could alter depending on the causes. Normally shelling is spread out around the circumference of the wheel, while spalls are more local.

Spalls result from the fracture under loading of a hard and brittle martensite steel phase which forms when the wheel tread locally undergoes rapid heating and cooling due to wheel skidding from braking, or lateral slip at special track work and check rails.

Shelling results from a subsurface rolling contact fatigue defect which forms due to pure rolling contact fatigue, or under the multiple actions of tangential stresses predominantly at stringers of oxide inclusions in the wheel steel, or under normal, lateral and traction loads and residual stresses.

Spalling defects can range in size depending on the age and depth of the defect. Their frequency can be such that the entire tread circumference is covered with craters to the extent that they become joined. Wheel tread condition, particularly spalling, has a pronounced effect on wheel and brake block life.

Pitting is the presence of very small marks on the tread. It can be the initial stages of spalling but is not in itself a concern.

Refer to Table 6:1 for description of the defect and actions to be taken.

The higher class of spalling shall be reported if there is any doubt about the severity of the defects.

Refer to Section 4.6 for inspection of defects related to wheel tread impact load detectors and overall length of defect.


Figure 6:1 – Class 1 Spalling


Figure 6:2 – Class 2 Spalling


Figure 6:3 – Class 3 Spalling


Figure 6:4 – Class 4 Spalling

Table 6:1 - Spalling

Class	Description of defect	Action required	Speed restriction
1	Spalled regions with cavities less than 12 mm in diameter. Maximum 10%-wheel coverage	No action required	Normal speed
2	Spalled regions with cavities less than 25 mm in diameter. Maximum 20%-wheel coverage. The edges of the spalls could be sharp and jagged.	Re-examine carefully to ensure that no Class 3 spalls exist. Defects shall be reported.	Normal speed
3	Spalled regions with cavities greater than 25 mm in diameter, no deeper than 3 mm. The edges of the spalls could be sharp and jagged. Maximum 50%-wheel coverage.	Locomotives & passenger: Remove from service within 14 days. Wagons & infrastructure maintenance: Work out of service.	Normal speed
4	Extensive spalling 3 mm or more deep, sharp and jagged. More than 50%-wheel coverage.	If found pre-trip or at a depot, the wheel shall not enter service. If found en-route continue at reduced speed with the brakes cut out or work out of service.	Speed 40 km/h maximum

7 Wheel flats

Wheel flats occur when the wheels lock-up under braking and slide or skid along the rail while the train is in motion, see Figures 7:1 to 7:3. The heat generated when skidding will affect the underlying material. If the temperature is high enough and is followed by rapid cooling, the material will transform into a hard, brittle phase called martensite which also expands in volume. Due to the brittleness and the internal stresses caused by the difference in volume, cracks will start to generate in and/or around the martensite patch when the wheel starts rolling again. This will eventually lead to further wheel damage such as spalling. The resultant impact forces are detrimental to the track structure and reduce the life of other bogie components, particularly bearings.

If there is any doubt about the severity of a wheel flat, the higher class of defect shall be reported.

Refer to Table 7:1 for description of the defect and actions to be taken.

When measuring skidded wheel defects, the effective length of the defect should be assessed. Often using a straight edge and rocking it on the flat and the immediate area near the visible flat spot area, will reveal the total length of the affected tread. It is this overall length that shall be used for corresponding actions.

Refer to Section 4.6 for inspection of defects related to wheel tread impact load detectors and overall length of defect.

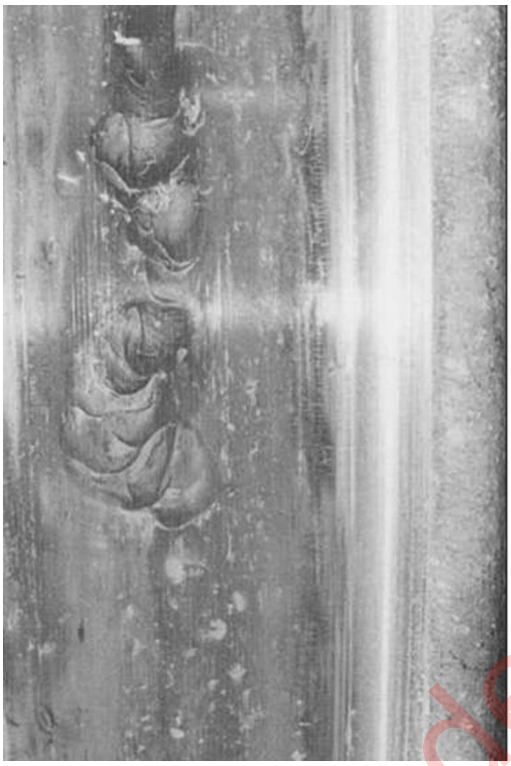


Figure 7:1 – Class 3 skidded wheel (multiple class 2 skids)

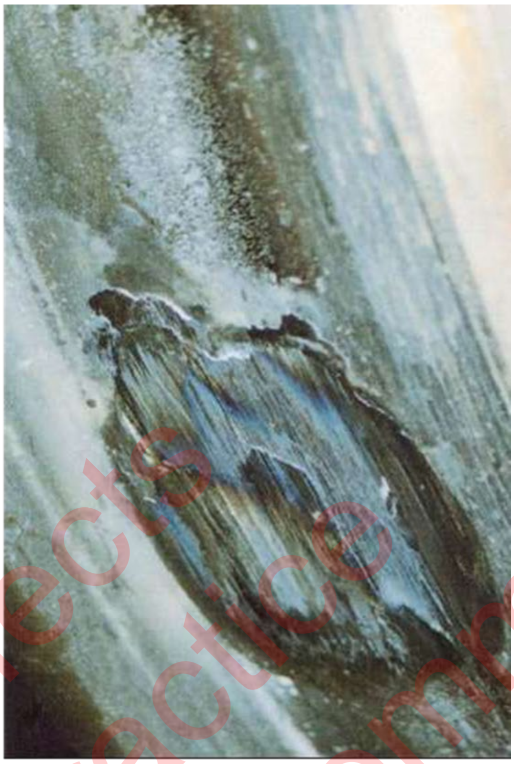


Figure 7:2 – Class 4 skidded wheel

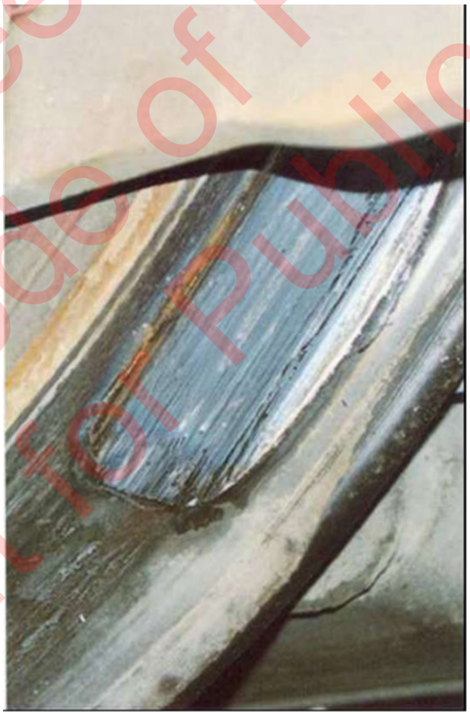


Figure 7:3 – Class 5 Skidded wheel

Table 7:1 – Flat wheels

Class	Description of defect	Action required	Recommended speed restriction
1	Single skid length less than 25 mm.	No action required.	Normal speed
2	Single skid length between 25 mm and 40 mm[a] or multiple Class 1 skids.	Defects shall be recorded by the RTO and may be required to be reported to the RIM. Trim blocks may be used.	Normal speed.
3	Single skid length between 40 mm[a] and 60 mm or multiple Class 2 skids.	Work out of service. Defects shall be recorded by the RTO and may be required to be reported to the RIM.	60 kph
4	Skid length between 60 mm and 100 mm or multiple Class 3 skids.	If found pre-trip or at a deport, the wheel shall not enter service. If found en-route continue at reduced speed with the brakes cut out and work out of service.	60 kph
5	Skid length greater than 100 mm or multiple Class 4 skids.	If found pre-trip or at a depot, the wheel shall not enter service. If found en-route, remove built-up metal prior to movement to the nearest siding at a speed nominated by the attending maintenance officer and RIM. Wheel shall be made safe for movement from siding prior to the rolling stock being moved.	Movement from siding to be assessed in conjunction with the RIM.

[a] Queensland Rail use 50mm.

NOTE 1. Trim blocks can be a fire hazard and cause thermal stresses to the wheel.

NOTE 2. The best measure to minimize damage to track and wheelset bearings is to remove skidded wheels from service as soon as possible.

8 Scaled wheels

Scaling is the build-up of metallic material on the surface of the wheel tread, see Figures 8:1 to 8:2. It is usually attributed to sticking brakes which cause the wheel to skid or slide on the rail, thus heating the contact patch to the stage where the wheel material becomes soft enough to flow on the tread surface.

The flowing material mixes with brake dust and other foreign material and is deposited back onto the wheel where it cools in layers, giving the tread a scaly appearance.

Scale can cover the entire wheel surface or any part thereof. The severity of the scaling is assessed by measuring the height of the scale above the normal wheel tread surface.

If there is any doubt about the severity of the scaling, the higher class shall be reported.

Note that severity Classes 1 and 2 are not applicable to scaled wheels; the minimum detectable amount of scaling is classified as a Class 3 defect.

Refer to Table 8:1 for description of the defect and actions to be taken.

Refer to Section 4.6 for inspection of defects related to wheel tread impact load detectors and overall length of defect.

Figure 8:1 – Class 3 Scaled wheel

Figure 8:2 – Class 4 Scaled wheel

Table 8:1 - Scaled wheels

Class	Description of defect	Action required	Speed restriction
1 & 2	Classification not relevant	Not relevant	Not relevant
3	Light surface smearing too small to measure with a standard rule	Examine brake gear for defects	Normal speed
4(i)	Scale height up to 5 mm	If found pre-trip or at a depot the wheel shall not enter service. If found en-route clear the section at reduced speed with vehicle brakes cut out	Speed 25 km/h maximum
(ii)	Scale height 5 mm to 10 mm		Speed 5 km/h maximum
(iii)	Scale height 10 mm to 15 mm		Speed 5km/h maximum
5	Scale height greater than 15 mm	Rectify defect in the section before movement to the nearest siding at a speed nominated by the attending maintenance officer	NOT TO RUN until wheel is rectified

9 Arrises and other flange defects

9.1 General

Arrises and other flange defects include wear grooves, machining grooves or steps, flat tops and other damage can occur in service.

9.2 Arrises

Arrises or raised lips on the top of the wheel flange are due to metal flow. If allowed to progress to a sufficient extent they can result in points being split, particularly if occurring in conjunction with steep or thin flanges.

If a brake block contacts an arris, they will rapidly heat and cool resulting in thermal cracking. Arrises are classified according to the height above the normal top of the flange.

If arrises are frequently occurring, the root cause should be investigated. The root cause could be lack of proper rail gauge face lubrication and/or excessive force on the flange due to a rolling stock defect.

Refer to Table 9:1 for description of the defect and actions to be taken.

9.3 Unacceptable flange conditions

Several flange conditions experienced in service are unacceptable and pose a significant risk of derailment and/or damage to track components. Certain patterns of wear and damage to the flange surface, particularly on the flange top and back, can also result in incidents and therefore when found should be marked for repair or replacement. Irregularities can arise from inappropriate manufacturing or maintenance procedures as distinct from service conditions. Condemning gauges cannot always detect irregularities of this kind even though they could render a wheel condemnable.

Typical conditions are illustrated in Figure 9:1 below and include the following:

(a) Wear grooves, gouges, or deformation on the top portion of the flange or back face.

(b) With the exception of witness marking; undercut, coarse marks or a step-like surface caused by wheel machining.

(c) Abrupt changes in flange profile.

(d) Wide flat faces on the flange top.

(e) Sharp or square flange top.

(f) Irregularities in contour or profile.

All the above irregularities have the capacity under certain conditions to induce rail climb or to split points. Wheelsets with these defects shall be removed from service. Examples of track conditions aggravating the situation are damaged switch tips/point blade tips or a switch not properly seated against the stock rail.

Wheels with a sharp flange top can develop fatigue cracks within the flange.

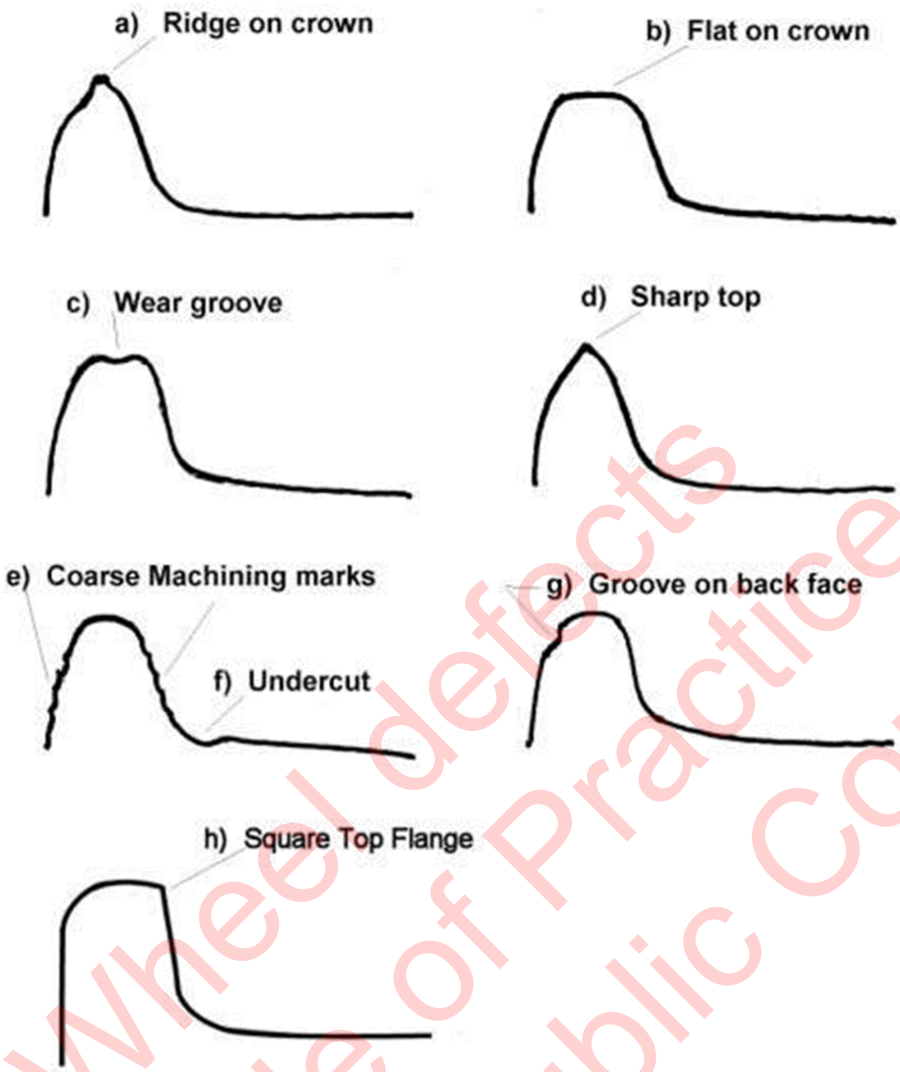
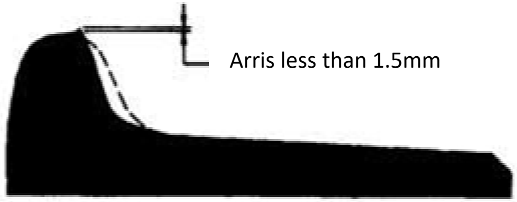
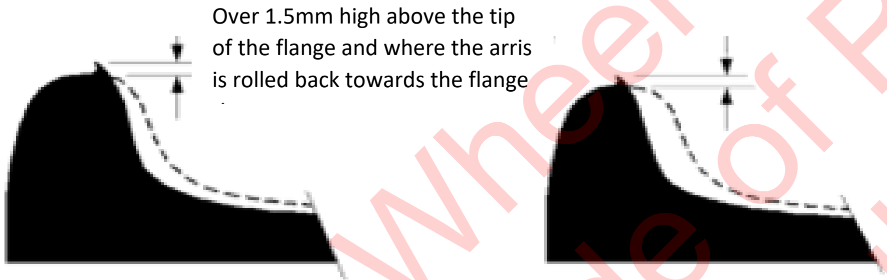
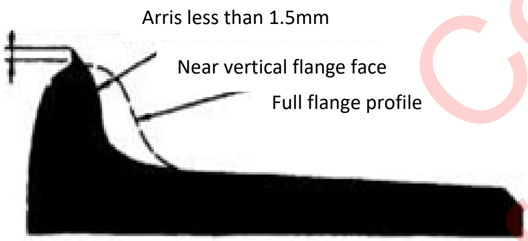


Figure 9:1 – Unacceptable flange conditions

Table 9: 1 – Arises Table

Class	Description of defect	Action required	Speed restriction
1	Classification not relevant	Not relevant	Not relevant
2		Re-examine carefully to ensure that no thermal cracks exist. Defects shall be reported.	Normal speed
3		Locomotives and passenger: remove from service within 14 days. Wagons and infrastructure maintenance: Work out of service.	Normal speed
4		If found pre-trip or at a depot, the wheel shall not enter service. If found en-route continue at reduced speed with the brakes cut out after traffic approval from the attending maintenance officer or remove from service.	Speed 40 km/h over points, cross-overs and turnouts.

10 Tread and flange – wear and flow

10.1 General

Wheel wear and condition is determined by application of a standard wheel condemning gauge (refer to Appendix D). Flange condition is determined in relation to the thickness, slope and height above the tread.

Flange and tread condition also require evaluation of plastic flow such as the presence of arrises (flange lips) or rolled edges.

Vehicles should leave a repair facility with a sufficient flange thickness wear margin, which will allow operation until the next wheel inspection is due to be carried out by the RTO. Refer to the RIM for other specific requirements for each Network.

Refer to Table 10:1 for description of the defect and actions to be taken.

10.2 Tread and flange wear conditions

10.2.1 Steep flanges

To determine whether the flange is partly or wholly steep, the whole wheel shall be visually examined. Flange steepness shall be assessed at the circumferential position of maximum apparent flange steepness. If there is any doubt in the visual assessment, the flange steepness shall be checked with a condemning gauge – refer to Appendix D for guidance.

All bogies with steep flanges shall be further examined for other defects.

Steep flanges can be an indication of other problems, for example:

(a) One steep flange only could indicate a wheelset that has a variation in wheel diameters.

(b) Two steep flanges on diagonally opposite corners could indicate a crabbing effect due to side frame misalignment.

(c) Two steep flanges on same side could indicate mismatched side frame lengths.

(d) Four steep flanges could indicate a hunting condition caused by worn friction wedges or side-bearers.

10.2.2 High flanges

The height of a flange above the tread shall not exceed 35 mm as shown in Table 10:1. The height may be determined by the application of an appropriate wheel gauge. Wheels with this condition can lead to the flange tip bottoming through track features such as K crossings and frogs, increasing wear and the risk of derailment. High flanges can also damage fishplates and bolts on light rails, cause damage to inductive type axle counters, and transducers used by hot box and wheel tread impact detectors.

10.2.3 Hollow tread

Hollow tread limiting dimensions should be ascertained from the RIM for the networks on which the rolling stock is to operate.

Hollow tread results in the loss of effective wheel conicity that produces high flanges and significantly reduces the tracking ability of a bogie. To determine the presence of hollow tread it is necessary to carry out a visual examination, which includes the use of a gauge. Appendix D provides additional information on types of gauges commonly used.

The hollow tread limit is set to manage the following issues:

(a) Rolling contact fatigue and deformation of plain rail.

(b) Damage at switches and crossings.

(c) Worsened steering – resulting in increased susceptibility to hunting and increased fuel consumption.

10.2.4 Rolled edges / Spread rim

Rolled edges are the result of metal being rolled across the tread toward the outside (for flangeless wheels also the inside) of the wheel, where it forms a lip overhanging the rim face.

The lip, thus formed, facilitates initiation of thermal and fatigue cracks which can progress into the rim face. This can result in a severely increased risk of a catastrophic wheel failure.

Spread rim is the result of a local lateral rim surface flow caused by out-of-round wheel impacts and/or rim weakening due to circumferentially oriented fatigue cracks. Figures 10:1 and 10:2 give example of local lateral rim surface flow and spread rim. High lateral contact stresses due to incorrectly tracking vehicle often is a contributing factor. See also description in Section 11.3 “Shattered Rim Defects”.

Any rolled edge or lip of this type which extends more than 3 mm past the vertical face of the rim as shown in Figure 10:3 is classified as a Class 3 defect. Vehicles with this defect shall be marked and worked out of service. No speed restriction is required.

Any wheel identified with a spread rim / shattered rim shall immediately be removed from service.

Any cracks found on the rolled edge shall be treated as a Class 4 thermal crack.

10.2.5 Flange plastic flow

Plastic flow towards the top of the flange can occur in curves and turn-outs as a result of poorly steering bogies and high friction between wheel and rail. Worn rail heads and worn wheel profiles will aggravate the situation, particularly if the worn profiles mismatch so that two-point contact is established between wheel and rail. This can lead to a steep flange or generation of a sharp edge or burr on the active part of the flange that could impose an increased risk of derailment. See also Section 9.2 Arrises.

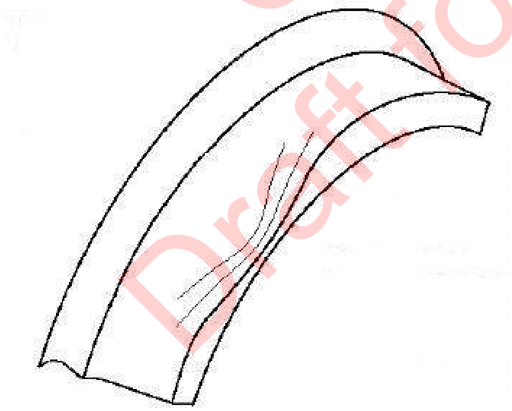


Figure 10:1 – Lateral rim surface flow

Figure 10:2 – Spread rim

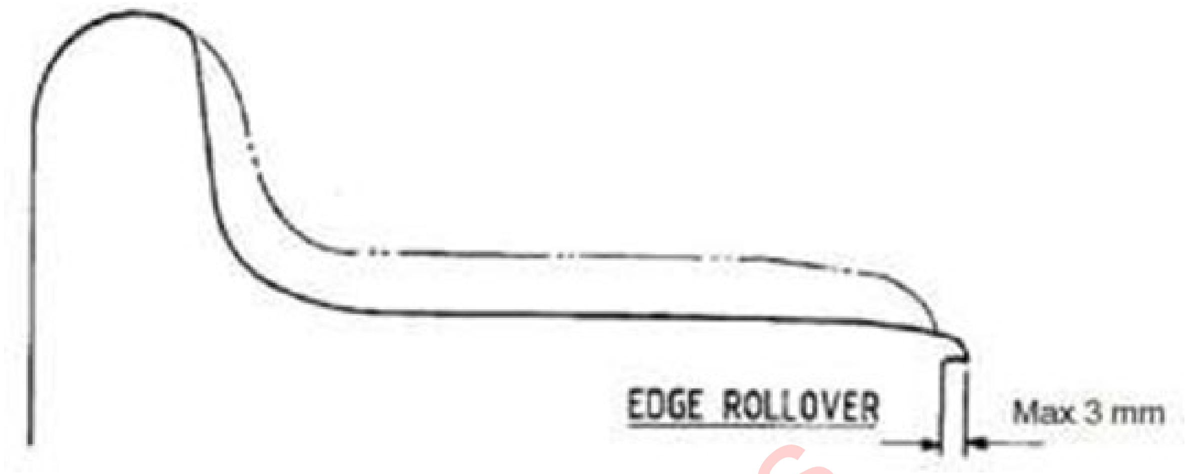


Figure 10:3 – Rolled edge limit

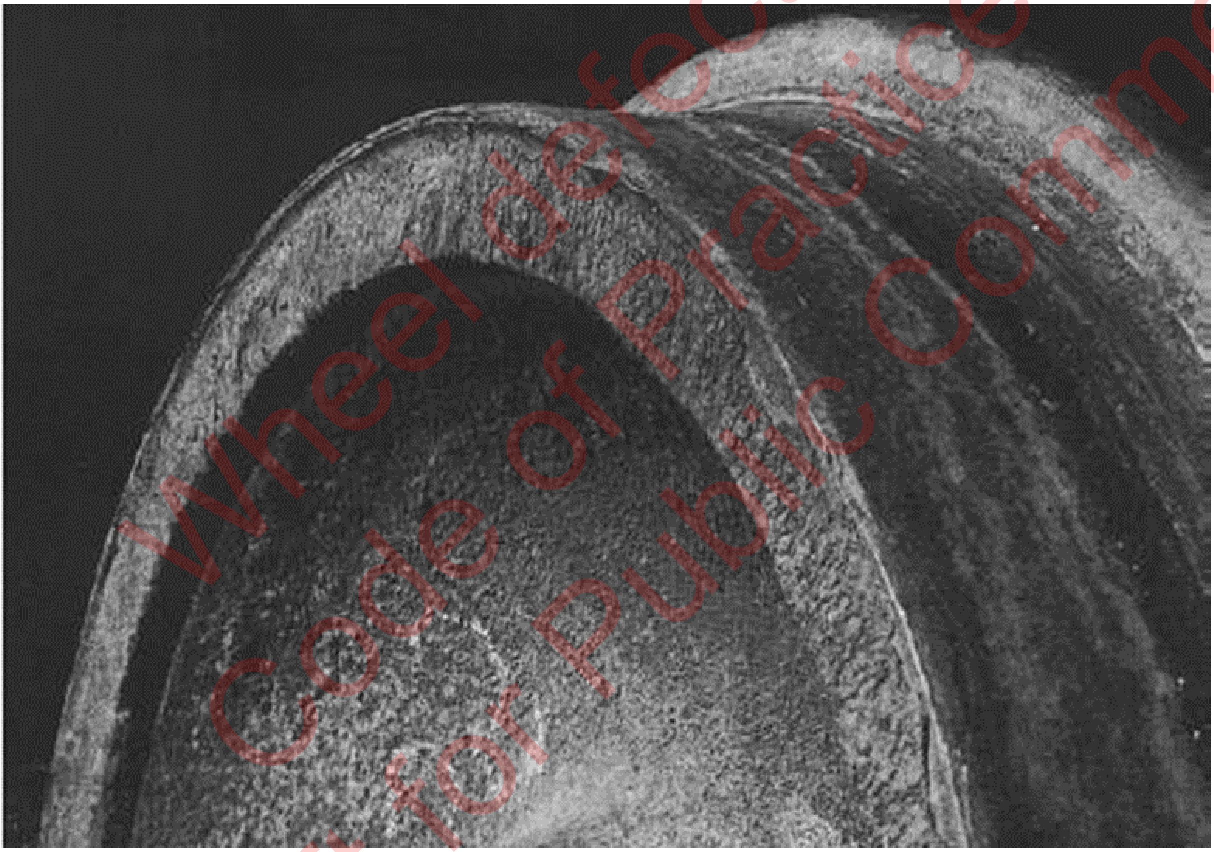


Figure 10:4 - Rolled edge

Table 10:1 – Tread and flange wear and flow

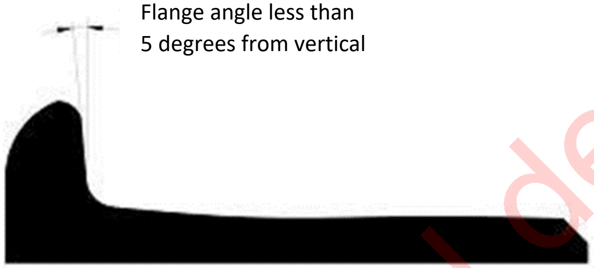
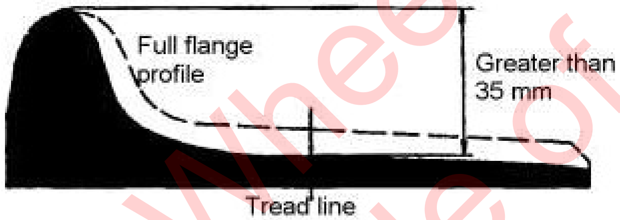
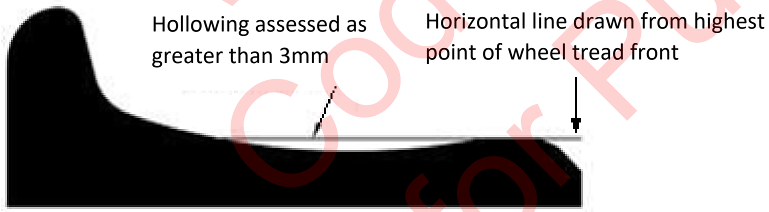
Class	Description of defect	Action required	Speed restriction
1 & 2	Classification not relevant	Not relevant	Not relevant
3 Steep flanges		Locomotive and passenger: Remove from service within 14 days. Wagons and infrastructure maintenance: Work out of service. Examine bogie and check wheel diameters for possible cause of steep flanges. Note: A steep flange in conjunction with a Class 2 arris is a Class 4 defect. Treat as per Class 4 arris (Table 10:1)	Normal Speed
3 High flanges		Locomotives and passenger: Remove from service within 14 days. Wagons and infrastructure maintenance: Work out of service.	Normal Speed
3 Hollow tread		Locomotives and passenger: Remove from service within 14 days. Wagons and infrastructure maintenance: Work out of service. Note that the 3 mm hollow wear limit applies at any point across the tread.	Normal Speed

Table 10:1 – Tread and flange wear and flow

Class	Description of defect	Action required	Speed restriction
1 & 2	Classification not relevant	Not relevant	Not relevant
3 Thin flanges	See Table 4:2 	Locomotive and passenger: Remove from service within 14 days. Wagons and infrastructure maintenance: Work out of service.	Normal speed
3 Rolled flanges		Locomotive and passenger: remove from service within 14 days. Wagons and infrastructure maintenance: Work out of service.	Normal speed

11 Damaged / fractured wheels

11.1 General

The severity Classes 1, 2 and 3 are not applicable to damaged or fractured wheels.

11.2 Cracked or broken web / plate

A material fault or mechanical damage on the wheel web / plate can induce a fatigue crack which depending on the position on the web often propagates circumferentially around the web. Increased stress levels due to wheel rim overheating increase the risk.

Any wheelset detected with a cracked web / plate shall be removed from service immediately and the wheel not used again in service. The root cause of the incident should be investigated, and actions taken to prevent recurrence.

11.3 Shattered rim defects

Shattered rim, deep shelling and spread rim are defects counted as shattered rim defects, see Figure 11:3 to 11:4. Their appearance can vary depending on where in the rim the defect is initiated. Also, the wheel rim residual stresses and the load conditions have an influence.

Shattered rim defects originate from a sub-surface fatigue crack normally initiated at a slag inclusion, void or another type of metallurgical inhomogeneity within the wheel rim. Increased stress levels as a result of track irregularities, e.g. corrugation, or wheel out-of-roundness promote the initiation. After a propagation stage normally including several hundred thousand kilometres of travelled distance a substantial part of the wheel tread could break away. Until the sub-surface crack becomes surface-breaking, it can only be detected in service by use of ultrasonic non-destructive testing. Appendix C provides additional guidance on inspection technologies. Once the crack has propagated sufficiently to reach the rim face, they can be found at visual inspection. Visual indicators include rolled edge or a bulging on the front face.

The consequences of a loss of a wheel tread segment due to the full development of a sub-surface crack can be severe, especially if the segment includes the wheel flange, and involves a substantial derailment risk. Due to the safety implications higher speed applications often undergo controls to mitigate the derailment risk associated with shattered rim defects.

Preventive measures include:

(a) improvement of steel quality with respect to cleanliness, non-metallic inclusions and homogeneity;

(b) removal of high impact wheels from service;

(c) improvement of track maintenance, particularly rail corrugation grinding.

Any wheel identified with a shattered rim defect shall immediately be removed from service and the root cause investigated. For small shattered rim defects found in an early stage at ultrasonic inspection the time for removal can be adapted to operating conditions.

11.4 Cracked or broken wheel rim

Cracked or broken wheel rims are characterised by brittle fracture transverse to the running direction originated from stress concentration or internal defect in the wheel rim. This type of defect is referred to as a fatigue crack, and usually appears as a solitary crack and shall not be confused with thermal cracks, see Figure 11:1.

Any fatigue crack found in a wheel rim shall be classified as a Class 4 defect or a Class 5 defect (see Table 11:1).

11.5 Cracked or broken flange

Flange failures can be caused by insufficient track clearance or too high flanges. Metallurgical inhomogeneities or manufacturing errors can also be the cause of fatigue crack initiation leading to flange failure. These types of defects often lead to large pieces of the flange falling off in service.

Any fatigue crack found in a wheel flange shall be classified as a Class 4 defect or a Class 5 defect (see Table 11:1).

11.6 External wheel damage

External wheel damage generally occurs as the result of a heavy impact on the wheel and could show up as a chip or gouge in the wheel flange or a bruise on the wheel tread, see Figure 11:2. A fatigue crack can start at this defect and propagate quickly through the entire wheel. Heavy impacts from a derailment often lead to distortion of wheels and/or axles.

A close visual examination shall be made of both flange surfaces and wheel treads in order to detect the presence of any damage.

Any chip or gouge in a wheel which is more than 25 mm long and/or 12 mm wide shall be classified as a Class 4 defect (see Table 11:1).

Figure 11:1 – Cracked or broken web

Figure 11:2 – Scrape, dent or gouge

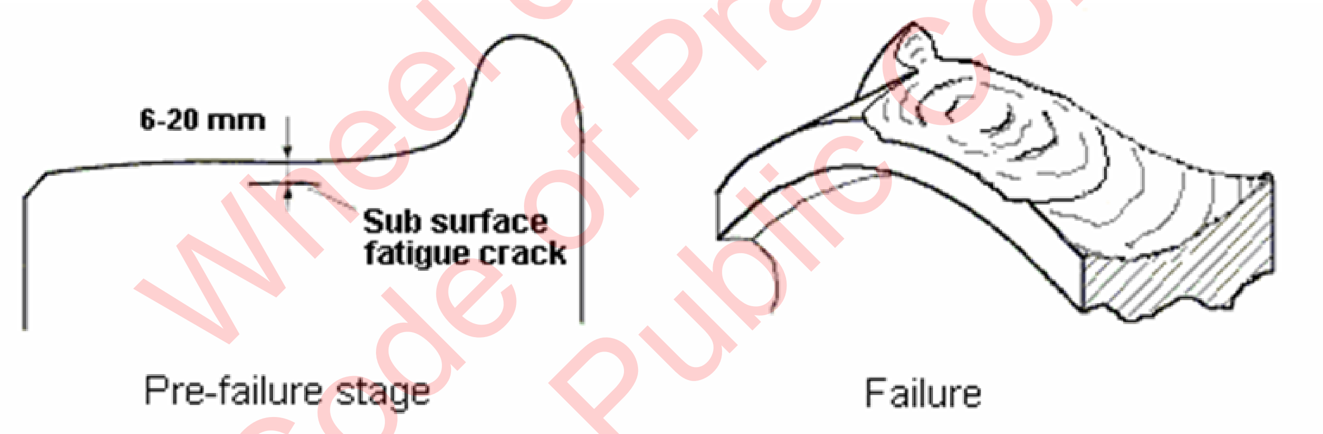


Figure 11:3 – Shattered rim

Figure 11:4 - Spread rim

Table 11:1 – Damaged / Fractured Wheel Table

Class	Description of defect	Action required	Speed restriction
1,2 & 3	Classification not relevant	Not relevant	Not relevant
4	Fatigue cracks in wheel rim or flange Solitary cracks that are not running through the rim of the wheel (no critical propagation), usually initiated from a manufacturing defect. External wheel damage generally results from heavy impact loads on the wheel which can show up as a chip or gouge in the flange or as a bruise on the tread or a wheel distortion.	If found pre-trip or at a depot, the wheel shall not enter service. If found en-route continue at reduced speed with the brakes cut out or remove from service	Speed 40 km/h Maximum
5	Fractured wheel Any crack running though the rim, web or hub of the wheel Shattered wheel Circumferential crack visible on rim face, often in combination with break-away of rim material	Examine defect in the section before movement to the nearest siding at a speed nominated by the attending maintenance officer.	Not to run until wheel has been inspected

12 Overheated wheels

Hot or overheated wheels are identified as follows:

(a) For wheels which have been painted on the plate surface with a heat-sensitive paint blistering or discolouration of the paint below the rim of the grey temperature indicating coating. By a heat-sensitive paint is meant a paint of light colour that turns brown at temperatures above 250°C, e.g. grey alkyd paint.

(b) For wheels that have not been painted, blueing discolouration or rusting of the plate surface below the rim. Depending on temperature a freshly oxidised surface will appear pink, violet or blue in colour, and will become darker with age, see Figure 12:1.

Any wheel which has become severely overheated due to excessive braking or sticking brakes is a Class 4 defect and should be removed from service. Refer to Table 12:1 for description of the defect and actions to be taken for unpainted wheels and Table 12:2 for painted wheels.

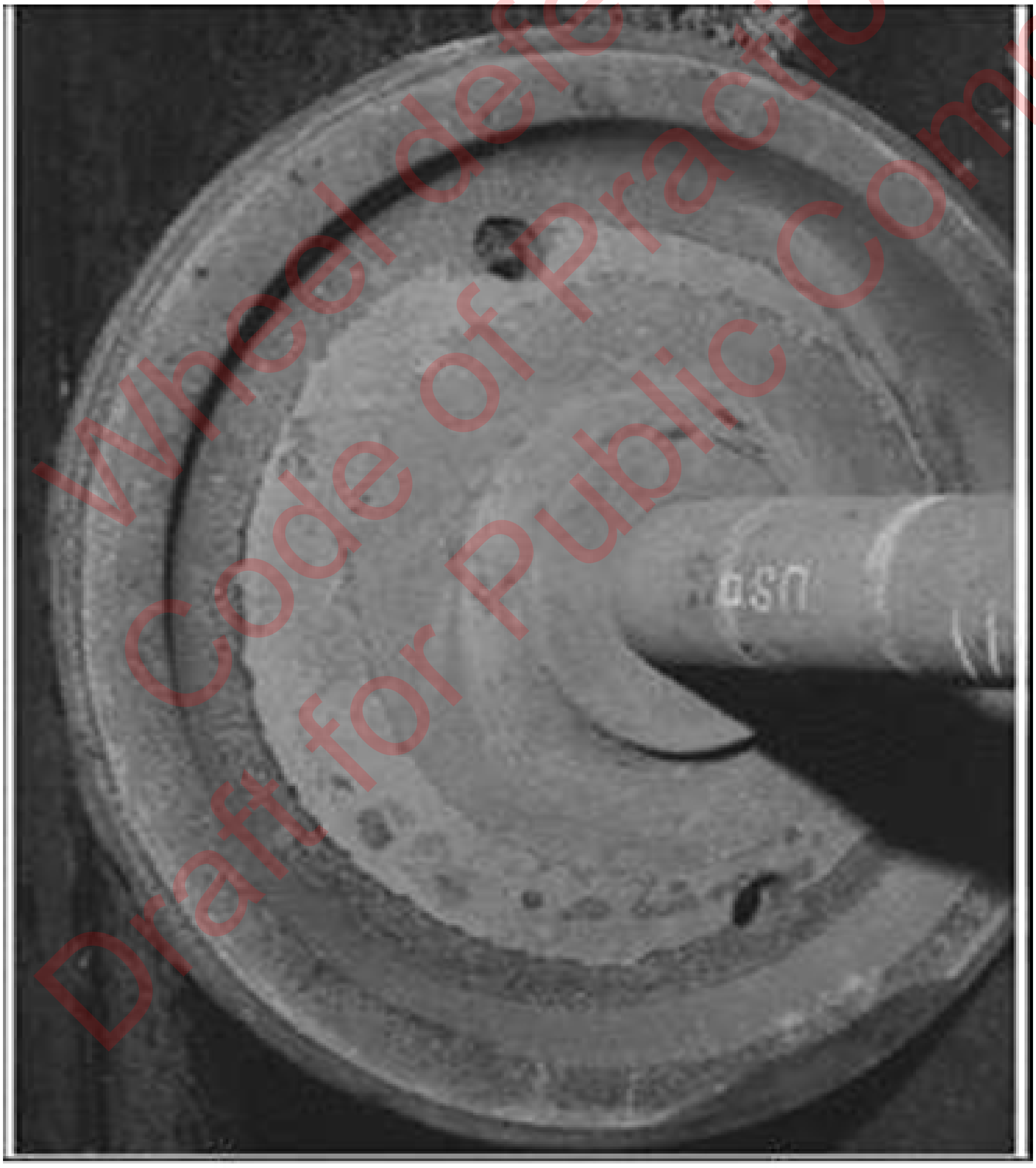


Figure 12:1 - Overheated wheel

Table 12:1 – Overheated unpainted wheels

Class	Description of defect	Action required	Speed restriction
1 & 2	Classification not relevant	Not relevant	Not relevant
3	**Rim oxidation (Rim overheated)** Oxidation evident on wheel rim and web but less than 80 mm from the intersection between the back or front face and the underside of the rim.	Work out of service	Normal speed
4	**Web oxidation (Web overheated)** Oxidation evident on wheel rim and web greater than 80 mm from the intersection between the back or front face and the underside of the rim	If found pre-trip or at a depot the wheel shall not enter service and wheelset to be removed. If found en-route, continue at reduced speed with brakes isolated or removed from service.	Speed 40 km/h maximum
5	**Wheel overheated I combination with thermal cracks** A class 4 overheating combination with thermal cracks classified as Class 3,4 or 5 according to Table 6:1	Examine defect in the section before movement to nearest siding at speed nominated by the maintenance officer.	Not to run until wheel has been cleared by the maintenance officer.

Table 12:2 – Overheated painted wheels

Class	Description of defect	Action required	Speed restriction
1 & 2	Classification not relevant	Not relevant	Not relevant
3	**Rim Overheated** Paint blistering and discoloration (browning) on web but less than 80 mm from the intersection between the back or front face and the underside of the rim.	Work out of service	Normal speed
4	**Web with paint burn off (Web overheated)** Paint blistering and discoloration (browning on web greater than 80 mm from the intersection between the back or front face and the underside of the rim.	If found pre-trip or at a depot the wheel shall not enter service and wheelset to be removed. If found en-route, continue at reduced speed with brakes isolated or remove from service.	Speed 40 km/h maximum
5	**Wheel overheated in combination with thermal cracks** A class 4 overheating combined with thermal cracks classified as Class 3, 4 or 5 according to Table 5:1.	Examine defect in the section before movement to nearest siding at speed nominated by the maintenance officer.	Not to run until wheel has been cleared by the maintenance officer.

NOTE 1: Overheated low stress wheels may be treated more leniently than conventional wheels (e.g. Class 4 wheel can be treated as Class 3).

13 Tread checks

Tread checks should not be confused with thermal cracks. Tread checks are caused by high axle loads or poor steering vehicles. Lateral and longitudinal surface traction forces can produce a series of fine checks on the wheel tread caused by rolling contact fatigue. These are generally inclined at an angle and most commonly occur near the front face of the wheel and flange where the wear rate is low. Wheels frequently subjected to sharp curves could have checking approaching a circumferential direction. Because the checking is at an acute angle to the surface in cross-section it will feel rougher across the checking in one direction than in the opposite direction.

Wheels should be scheduled for machining if spalling of pieces from the surface has reached the stage shown in the Figure 13:1 below. These spalls are approximately 1 mm wide.

Refer to Table 13:1 for description of the defect and actions to be taken.

Figure 13:1 – Tread checks

Table 13:1 – Tread checks

Class	Description	Action required	Speed restriction
1	Wheel tread checks Inclined fine lines close together on wheel tread, commonly on the field side of the wheel. Often found on high axle load vehicles.	No action required	Not applicable.

14 Misaligned brake gear

14.1 General

The most common occurrence of misaligned brake gear is where the brake block overhangs the side of the wheel rim. This not only results in uneven wear of the blocks and rapid reduction in block life, but also in excessive heat input into the outer edge of the tread and rim face. The condition can be temporary or permanent. Blocks could also wear unevenly against the running face of the flange.

14.2 Temporary brake block overhang

Where an overhanging brake block is found and there is no evidence of shouldering on the block, no ridges on the tread and no Class 4 thermal cracks, the overhanging block could be a temporary condition (see Figure 14:1).

Consideration shall be given to the lateral float of the wheelset combined with the brake rigging clearances to determine if the overhang is temporary.

If bogie inspection indicates that the overhang is temporary, then the vehicle is suitable for service with regular block inspections.

On bogies where the brake rigging is rigidly connected laterally there should be no overhanging blocks. If found, corrective action shall be taken to adjust the rigging and/or replace worn components.

If there is any evidence of other wheel defects, the vehicle shall be handled in accordance with the applicable clauses of this section.

Where non-metallic and/or segmented blocks are used, attention shall be given to the presence of thermal cracks and skidded wheels.

If a shoulder has been worn on the edge of the block face, the defect shall be handled as prescribed in Section 14.3 below. Note that non-metallic blocks will not necessarily exhibit a definite shoulder as the overhanging portion tends to break away before achieving a recognisable size.

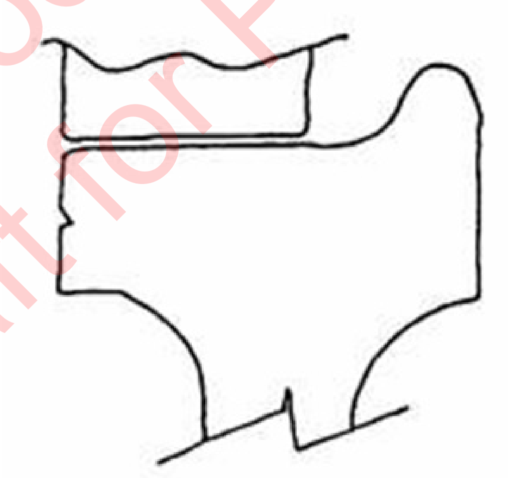


Figure 14:1 – Temporary break block overhang

14.3 Permanent brake block overhang

Where an overhanging block is found and determined to be a permanent fault the vehicle shall be withdrawn from service until the fault has been corrected. Permanent faults are indicated by evidence of a shoulder or groove on the block face as shown in Figure 14:2, a ridge on the wheel tread as shown in Figure 14:3, or Class 4 thermal cracks at the edge of the wheel tread.

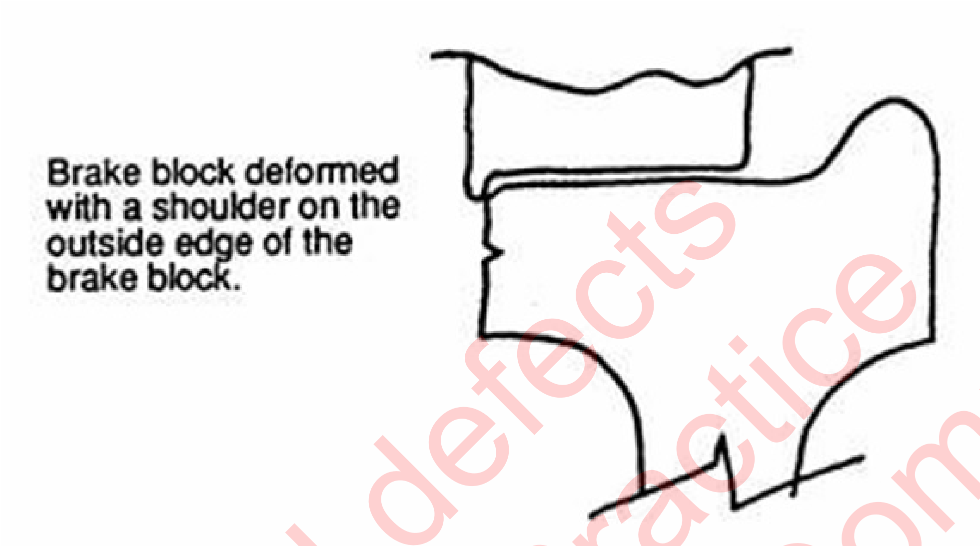


Figure 14:2 – Permanent brake block overhang

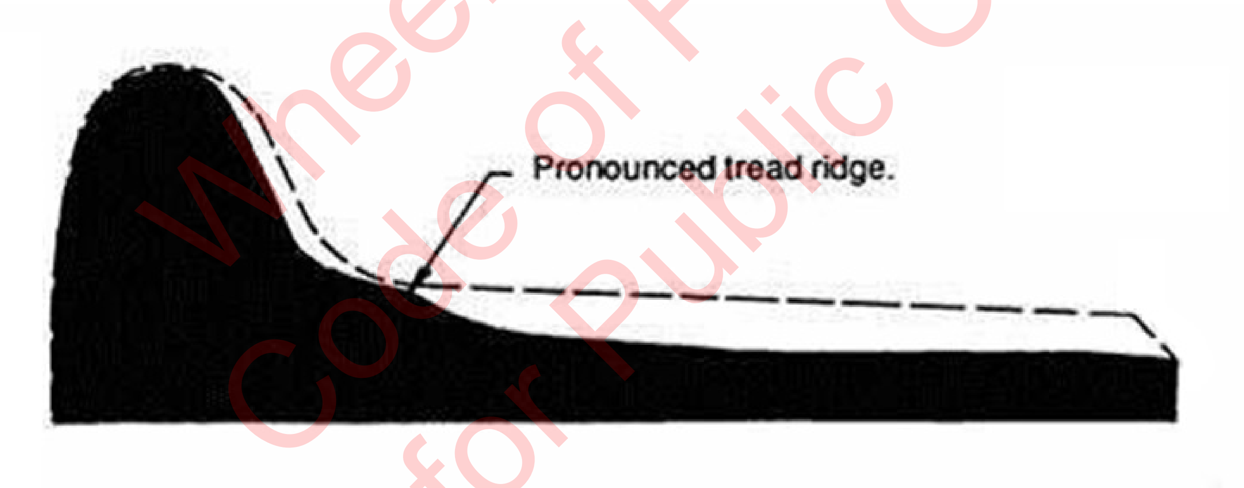


Figure 14:3 – Tread ridge due to block overhang

Note: The tread ridge as shown in Figure 14:3 could also be caused by a wheelset tracking error. In that case the tread ridge is accompanied by a greater flange wear on the wheel at the opposite end of the axle.

15 Out-of-round wheels

Out-of-round wheels occur where there is excessive variation in the radial measurement of the wheel tread. The wheel tread circumferential shape could be oval or corrugated but this is generally not observable to the eye. However, out-of-round wheels produce high impacts when passing over impact load detectors and produce a characteristic thumping or vibration with train passage.

There are four common forms of out-of-round wheels:

(a) Tread defect initiated - Produced when spalls and wheel flats are pounded out during service.
They will also facilitate the initiation of shattered rims

(b) Wear initiated - Also known as polygonization or wheel corrugations. This type of out-of-round defect produces a series of corrugation-like nonhomogeneous wear around the circumference of the wheel. Causes include non-uniform wheel rim hardness, non-uniform brake application, and torsional oscillation of wheelset in curves or under traction.

(c) Maintenance/machining initiated - This form of out-of-round wheels is produced by any of the following:

i. An off-centre mounted wheel.

ii. A new wheel machined off centre.

iii. An axle with its centre off by a machining error or a worn axle centre.

iv. Excessive wheel lathe clamping forces on the wheel rim, generating a three peak polygon wheel shape.

(d) Manufacture initiated - This form of out-of-round defect concerns cast wheels with unmachined tread (Griffin process). Low areas on the tread can be found on those wheels adjacent to the remnants of each riser on the front face of the wheel web just inside the rim. The regular spacing of the risers can produce severe vibrations.

Appendix A Wheel profile measuring points definitions (normative)

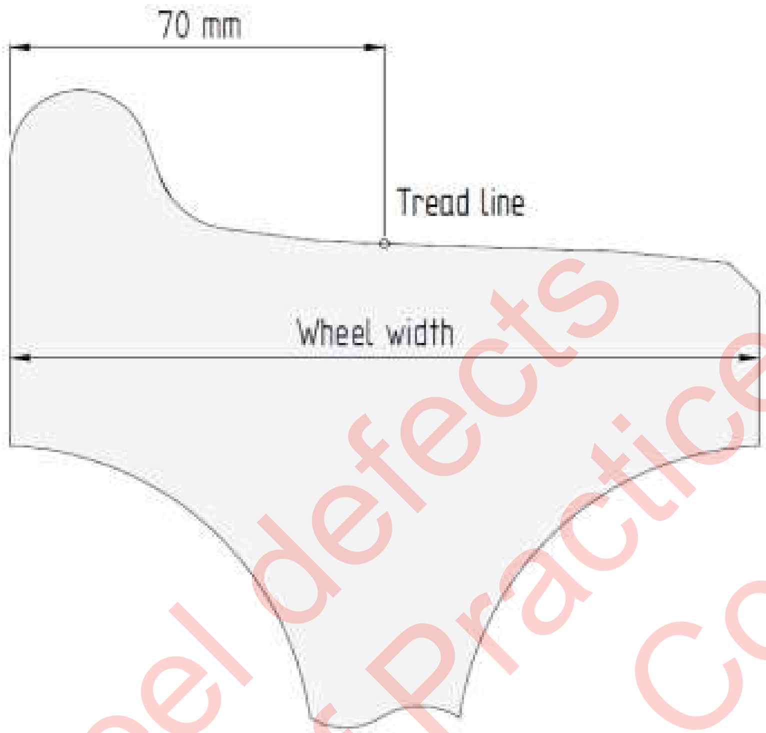


Figure A:1 – Tread line

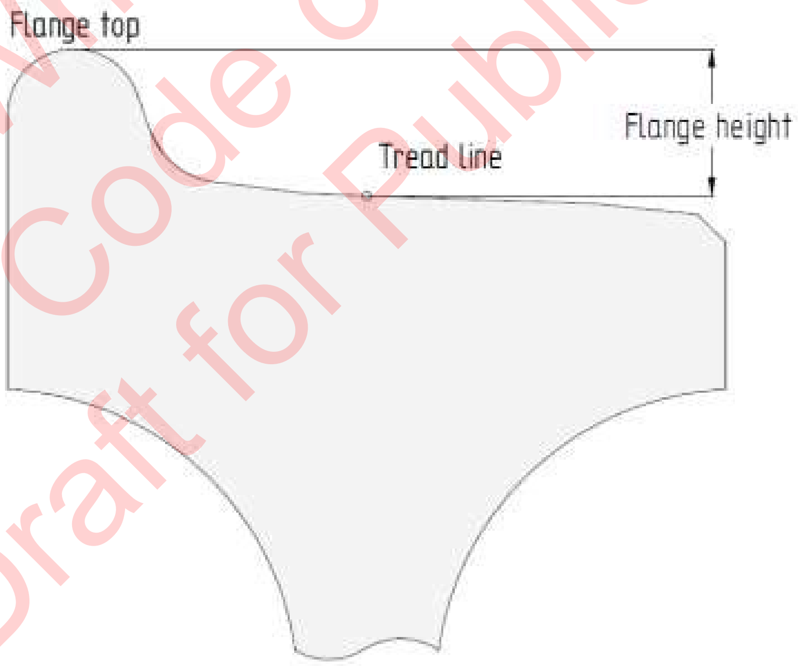


Figure A:2 – Flange height

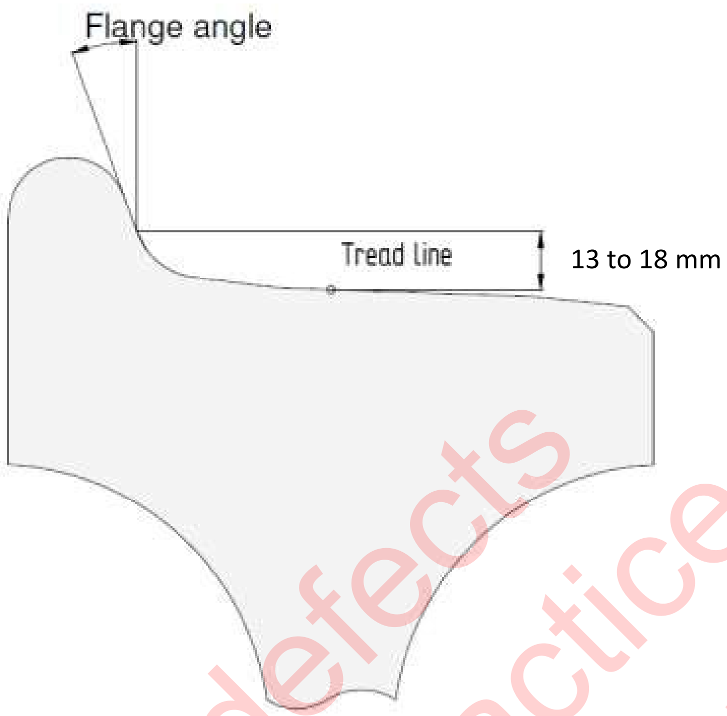


Figure A:3 – Flange angle
Flange angle is measured at any point between 13 -18 mm above the tread line point.

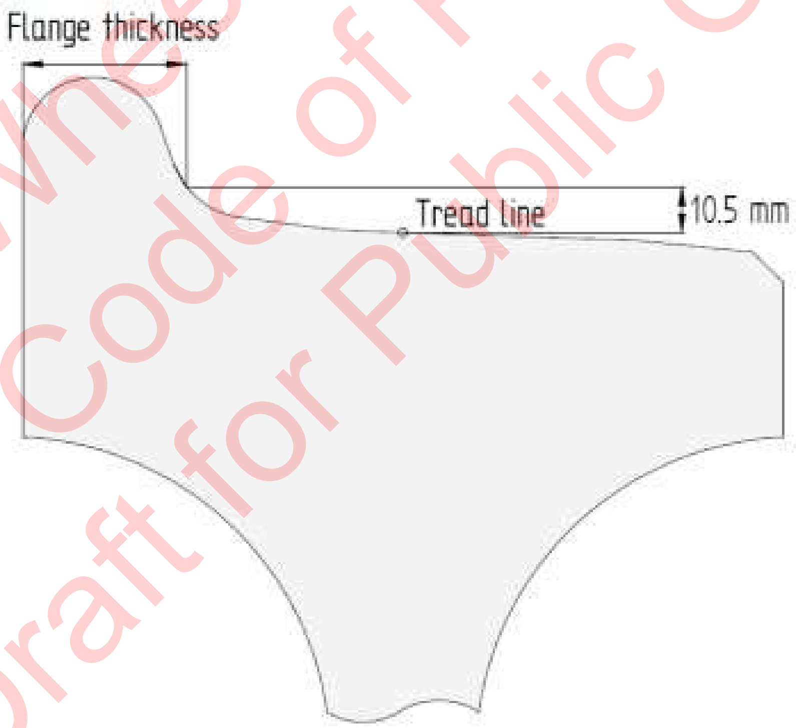


Figure A:4 – Flange thickness
Flange thickness is generally measured at 10.5 ± 0.5 mm above the tread line point; however it is noted that Queensland Rail use 16mm ± 0.5 mm above the tread line point.

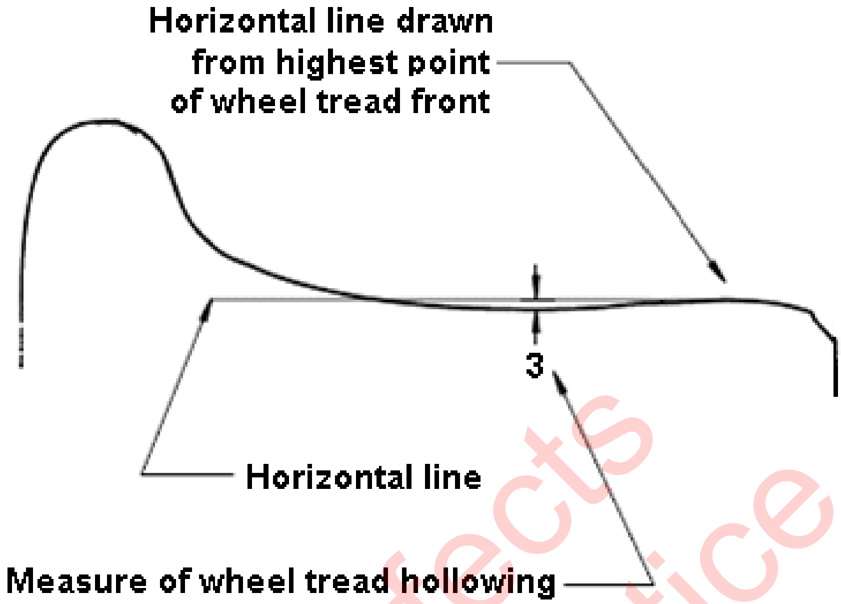


Figure A:5 – Tread hollowing
Note that the 3 mm hollow wear limit applies at any point across the tread.

Appendix B Wheel profile gauges (normative)

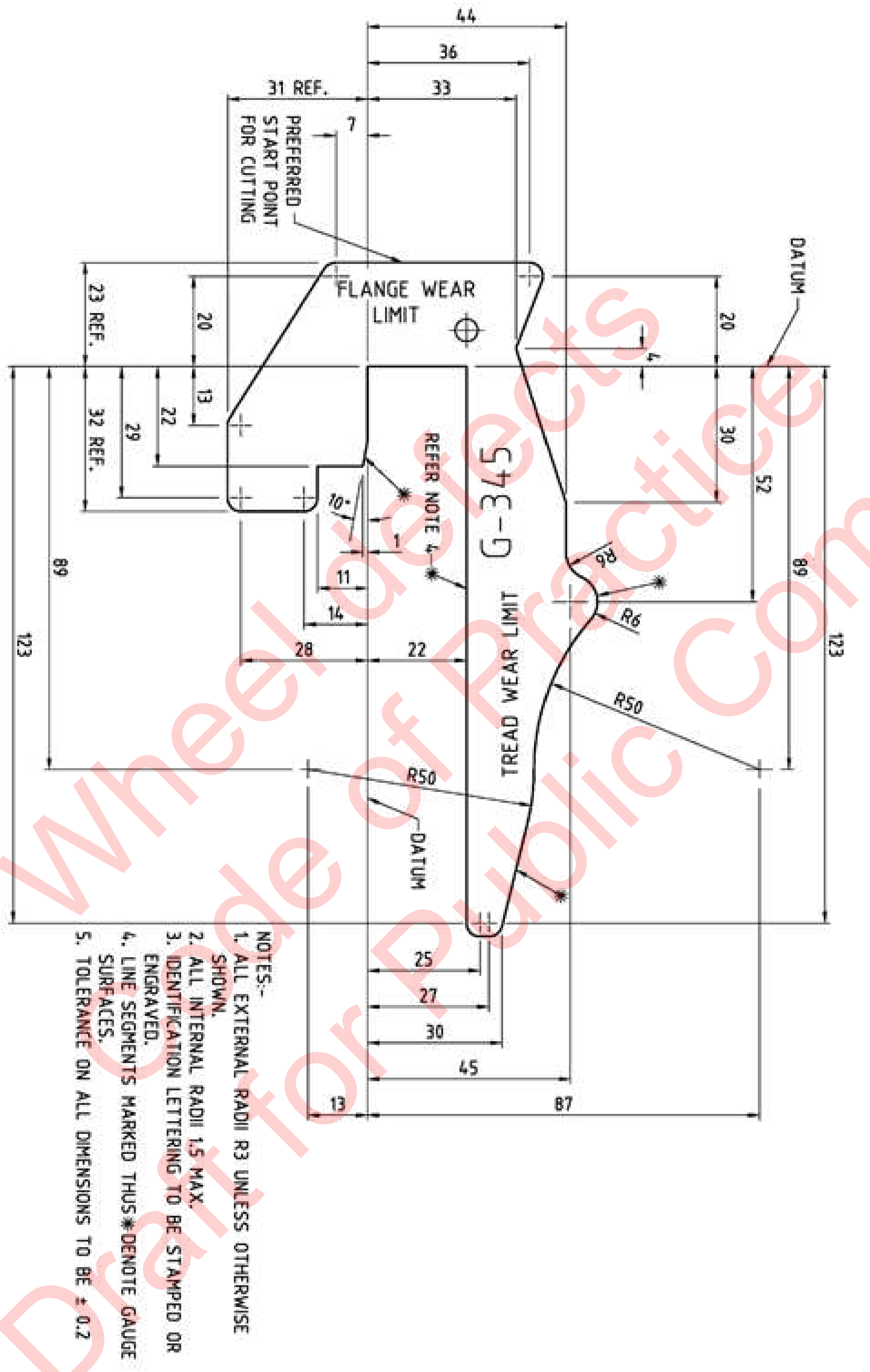


Figure B:1 - Gauge G-345 (Narrow gauge use only)

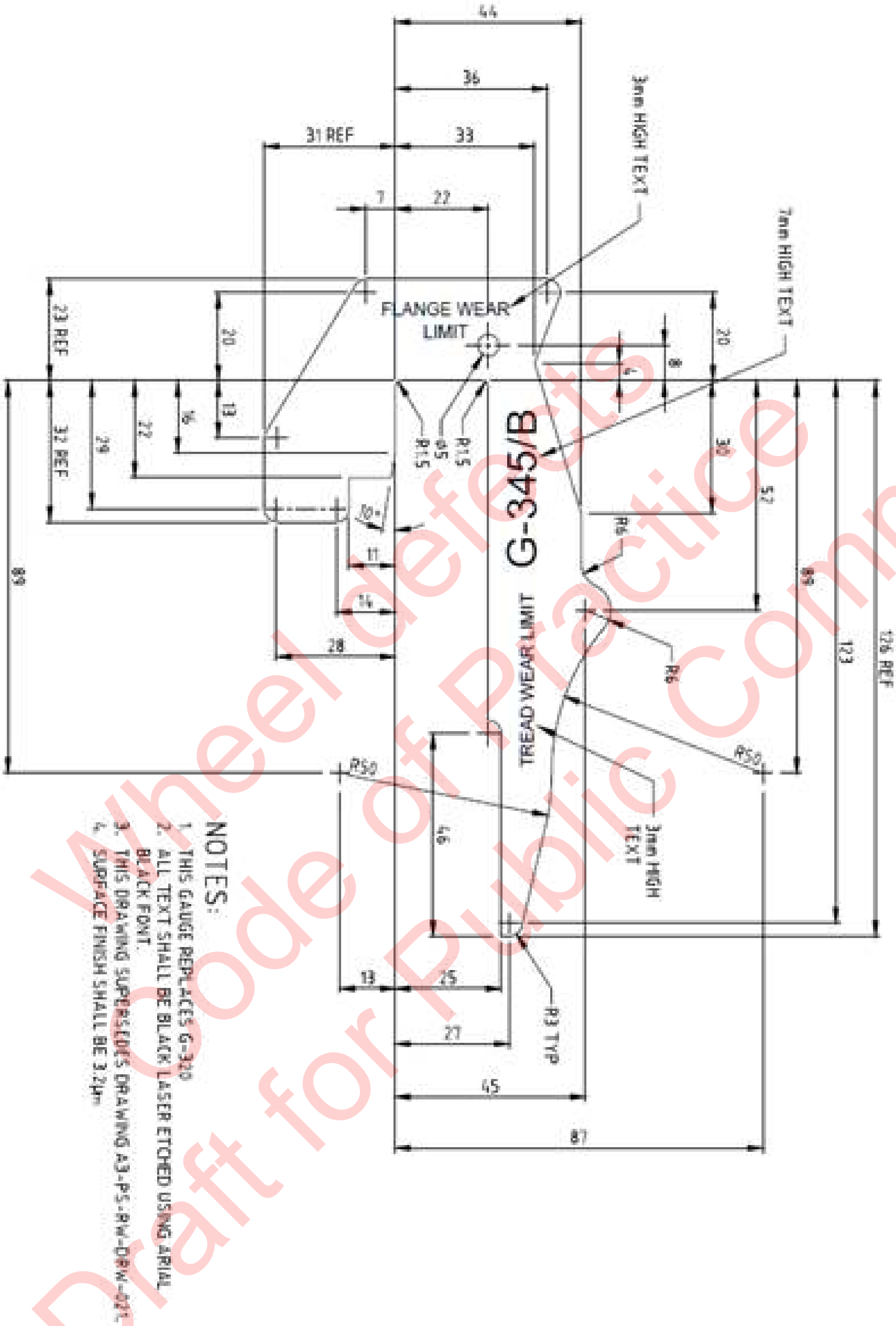
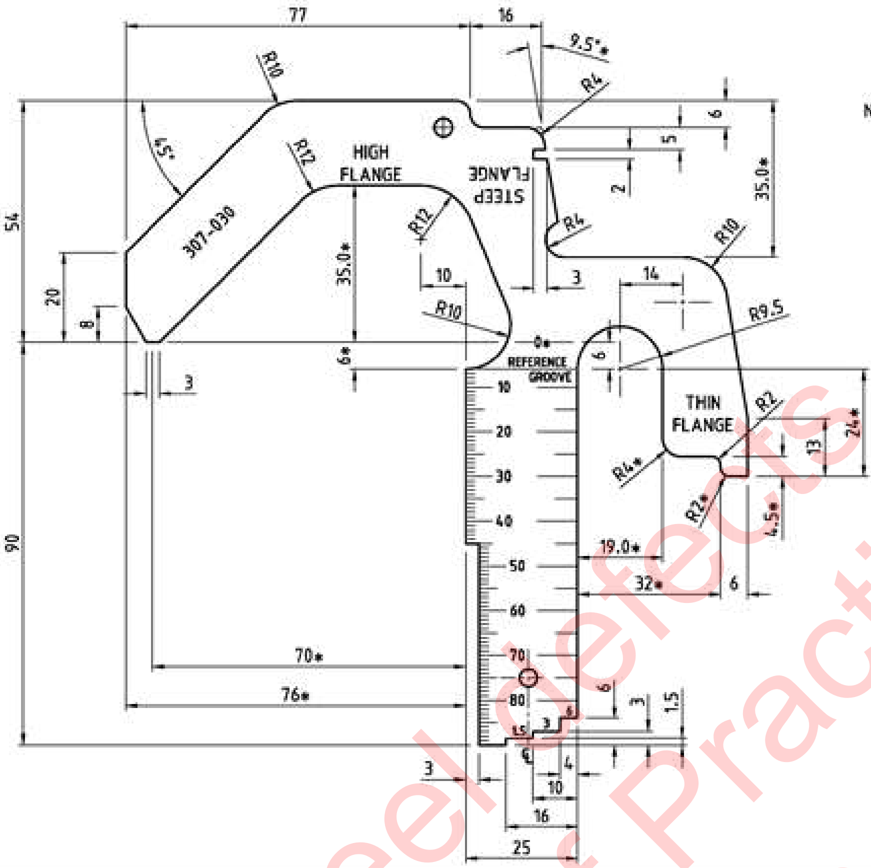


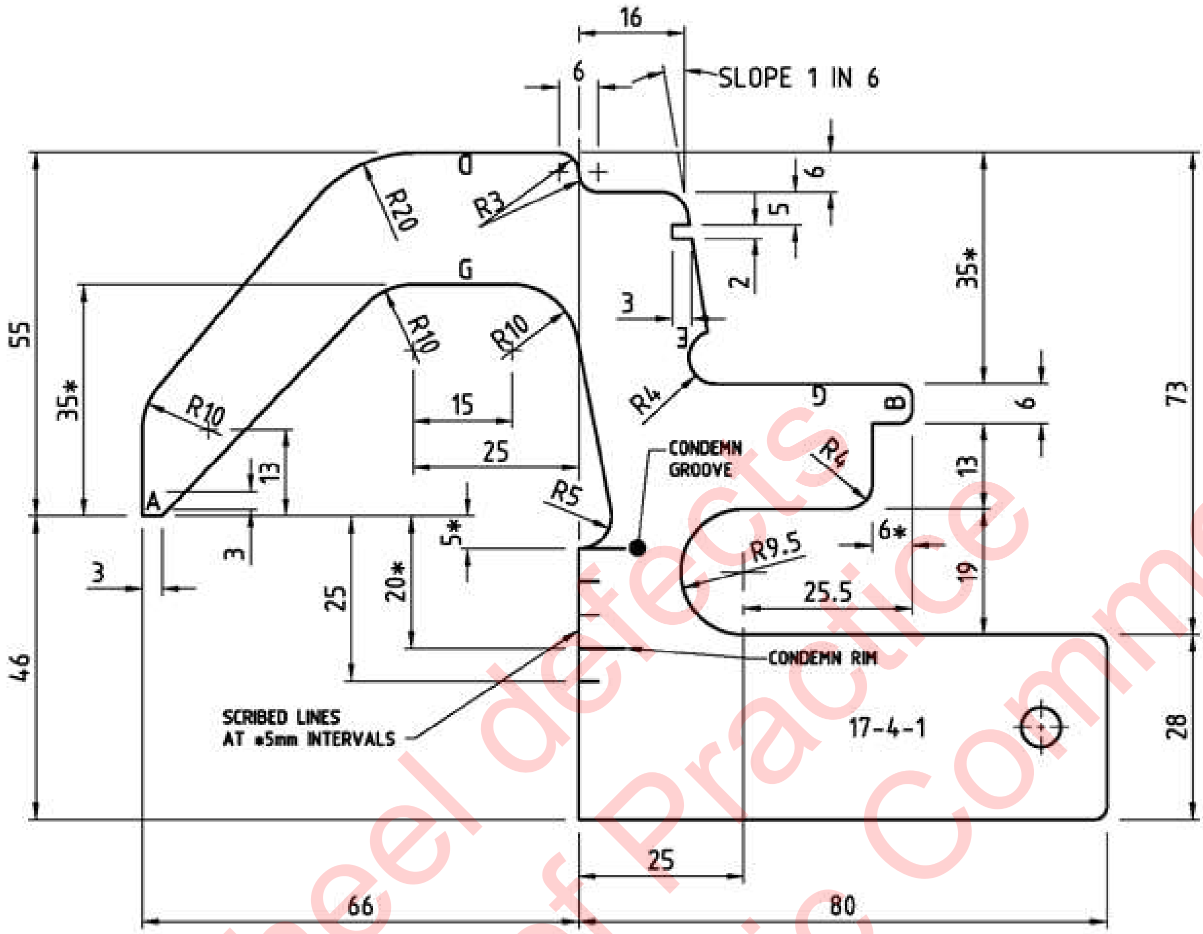
Figure B:2 - Gauge G-345/B



NOTES:

1. ALL EDGE SURFACE FINISH TO BE 0.8µm.
2. GRADUATION SCALE & ALL DIMENSIONS MARKED WITH * TO BE TOLERANCED ±0.1.
3. ALL RADII TO BE 3.0 UNLESS OTHERWISE STATED
4. GRADUATION SCALE MARKINGS AND LETTERING TO BE ENGRAVED ON BOTH SIDES OF THE GAUGE.
5. ALL ENGRAVING TO BE 3.0 IN HEIGHT EXCEPT FOR CONDEMNING NOTATION WHICH ARE 2.5 CHARACTER HEIGHT AND HIGHLIGHTED IN RED.

Figure B:3 - Gauge 307 – 030



NOTES: 1. GAUGE MARKED BOTH SIDES AS SHOWN UNLESS OTHERWISE SPECIFIED.
2. ALL RADII NOT DIMENSIONED TO BE 2.
3. ALL DIMENSIONS ±0.5mm UNLESS OTHERWISE SPECIFIED.
4. DIMENSIONS MARKED * ±0.2mm.

Figure B:4 – Gauge 17-4-1

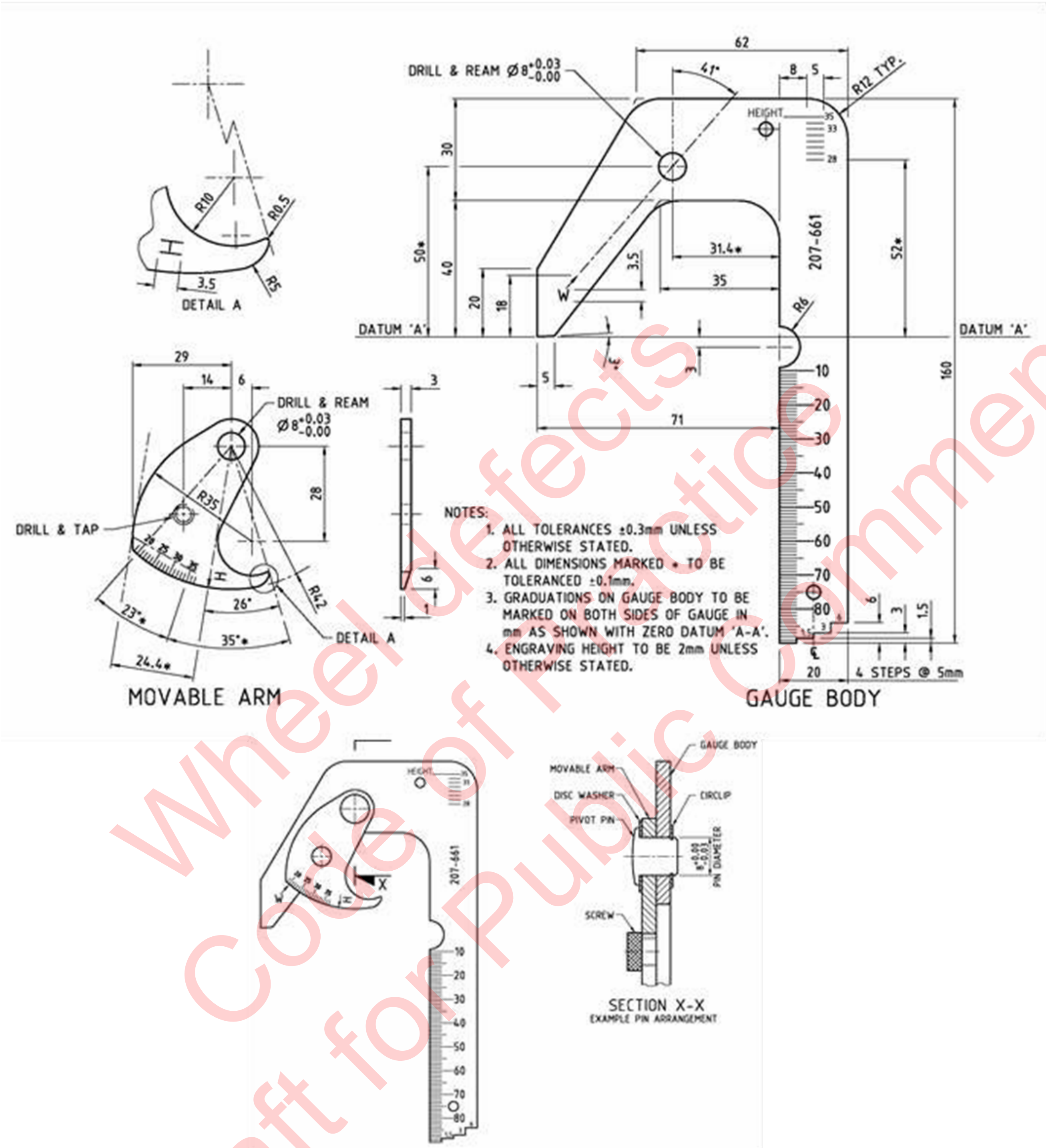


Figure B:5 – Gauge 207 – 661

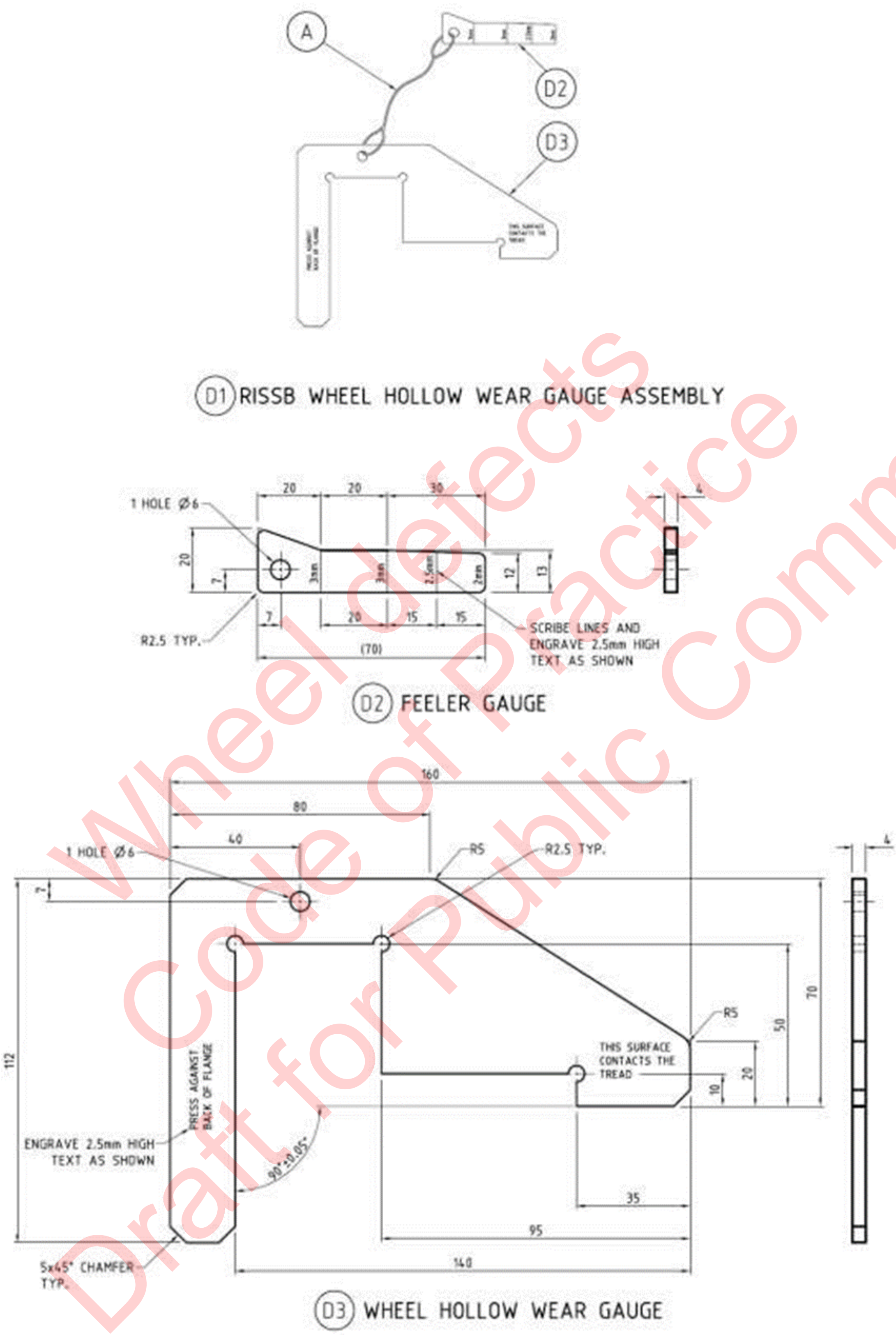


Figure B:6 – RISSB Wheel hollow wear gauge

Appendix C Inspection technologies

C.1 Common wheel inspection technologies

Many RTOs utilise wheel inspection technologies such as:

(a) optical systems for the measurement of wheel profile condition;

(b) eddy current and alternating current field measurement (ACFM) techniques for the detection and quantification of surface cracking; and

(c) ultrasonic-based systems for the assessment of residual stresses, ultrasonic testing of the wheel rim for the detection of internal discontinuities.

C.2 Wheel impact load detectors

Many rail networks have installed wheel impact load detectors (WILD) to identify tread defects. Where these systems are installed and the data is recent, the impact force should be used as the primary measure to assess the removal of wheels. Where WILD data does not exist or is not current, measurement of the physical dimensions of the tread defect is the primary method for assessing the removal of wheels. When inspecting the defect there could be components of out of round, which can increase the impact force to a much higher defect classification than the physical size. This should always be taken into consideration when classing a tread defect. Refer to Figure 4:1 for an example of a spall approximately 22 mm in size; however, the actual affected area is approximately 110 mm.

When measuring defects in Sections 5, 6, 7 and 8 the effects of wheel tread geometry such as that illustrated in Figure C:1 should be taken into consideration, and a review of available wheel impact data carried out.

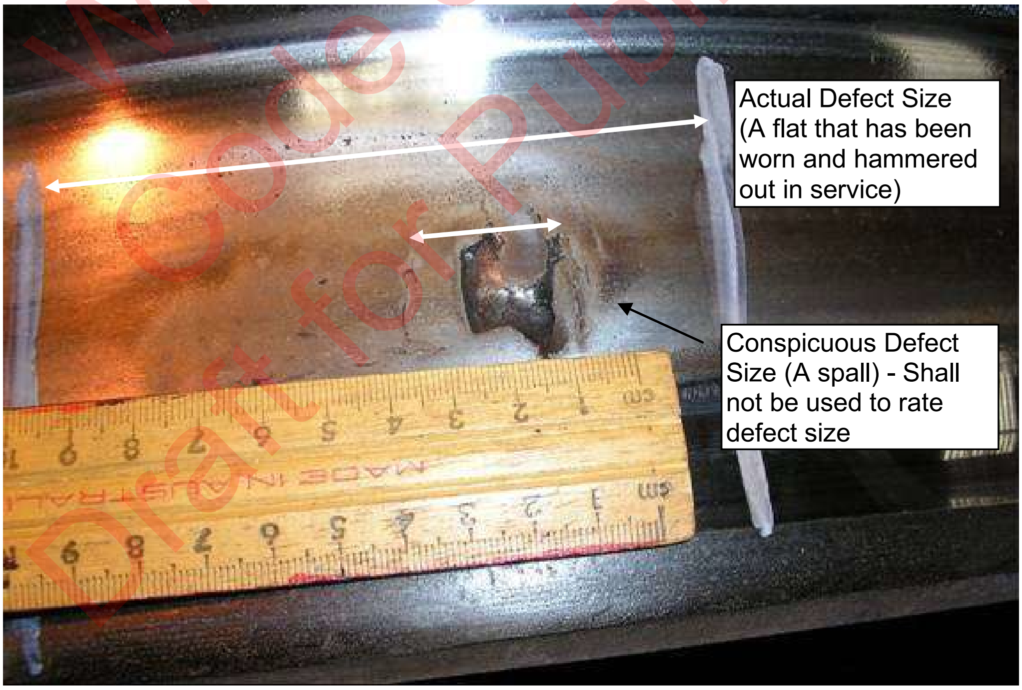


Figure C:1 – Compound tread defect

The length of time a wheel with a tread condition that results in impact loading remains in service may further alter the tread condition, resulting in increased impact loading. The example shown in Figure C:1 indicates a tread which has started to collapse due to repetitive impact loading. On close inspection the discolouration reveals a larger defect than that of the spalled area.

Additionally, when reviewing the actual size of a tread defect a straight edge may be used on the tread defect area, which is rocked back and forth to determine the true affected area. The RIM and RTO shall agree on limits and removal criteria for impact force levels and the corresponding defect sizes and duration in service.

Appendix D Application of wheel gauges

D.1 Types of gauges

A common type of freight wheel condemning gauge is shown in Figure D:1. Sections D.2 to D.5 show how to use these example gauges. Each Rail Network or RTO may develop their own specific gauge and application method for measuring critical wheel dimensions. Refer to Section 5 for limiting dimensions.

Refer to Appendix B for gauges applicable to specific rail networks or operations.

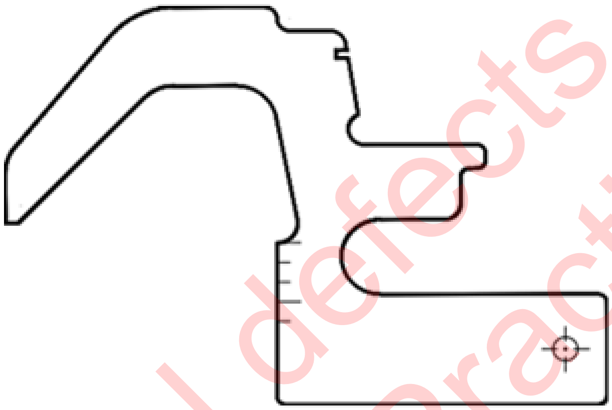


Figure D:2 – Condemning gauge

D.2 High flange

Hold the gauge against the rim back as shown in Figures D:2 & D:3 with the long leg pointing to the centre of the wheel. A wheel with an acceptable flange height is shown in Figure D:2. If the flange touches the high flange section of the gauge, the flange is high (greater than 35 mm) relative to the tread, as shown in Figure D:3.

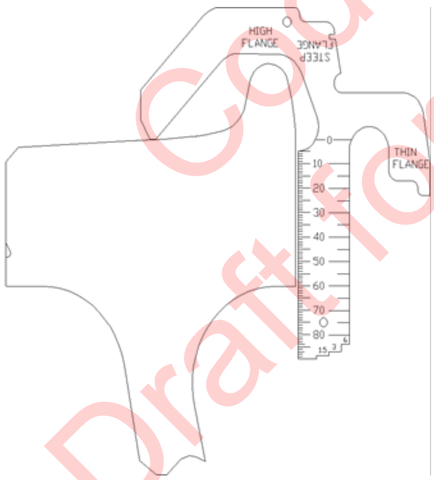


Figure D:2 – Gauging for high flange (acceptable)

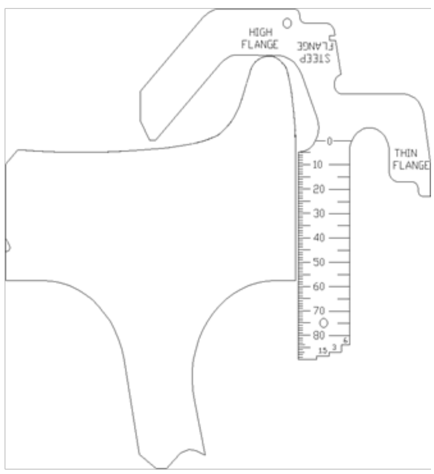


Figure D:3 - Gauging for high flange (condemn)

D.3 Thin flange

Hold the gauge against the rim back, as shown in Figures D:4 & D:5, with the long leg pointing to the centre of the wheel. If the flange thickness is satisfactory, the gauge short arm, which is marked thin flange, should not be able to fit over the flange and allow the tip to make contact with the tread area - refer Figure D:4. Refer to Section 5 for limiting dimensions for thin flange.

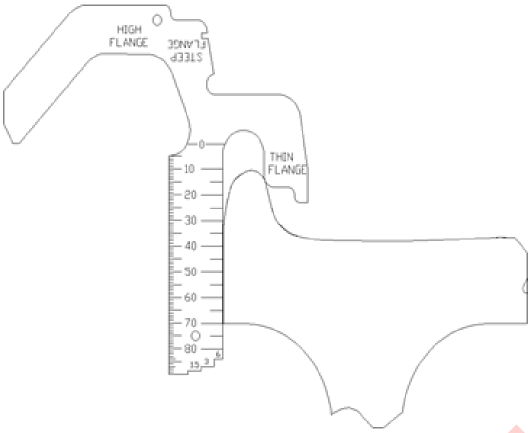


Figure D:4 – Acceptable Gauging for thin flange (acceptable)

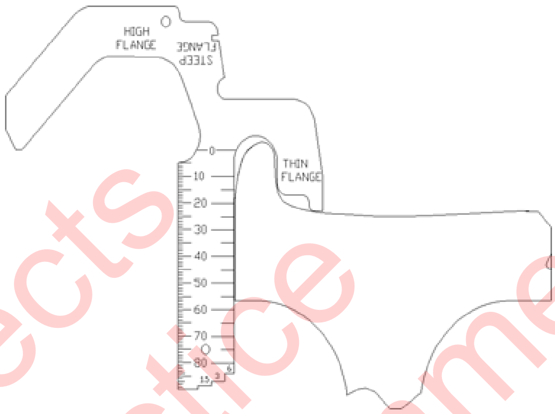


Figure D:5 - Gauging for thin flange (condemn)

D.4 Steep flange

Hold the gauge so that the edge opposite the high flange mark is flush with the tread surface as shown in Figures D:6 & D:7. The long leg of the gauge should point away from the centre of the wheel. An acceptable flange angle is where no part of the gauge above the slot is touching the flange surface as per Figure D:6. If any part of the gauge above the slot at point 'B' touches the flange surface, this indicates that the wheel has a steep flange - refer Figure D:7.

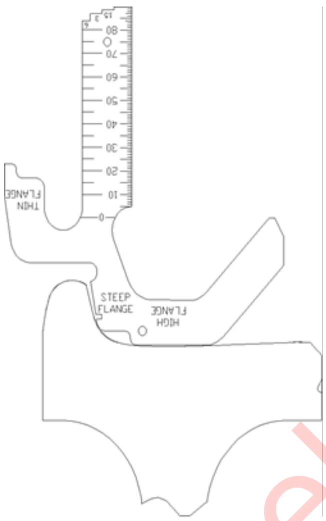


Figure D:6 – Acceptable Gauging for thin flange (acceptable)

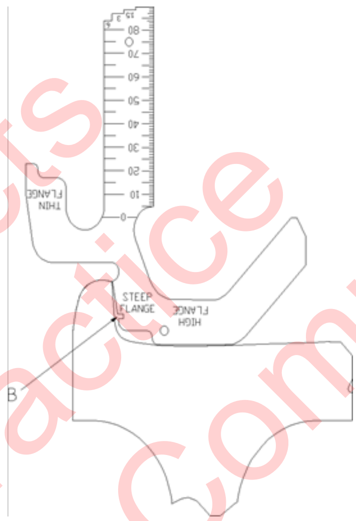


Figure D:7 Gauging for thin flange (condemn)

D.5 Rim thickness

The Rim Thickness is defined according to Figure 3:1. Hold the gauge on the rim back as shown in Figure 4:9 with the long leg pointing towards the centre of the wheel. Ensure that the tip of the gauge long arm is touching the wheel tread area. The scale reading adjacent to the rim back edge at point “A” is the rim thickness – refer to Figure D:8.

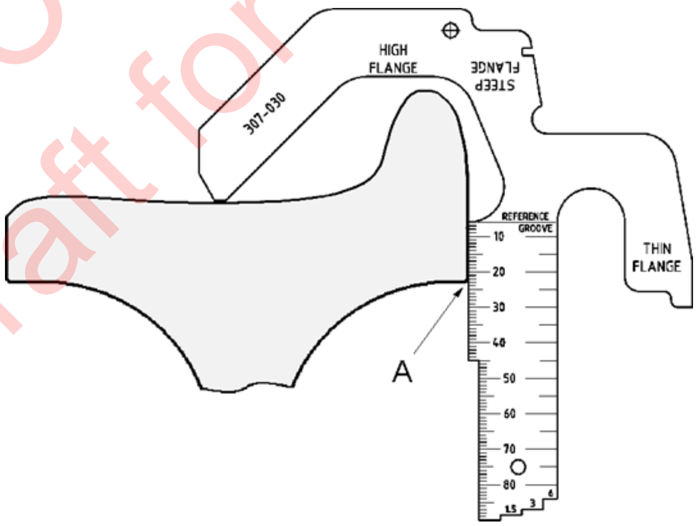


Figure D:8 – Gauging rim thickness

Note: If the back face contains a chamfer, the gauge scale shall be read at the same height as the rim underside.

D.6 Wheel condition warning gauges

Warning gauges (special purpose) may be developed by rail networks or RTOs and used for the identification of wheels that are approaching the condemning limit but have not reached that limit.

D.7 Wheel tread hollowing

Hold the gauge (1) tight against the rim back face as shown in Figure D:9 and move it downwards until it touches the front part of the tread. Check the distance between tread and gauge with the feeler (2) at the position of maximum tread hollowing (hw), wherever this occurs across the tread. Determine the value of tread hollowing (hw) with the feeler as follows:

- Feeler cannot be inserted: hw< 2 mm
- Feeler can be partly inserted: Read the value of hw on the feeler graduation
- Feeler can be fully inserted: hw> 3 mm

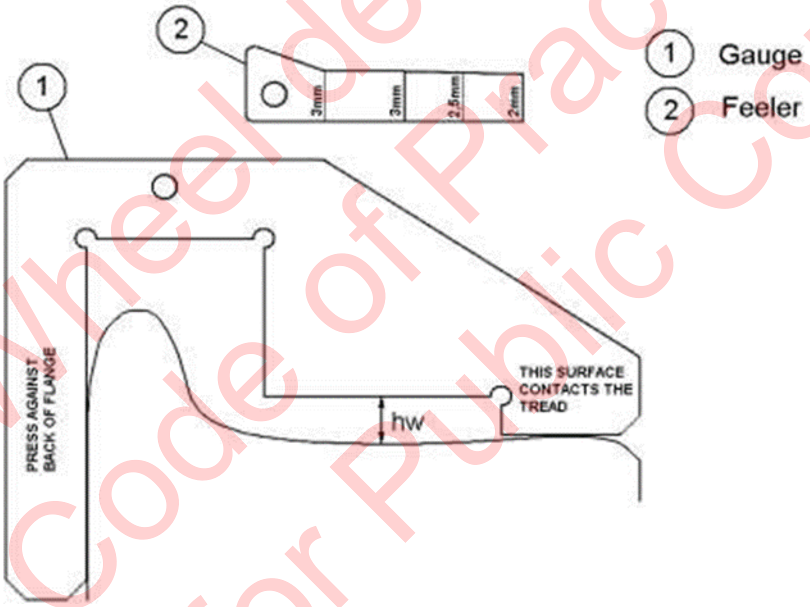


Figure D:9 – Gauging tread hollowing

Appendix E Repair guidance

E.1 General

The repair guidance provided in Appendix E is informative and therefore not provide comprehensive guide for the repair of wheels.

The guidance is intended to complement the requirements of AS 7514.

The user is to assess whether the repair guidance provided meets their organisation's operational environment and risk profile.

E.2 Thermal cracks

Thermal cracks shall be rectified by turning to a depth that ensures all cracks are eliminated.

Where significant cracks are identified, the location of the crack should be marked by the wheel lathe operator on the rim to allow for inspection to ensure the full extent of the crack has been removed. After machining, carry out non-destructive crack detection using, for example, magnetic particles, dye-penetrant or visual inspection.

The brake system to be checked for correct operation and the correct type of brake blocks on any vehicle that is detected with thermal cracks.

E.3 Spalling and shelling

Rectify spalling or shelling by machining to a sufficient depth (3 mm minimum) to completely eliminate it and carry out crack detection after machining.

Check the axle bearings and related equipment of a bogie found to have spalled or shelled wheels for the effects of vibration.

Remove axle bearings for inspection where Class 4 spalling has occurred.

E.4 Wheel flats

The tread shall be machined to a minimum of 3 mm below the wheel flat defect area. The heat affected material shall be removed completely; otherwise further issues requiring further re-profiling are likely to occur once the vehicle returns into service.

The heat affected material can to some extent be identified by its difference in hardness and that it could contain cracks. By observing the cutting tool, the sound from it, the chip breaking and the shine from the turned surface as the tool passes over the damaged tread area, it is often possible to judge when all the heat affected material has been removed.

If the length of the wheel flat is less than 25 mm then cutter blocks may be used in place of brake blocks to restore the wheel to serviceable condition after which normal brake blocks shall be fitted. Alternatively, trim blocks (blocks with an abrasive layer allowed to remain on vehicle) may be used.

Bogies with wheelsets that have been operating with Class 4 wheel flats shall, due to the vibrations induced, be thoroughly examined for evidence of loose, misaligned or damaged components, particularly in relation to axle-boxes and bearing adaptors.

Bearings should be removed for inspection after Class 4 wheel flats due to the risk of bearing damage.

E.5 Scaled wheels

For wheels having less than 1 mm depth of build-up on the tread area a cutter block may be used to restore the wheel to serviceable condition after which a normal brake block shall be fitted.

When rectifying the defect it is important to remove all overheated wheel tread material by machining to a depth (3 mm minimum) sufficient to completely eliminate the defect.

Unless the cause of the incident is obvious, e.g. a not released handbrake/parking brake, any vehicle that is found with any amount of scaling on the tread should undergo a single car brake test as soon as possible.

The axle bearings and related equipment of a bogie found to have operated with Class 4 scaling on its wheels shall be checked for the effects of vibration.

Axle bearings shall be removed for inspection where Class 4 scaling has occurred.

If the scale height can be reduced by chipping or grinding before movement of vehicle the speed restrictions given in Table 8:1 can be moderated according to appropriate subclass (i), (ii) or (iii).

E.7 Tread and flange wear

Tread and flange wear conditions shall be repaired by reprofiling the wheelset.

E.8 Damaged / fractured wheels – external wheel damage

Marks on the flange or tread shall be corrected by machining unless they meet the following criteria:

(a) Less than 25 mm in length and width.

(b) Located in central region of wheel tread (shaded area in Table 1 for thermal cracks).

(c) Depth less than 3 mm.

(d) Any raised metal around the marks is less than 1 mm above the original tread surface.

Chips on the outer edge of the wheel tread greater than 2 mm in depth or 25 mm in length shall be removed by machining. Any local rollover shall be treated as a rolled edge.

Marks elsewhere on the wheels less than 3 mm deep may be locally ground to remove sharp edges. Wheels with scrapes, dents or gouges that cannot be corrected by either of these methods shall be condemned.

Derailed wheelsets (in the absence of other specific criteria, those which have been involved in a derailment where the wheelset is derailed for more than 60 metres, or at greater than 15 km/h, or other abnormal conditions) shall be checked for distortion by using a three point test of the rim to rim distance, or by measuring the run-out as the axle is revolved between centres or on its own bearings – refer AS 7517 for tolerance requirements. If a wheel is found to be distorted it shall be condemned.

E.9 Overheated wheels

Overheated wheels may be repaired by machining to remove any visible surface damage and then a further 20 mm off the diameter (10 mm off the rim thickness). Wheels should be condemned if they are at the last turn diameter.

Alternatively, wheels that are severely overheated should be thoroughly inspected for deformation and/or change of residual stress state. In case large tensile stresses have been formed in the wheel rim, the wheel shall be condemned.

Various techniques and methods are available for assessing the residual stress levels within the wheel rim. However, the limits and instructions outlined by the specific operator/maintainer shall be adhered to. If there is any doubt as to the soundness of the wheel, the wheel shall be condemned. Note that a procedure for non-destructive assessment of residual stresses in wheels is outlined in EN 13262.

E.10 Tread checks

Checking shall be removed by machining to a depth sufficient to ensure all defects are removed. Magnetic particle inspection or dye penetrant may be used to ensure that the cracks have been completely removed.

E.12 Out of round wheels

Wheelsets with tread defect or wear initiated out-of-round wheels should be machined to the tolerances given in AS 7517.

Wheelsets with maintenance initiated out-of-round wheels should have the off-centre defective component replaced and the wheelset checked against the tolerances given in AS 7517.

Appendix F Bibliography

The following referenced documents are used by this Code of Practice for information only:

- EN 13262 Railway Applications - Wheelsets and Bogies - Wheels - Product Requirement.
- Field Manual of the AAR Interchange Rules.
- FreightCorp Examiner’s Pocket Field Manual EFR.0004 dated September 1996.
- Guidance on Railway Wheelset Tread, Gauging and Damage” published by the UK Rail Safety and Standards Board (UK RSSB GM/GN2497)
- Interfleet report ITLR-T22393-001 "Development of a Wheel Tread Hollowing Gauge".
- International Heavy Haul Association "Guidelines to Best Practices for Heavy Haul Railway Operations: Wheel and Rail Interface Issues".
- John Holland Rail Procedure Rail-Plant-2-100-12 "Rail Wheel Inspection".
- Pacific National Train Inspection Manual TIM 03-08_04 "Wheel Profile & Tread Condition".
- Queensland Rail Specification SAF/SPC/0012/RSK "Wheel Defect Identification & Rectification".
- RailCorp ESR 0330 "Wheel Defect Manual".
- RCP-2304 "Identification and Classification of Wheel Defects", Draft Volume 5 from the Code of Practice for the Defined interstate rail network.
- ROA Manual of Engineering Standards and Practices.
- TransAdelaide "Rail Car Wheel Inspection Manual".
- UIC "Atlas of Wheel and Rail Defects".
- V/Line Procedure VEPR-009 "Wheel Management Strategy for Locomotive".
- V/Line Procedure VEPR-011 "Rail Wheel Defects, Inspection and Rectification".

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