Rail Industry Standard
RIS-2766-RST
Issue: Two **Draft:** Draft 3
Date: March 2023

Rail Industry Standard for Wheelsets

Synopsis

This document supports GMRT2466 and sets out requirements for the design, manufacture and maintenance of wheelsets and their components.

Published by RSSB

Issue Record

Issue	Date	Comments
One	02/12/2017	Created by combining the non-NTR content of GMRT2466 and relevant superseded guidance notes
Two	March 2023 [proposed]	Revisions include replacing the term 'TSI' with 'NTSN', clarify application of re-profiling tolerances, revision to recovery speed with large wheel flats and update of references to other documents

Revisions have been marked by a vertical black line in this issue except where "TSI" has only been replaced by "NTSN".

Superseded Documents

The following Railway Group documents are superseded, either in whole or in part as indicated:

Superseded documents	Sections superseded	Date when sections are superseded
RIS-2766-RST issue one Rail Industry Standard for Wheelsets	All	March 2023 [proposed]

Supply

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Part 1 Purpose and Introduction

1.1 Purpose

1.1.1 This document is a Rail Industry Standard for the design, manufacture and maintenance of wheelsets.

1.1.2 This document should be read in conjunction with the Rolling Stock National Technical Specification Notices (NTSNs) 'Locomotives and Passenger' (LOC&PAS) and 'Freight Wagons' (WAG) and Railway Group Standard GMRT2466.

1.2 Application of this document

1.2.1 Compliance requirements and dates have not been specified because these are the subject of internal procedures or contract conditions.

1.2.2 If you plan to do something that does not comply with a requirement in this RIS, you can ask a Standards Committee to comment on your proposed alternative. If you want a Standards Committee to do this, please submit your deviation application form to RSSB. You can find advice and guidance on using alternative requirements on RSSB's website www.rssb.co.uk.

1.3 Health and safety responsibilities

1.3.1 Users of documents published by RSSB are reminded of the need to consider their own responsibilities to ensure health and safety at work and their own duties under health and safety legislation. RSSB does not warrant that compliance with all or any documents published by RSSB is sufficient in itself to ensure safe systems of work or operation or to satisfy such responsibilities or duties.

1.4 Structure of this document

1.4.1 This document sets out a series of requirements that are sequentially numbered. This document also sets out the rationale for the requirement, explaining why the requirement is needed and its purpose and, where relevant, guidance to support the requirement. The rationale and the guidance are prefixed by the letter 'G'.

1.4.2 Some subjects do not have specific requirements but the subject is addressed through guidance only and, where this is the case, it is distinguished under a heading of 'Guidance' and is prefixed by the letter 'G'.

1.5 Approval and Authorisation

1.5.1 The content of this document will be approved by Rolling Stock Standards Committee (RST SC) on 9 December 2022 [proposed].

1.5.2 This document will be authorised by RSSB on 25 January 2023 [proposed].

Part 2 Requirements for Design

2.1 Wheelset design

2.1.1 For the design of wheelsets a consistent set of standards shall be applied for wheels, axles and their manufacture and assembly as a wheelset and their subsequent inspection and maintenance.

2.1.2 Where standards other than those mandated by the LOC&PAS NTSN, the WAG NTSN or GMRT2466 are permitted as defined in this document, the suitability of standards selected shall be demonstrated by reference to relevant experience in service, analysis, simulation and/or testing.

Rationale

G 2.1.3 This provides the consistent methodology to comply with the LOC&PAS NTSN (4.2.3.5.2) and WAG NTSN (4.2.3.6.2 and 4.2.3.6.3).

Guidance

G 2.1.4 The sets of standards available are subdivided typically into standards for design and for manufacture with separate standards for axles, wheels and wheelset assembly.

G 2.1.5 The following table gives five examples of consistent sets of standards for which there is service experience:

Case		1	2	3	4	5
Wheelset type	Journals	Outside	Outside	Outside	Inside	Inside
	Traction	Non-powered	Powered	Non-powered	Both	Both
	Wheel type	Forged and rolled	Forged and rolled	Cast	Forged and rolled	Cast
Axle	Design	BS EN 13103-1	BS EN 13103-1	BS EN 13103-1	BS 8535	BS 8535
	Manufacture	BS EN 13261	BS EN 13261	BS EN 13261	BS EN 13261	BS EN 13261
Wheel	Design	BS EN 13979-1	BS EN 13979-1	BS EN 13979-1	BS EN 13979-1	BS 5892-7
	Manufacture	BS EN 13262	BS EN 13262	BS 5892-7	BS EN 13262	BS 5892-7
Wheelset	Assembly	BS EN 13260	BS EN 13260	BS EN 13260	BS 5892-8	BS 5892-8

Case	1	2	3	4	5
NTSN Compliance					
LOC&PAS	Full	Full	National use	National use	Not applicable
WAG	Full	Not applicable	National use	National use	National use

Table 1: Examples of consistent sets of wheelset standards

G 2.1.6 The Association of American Railroads (AAR) Manual of Standards and Recommended Practices, Section G, 'Wheels and axles' and Section G 'Part II - Wheel and axle (shop) manual' sets out the design requirements, standard sizes and manufacturing requirements for wheels and axles. Matters relating to wheel tread profiles and wheelset dimensions are not applicable.

2.2 Wheelset geometry

2.2.1 When new, or following overhaul, the tread run-out (radial) and the wheel wobble (axial run-out) shall not exceed the values set out in Table *2*

Vehicle type	Maximum tread run-out (mm)	Maximum wheel wobble (mm)
Any vehicle permitted to operate above 125 mph and up to 140 mph	0.20	0.30
Locomotives and coaching stock operating at maximum speeds up to and including 125 mph	0.25	0.40
Freight vehicles operating at maximum speeds greater than 75 mph and up to and including 100 mph	0.30	0.40
Freight vehicles operating at maximum speeds between 60 mph and 75 mph	0.40	0.50
Freight vehicles operating at maximum speeds up to and including 60 mph	0.50	0.50
All other vehicles	As BS 5892, Part 6	

Table 2: Tread run-out and wheel wobble limits

2.2.2 When newly turned, the wheel tread profiles on each wheel shall be aligned with the wheelset axis.

2.2.3 Wheel tread profile shall be within a geometric tolerance of ±0.25 mm of the nominal.

2.2.4 On new or overhauled wheelsets the outside face of the rim of the wheel or tyre shall be flat to within ±0.25 mm.

2.2.5 Resilient wheels when new, or overhauled, shall have a maximum wheel axial run-out (wobble) of 0.75 mm for all vehicles.

Rationale

G 2.2.6 To limit the vertical and lateral oscillations generated during wheel rotation to prevent on-vehicle vibration and / or track damage.

Guidance

G 2.2.7 The risk of flange climbing and derailment is increased by irregularities, steps or sharp edges on the flange and flange tip. Sharp features, poor transitions and irregularities on the flange tip may increase the possibility of splitting switches.

G 2.2.8 See *4.7.4* for limits that apply when re-profiling in service.

2.3 Axle design

2.3.1 Axles for new wheelset designs shall use axle design standards that are consistent with the requirements for wheelsets (see *2.1*).

2.3.2 The axle design shall define the non-destructive testing (NDT) requirements for manufacture and all phases of the wheelset life and shall be set out in the technical documentation supplied with the axle (see *3.4*).

2.3.3 Where an axle coating and protective system is required this shall be recorded in the technical documentation for the axle.

2.3.4 For axles designed in accordance with BS EN 13103-1:2017 or BS 8535:2011 the axle material shall be selected from BS EN 13261 Grades EA1T, EA4T or EA1N.

Rationale

G 2.3.5 The choice of axle material can influence axle reliability and the inspection regime applied to the axle in service. Where high-strength steel axles are operated close to their permitted stresses the potential crack propagation rate could be correspondingly greater, hence necessitating an appropriately frequent inspection regime. A recognised standard of axle materials helps to achieve the required performance and reliability of the axle.

Guidance

G 2.3.6 The following is a non-exhaustive list of factors that are typically considered in axle design:

a) Maximum operational speed and cant deficiency.
b) Characteristic of loads applied to the axle, including vehicle loads, track inputs, wheel tread damage, mass of transmission components and transmission forces, braking forces, effects of wheel-slide and wheel-slip systems etc.

c) Loading regimes which could adversely affect the axle life, such as torsional vibrations.
d) The geometry between the axle features.
e) The effects of interference fits on the axle.
f) All potential stress concentrations and method of their elimination, for example, surface finish, geometry.
g) Maximum stresses that satisfy non-finite fatigue life requirements.
h) The material and heat treatment process to be used.
i) Manufacturing process, including surface finish.
j) Compatibility with NDT techniques that are to be applied to the axle during its life.
k) Effects of impact damage to the axle surface.
l) Effects of thermal and mechanical interaction between the brake disc and the mounting on the axle.

G 2.3.7 The effect of surface treatment can influence the axle fatigue performance of the axle, which can in turn affect the allowable fatigue stress.

G 2.3.8 The application of some blast cleaning processes can be beneficial in not only effectively cleaning the axle surface but also in generating a compressive stress in the surface. In this case the shot blast medium needs to be considered carefully to avoid obscuration of defects due to plastic modification of the surface.

G 2.3.9 Great Britain (GB) and European axle design standards have been developed over many years:

a) British Rail BASS 503 and BASS 504 design guides were produced for the design of axles for operation on track meeting British Rail track standards and quality at the time. These documents give limiting stress values for different parts of the axle and in so doing assumptions were included for the axle material, suspension characteristics and axle corrosion protection.
b) BS EN 13103-1 supersedes BS EN 13103 and BS EN 13104 and applies to both powered and non-powered (trailer) axles with outboard bearings. Axles with inboard bearings are addressed in PD CEN/TS 13103-2, and it is intended that a part 3 will be developed to address axles for urban applications.
c) BS EN 13103 and BS EN 13104 originated from UIC leaflets, where the most appropriate standard axle design would be selected on completion of the design calculations; that is, larger than the minimum design calculated. This ensured a margin of safety over the calculation values. In practice, axles were not therefore working at the limit values that the standards apparently permit.
d) In addition, BS EN 13103 and BS EN 13104 were developed from experience of typical mainland European infrastructure. Also, these design methods require that corrosion protection and axle maintenance regimes are considered.

G 2.3.10 A record of the coating system used on the axle is necessary because the need for, and specification of, an axle coating system can have a significant effect on the predicted life of an axle and the maintenance plan.

2.4 Wheel design

2.4.1 Wheels for new wheelset designs shall use design standards that are consistent with the requirements for wheelsets; see *2.1*.

2.4.2 New wheelset designs shall use monobloc wheels.

2.4.3 For wheels restricted to national use, the wheel material shall be selected from approved grades of steel for particular applications as set out in the table below.

Wheel type	BS 5892-3	BS EN 13262[3]	BS 5892-7	AAR
Freight, integral brake disc wheels	R7E	x[2]	x	x
Freight, cheek mounted brake disc wheels	R8E	x	x	x
Other freight wheels	R7T or R8T	ER7 or ER8	C64	M-107/M-208 class B
All passenger vehicle wheels	R8T or RS8T[1]	ER8	x	x
Other wheels	R8T	ER8	C64	M-107/M-208 class B

Table 3: Monobloc wheel material

Note: RS8T is not recommended for use on tread braked wheel applications.

Note: x - No approved grades of steel available.

Note: BS EN 13262 only applies to rim chilled wheels for this table.

2.4.4 For wheels designed in accordance with BS EN 13979-1, the wheel material shall be selected from BS EN 13262 Grades ER7 or ER8.

2.4.5 For cast wheels designed in accordance with BS 5892-7, the wheel material shall be BS 5892-7 Grade C64.

2.4.6 For wheels designed in accordance with AAR standards (see *G 2.1.6*), the wheel material shall conform to AAR standard M-107/M-208 Class B.

2.4.7 New wheel designs shall make provision for balancing without the need for holes in the wheel.

2.4.8 Tread braked wheels or wheels with disc brakes mounted on or integral with the wheel shall be designed to accommodate the thermal loads induced by braking cycles.

2.4.9 The wheel shall remain securely located on the axle when subject to the maximum thermal loading.

2.4.10 Where alternative standards are used, lateral displacement of the wheel rim, relative to the wheel hub, shall be within the criteria set out in 6.2.2 of BS EN 13979-1.

2.4.11 For monobloc wheels, the rim thickness at the final re-profiling may be reduced such that the wheel rim fatigue life becomes finite. The predicted fatigue life at final re-profiling shall be not less than three times the remaining service life.

Rationale

G 2.4.12 The objective is to provide robust and reliable wheel designs and help ensure materials selected are of a recognised standard and achieve the required performance and reliability. Monobloc wheels help eliminate the risk of derailment from loose or fractured tyre wheel arrangements. Consideration of thermal loadings due to braking helps to ensure safety of the wheelset against derailment from movement of the wheel on the axle or excessive displacement of the wheel rim.

Guidance

G 2.4.13 Eliminating holes for balance weights reduces the risk of wheel fatigue fractures emanating from stress raisers caused by the attachment of balance weights.

G 2.4.14 The recommended method of balancing is by machining in accordance with the respective standard.

G 2.4.15 The requirement that the predicted fatigue life at final re-profiling shall be not less than three times the remaining service life provides a contingency for uncertainties that can affect the wheel life assessment, such as the stress levels that can be locally generated in the wheel rim and the number of cycles when negotiating track features in the final part of its life.

G 2.4.16 The most severe thermal loading is produced through either:

a) Drag braking; or
b) The most arduous repeated braking cycle to be experienced by the vehicle (including an additional stop to represent peak thermal loading during the cycle).

G 2.4.17 The repeated braking cycle can be determined from a route simulation, including station dwell times, with additional brake applications added at the most arduous location identified in the simulation. Alternatively, the repeated braking could be cyclic brake applications with representative station dwell times.

G 2.4.18 The route simulation or repeated braking cycle reaches a maximum or saturation temperature, which the wheel is required to accommodate without losing the interference fit on the axle. This principle is applicable to all railway vehicles, although freight trains having greater start / stop cycle times could achieve the maximum temperature in a single cycle. The drag braking case for freight vehicle applications could generate higher temperatures in the wheel when holding a constant speed on a long gradient.

G 2.4.19 The list of factors in clause *G 2.3.6* for axle design also affects wheel design. In addition, the following factors are relevant for wheel design:

a) Thermal effects on the wheel to axle fit.
b) Thermal strains imposed by friction brake components.

c) The full range of wheel dimensions permitted.
d) Effects of thermal and mechanical interaction between the brake disc and the mounting on the wheel.

G 2.4.20 The following factors can affect calculating the predicted wheel fatigue life:

a) Steel cleanliness levels.
b) Permitted defects in the wheel rim, as set out in maintenance guidance related to tread defects and profile discontinuities (see 4.4).
c) Residual stress distribution in the worn wheel.
d) Transient loading at the tread corner when negotiating switches and crossings.

G 2.4.21 Where cast wheels are specified, BS 5892 Part 7 includes requirements for micrographic cleanliness.

2.5 Axlebox

2.5.1 The combination of axlebox and axle bearing designs shall be sealed to stop water ingress and contaminants.

2.5.2 New axlebox designs shall meet the requirements set out in BS EN 15827:2011 and the relevant component related standards.

2.5.3 Existing axlebox designs shall be used and maintained within the parameters specified for the relevant standards.

Rationale

G 2.5.4 This is to help control the risk of premature bearing failure and ensure the structural integrity of axleboxes.

Guidance

G 2.5.5 Sealing arrangements minimise the loss of lubricants during operation and protect the bearing from contamination due to the ingress of water and other foreign substances from the operating environment.

G 2.5.6 The function of the axlebox is to:

a) Ensure integrity of the installation and maintain location of the wheelset in the event of a bearing failure.
b) Transmit suspension loads.
c) Support other equipment such as life guards and sanding equipment.

G 2.5.7 Axle bearings can fail as a result of the passage of electrical current. A measure to help control this risk is to include axle current return brushes. The effect of high electrical resistance, typically due to glazing of rubbing surfaces where no or low current is experienced, can affect the axle bearings and measures implemented to help control the risks associated with the passing of electrical current.

G 2.5.8 Annex D of BS EN 15827:2011 lists the component related standards relevant to axleboxes and axlebox-mounted equipment.

G 2.5.9 Design accelerations have been harmonised between GMRT2100 and BS EN 13749:2021 but other values have been used in the past in GMRT2100 and other standards.

2.6 Axle bearing design

2.6.1 The axle bearing design life shall be determined using BS ISO 281:2007 or alternative equivalent method.

Rationale

G 2.6.2 To demonstrate the suitability of the selected bearing and to determine maintenance schedules.

Guidance

G 2.6.3 A method for calculating bearing life is set out in BS ISO 281. Bearing manufacturers will use their own methods, which include the effects of such things as material quality, cleanliness, heat treatment and geometry to provide more accurate prediction.

G 2.6.4 The following factors affect design of the axle journal bearing:

a) Radial, lateral and torsional loading, including mechanical loads appropriate to the input from track and vehicle.
b) Additional load inputs due to the effects of predictable wheel tread defects, for example, wheel flats.
c) The loads that can be attributed to the accumulated tolerance in the assembly and parasitic forces that can be produced within the suspension arrangement.
d) The full range of operating duties, rotating speeds and loads.
e) Selection of bearing grease, taking into account degradation and increasing water content of the grease over time.
f) Climatic conditions.
g) Thermal inputs.

2.7 Wheelset assembly design considerations

2.7.1 Wheels and other components that are secured to the axle by interference fit shall be designed to remain secure over the full range of operational conditions that the wheelset will experience to include as a minimum:

a) The thermal effects arising from the environment and service operation.
b) The effects of either traction or braking applied torque.
c) The potential effects of interference fit relaxation caused by the interference fit of adjacent components.

2.7.2 Wheelsets for new wheelset designs shall use standards for assembly that are consistent with the requirements for wheelsets (see *2.1*).

2.7.3 Components mounted on wheelsets shall be designed to accommodate the proof, thermal, fatigue and self-induced loads. This shall be demonstrated by calculation or structural analysis using loads derived from test, service or simulation.

2.7.4 Components mounted on a wheelset shall have a service life at least that of the wheelset or a multiple thereof. In addition, where a component can only be maintained or overhauled when the wheels are removed from the axle, then the component fatigue life shall be at least that of the wheels or a multiple thereof.

2.7.5 Any brake disc fasteners shall have a life commensurate with the life of the brake disc and compatible with the wheel life.

Rationale

G 2.7.6 The primary objective is to ensure the security of wheelset components in service to achieve the required levels of safety and performance. Additional requirements help ensure reliability and an economic service life (that is, the interval between overhauls) by requiring components fitted to wheelsets such as brakes and transmissions, to have service lives that are compatible with the overhaul requirements for the primary wheelset elements: the wheels and axle.

Guidance

G 2.7.7 Components mounted to the wheelset that are required to have a service life at least that of the wheelset or a multiple thereof, include: gear cases, gearboxes, axle hung traction motor mountings (suspension tubes), brush gear, brake discs and speed sensors.

G 2.7.8 Evaluation of the design life is undertaken using appropriate mechanical, thermal, braking and transmission loads, including track inputs. Additional predictable loads that are produced from wheelset damage, including tread damage, can be considered in the component design.

G 2.7.9 Aspects that influence the design of wheelset and the equipment fitted include:

a) All proof and fatigue loads and other design factors predictable throughout the required design life.
b) The thermal and mechanical loads transmitted to the mounting arrangement are to be consistent with those used in the wheel and / or axle design.
c) Assessment of the mechanical and thermal loads and the interaction with the wheel and / or axle to ensure that the installation remains secure at all times throughout the design life.
d) Mechanical loads appropriate to the input from track and vehicle, such as tread damage and transmission forces.
e) Centrifugal loads, for example on fasteners of split discs.
f) Localised and bulk thermal inputs.
g) Braking loads.
h) Effects of thermal and mechanical interaction between the brake disc and the mounting on the wheel or axle.
i) Variations through the service life from new to worn condition.

2.8 Corrosion protection

2.8.1 A coating and protection system applied to the wheels and axle shall be documented in the technical specification.

2.8.2 The technical specification shall include provision for the completion or addition of any corrosion protection after completion of all tests on the wheelset.

2.8.3 Materials that come into contact with the wheelset shall not have an adverse effect on the performance of the coating applied to the wheelset.

2.8.4 The technical specification shall include provision for the treatment of overhangs and other moisture traps at the axle to wheel interface and similar locations, to prevent corrosion.

Rationale

G 2.8.5 These requirements are to control and manage the risk from corrosion to wheelsets and the consequent risk of axle failure due to cracks initiating in areas and surfaces damaged by corrosion.

Guidance

G 2.8.6 The axle design process includes the effect of measures for protecting the axle and any necessary maintenance activities required to maintain axle integrity. The measures adopted, their application and maintenance are therefore an integral part of the wheelset design.

G 2.8.7 The choice of an axle protection system is influenced by a number of factors such as: application, speed, duty, protection required, maintenance policy and repair processes. The principal systems available for axle protection are summarised as follows:

a) Axles may have no protective coatings applied, such as AAR designed axles, where the surface is permitted to corrode. Such axles take into consideration the effect of corrosion and impact damage on surface finish by including additional allowance during their service life. These axles tend to be of a larger diameter and will often include a machining allowance for skimming of the corroded surface.
b) Traditional protective coatings are usually comparatively thin and will generally only provide protection against corrosion, not being sufficiently robust to prevent impact damage to the surface. These coatings are usually comparatively simple to apply and remove. Such coatings may be suitable for surface NDT techniques.
c) Thick coatings made up of several different layers each providing a different function in the protection system. Often the outer layer consists of a rigid material which resists impacts from ballast, ice and other debris on the track. These coatings may prove unsuitable for surface NDT techniques and may require complete removal to enable surface inspection.

G 2.8.8 The following factors have an effect on the selection of a coating and protection system to be applied to a wheelset:

a) Mechanical and impact damage.

b) Environmental factors, corrosive material that the wheelset could come into contact with.
c) Potential for galvanic corrosion between components.
d) Adhesion to substrate material at the manufactured surface finishes.
e) Effects of products remaining on the surface.
f) Susceptibility to corrosion spreading beneath the coating if damaged locally.
g) Repair systems that are likely to be necessary to rectify damage (including facilities and time constraints).
h) Systems necessary for the removal of the coating at overhaul.
i) Disposal of waste materials.

G 2.8.9 Materials that can have an effect on the coating when they come into contact with the wheelset include: NDT consumables, coupling compounds, and other protective materials such as those applied to axle body transitions.

G 2.8.10 Areas left uncoated or unpainted for ultrasonic testing can be protected with suitable material, typically by one which is transparent to ultrasound, before storage, transportation or fitting to a vehicle.

G 2.8.11 The axle body surface can be blast cleaned to improve keying of the corrosion protection medium applied to the axle body. The process applied to the axle surface can affect the material fatigue strength.

G 2.8.12 RSSB research project T1223 (2022) looks at the theory and practice of wheelset coating systems. It includes a report giving technical guidelines for wheelset coatings and a coating systems selection tool, in the form of a weighted decision matrix, that can be used to assist in the selection of the optimum coating system.

Part 3 Requirements for Railway Wheelset Manufacture and Assembly

3.1 Wheelset components

3.1.1 Axle testing

3.1.1.1 In addition to NDT requirements specified for manufacture, axles shall be successfully tested using the ultrasonic axle test regime required for maintenance.

Rationale

G 3.1.1.2 The ultrasonic axle testing undertaken during manufacture is intended to be representative of the ultrasonic axle testing undertaken during the axle's service life. The ultrasonic testing requirements included within EN 13261 specify a relatively basic probe technology which may be inferior to the subsequent maintenance testing. These basic ultrasonic testing requirements may result in the acceptance of axles that prove to be opaque to the more sensitive techniques applied during maintenance. When ordering axles, the ultrasonic testing requirements are defined.

Guidance

G 3.1.1.3 Opacity can be caused by relatively large grain size within a material adversely affecting the transmission of ultrasonic sound wave through the material, particularly important for N grade materials. This condition results in the affected axle being rejected as ultrasonic axle testing (UAT) is not possible. Testing for this condition prior to assembly removes the majority of axles affected by this condition at an early stage, although it is believed the condition can occur some time after manufacture.

G 3.1.1.4 All new axles are subject to magnetic particle inspection (MPI) or an equivalent validated procedure, before assembly, to ensure they are free of surface-breaking defects.

3.2 Replacement components for British Rail wheelset designs

3.2.1 Replacement axles

3.2.1.1 Replacement axles shall be manufactured in accordance with BS 5892-1:1992 Grade A1T, A4T or A1N.

3.2.1.2 Axles manufactured in accordance with BS 5892 Part 1 shall be subject to the micrographic cleanliness examination requirements set out in BS EN 13261 clause 3.4.1.

3.2.1.3 Replacement axles shall additionally be subject to the following tests, which are optional in BS 5892 Part 1:

a) Impact test (BS 5892 Part 1 clause 8.3.4).
b) Ultrasonic testing (BS 5892 Part 1 clause 9.3.1) to demonstrate that the axle body is transparent to ultrasound.

c) MPI (BS 5892 Part 1 clause 9.3.2), or inspection process of at least equivalent sensitivity, over the whole surface area, excluding the axle ends. This testing shall be carried out after finish machining and prior to fitment of any components.

3.2.1.4 Replacement axles shall have a hydrogen content in accordance with BS EN 13261.

Rationale

G 3.2.1.5 The additional requirements are specified to assure product quality to an equivalent level to that provided by European standards that are current at the time of issue of this standard or that in time supersede them.

3.2.2 Replacement monobloc wheels

3.2.2.1 For replacement wheels to British Rail designs, the wheel material shall be selected from BS 5892, Part 3, Grades R7E, R8E, R7T, R8T or RS8T, with the grade and heat treatment selected in accordance with the original design or shown to be equivalent.

3.2.2.2 Replacement wheels shall be manufactured in accordance with BS 5892, Part 3.

3.2.2.3 Replacement wheels shall be subject to the micrographic cleanliness examination requirements set out in BS EN 13262, clause 3.4.1.

3.2.2.4 Replacement wheels shall additionally be subject to the following tests, which are optional in BS 5892 Part 3:

a) Uniformity of rim hardness (BS 5892-3, clause 8.3.6.1).
b) Ultrasonic test (BS 5892-3, clause 8.3.7). The wheel rims ultrasonically tested for internal defects:
   i) Wheelsets operating up to 125 mile/h – no defect larger than 2 mm.
   ii) Wheelsets operating above 125 mile/h – no defect larger than 1 mm.
c) Residual stress for rim chilled wheels (BS 5892-3:1992, clause 10.6).

Rationale

G 3.2.2.5 The additional requirements are specified to assure product quality to an equivalent level to that provided by current European standards.

Guidance

G 3.2.2.6 It is permissible to ultrasonically test the wheel rim using the method specified in BS EN 13262:2020.

3.2.3 Replacement wheel centres

3.2.3.1 Replacement wheel centres shall be manufactured to the requirements of BS 5892-2:1992.

3.2.3.2 The grade of steel used in the manufacture of wheel centres shall be Grade U as set out in BS 5892-2:1992 with the the hydrogen content not exceeding 2 parts per million (ppm).

Rationale

G 3.2.3.3 The additional requirements are specified to assure product quality to an equivalent level to that provided by current European standards.

3.2.4 Replacement tyres and retaining rings

3.2.4.1 Replacement tyres shall be manufactured to the requirements of BS 5892 Part 4. The approved grades of steel are either B5E or B6E.

3.2.4.2 Replacement tyres shall be tested in accordance with the 'mandatory and optional' requirements of BS 5892 Part 4. The hydrogen content shall not exceed 2 ppm.

3.2.4.3 Replacement retaining rings shall be manufactured to the requirements of BS 5892, Part 5.

Rationale

G 3.2.4.4 The original components were manufactured to British Rail procedures and specifications, which are no longer available. The British Standards specified and any additional requirements allow an acceptable replacement to be manufactured.

Guidance

G 3.2.4.5 To ensure tyres are free from internal defects they can be tested in accordance with the ultrasonic test method specified in BS EN 13262 with a maximum defect size < 2 mm. The ultrasonic technique is to have minimal or no dead zone.

3.3 Assembly

3.3.1 Wheelset assembly

3.3.1.1 Wheelsets shall be assembled in accordance with the requirements of the relevant standard: BS EN 13260, BS 5892 Part 6, BS 5892 Part 8 or AAR standards (see *Wheelset design*).

Rationale

G 3.3.1.2 Application of a consistent set of standards is required throughout from design to assembly to maintenance to ensure that safe and reliable wheelsets are placed into service.

3.3.2 Used components

3.3.2.1 When any component is reused during manufacture and assembly, the requirements set out in *2.7* shall be satisfied.

3.3.2.2 Components with a life limited to less than the period before the next due inspection shall not be reused.

Rationale

G 3.3.2.3 This requirement controls the risk of reusing components such as axles, axleboxes and brake discs when assembling wheelsets prior to service operation.

Guidance

G 3.3.2.4 Wheelsets may be assembled with used components provided that they satisfy the defined maintenance requirements.

3.3.3 Prohibited components

3.3.3.1 The following components shall not be reused once removed from a wheelset:

a) Tyres once removed from a wheel centre.
b) Tyre retaining rings (Gibson rings).
c) Brake disc security bolts.
d) Balance weight bolts.
e) Unoverhauled axle bearings.
f) Axle end-cap locking plates.

3.3.3.2 Except for seals designed for reuse that have been examined and found serviceable, any gaskets or rubbing seals fitted to the axle end, axlebox end or any axle end equipment shall not be reused once removed from a wheelset.

Rationale

G 3.3.3.3 This requirement ensures wheelsets do not fail as a result of reusing components with limited life or in an unsatisfactory condition.

Guidance

G 3.3.3.4 It is important that the integrity of seals and gaskets is maintained, as water ingress is a major contributor to bearing failures.

3.3.4 Replacement wheelsets to established designs

3.3.4.1 Replacement wheelsets to British Rail and older designs shall be assembled in accordance with BS 5892-6:1992.

3.3.4.2 Tyre installations using retaining rings shall use only a single piece ring; make-up pieces are not permitted.

3.3.4.3 Carriage and coaching stock derivative wheels with tyres shall have a gap between the tyre snip end and the wheel centre of no greater than 1 mm (see dimension X in Figure *1*).

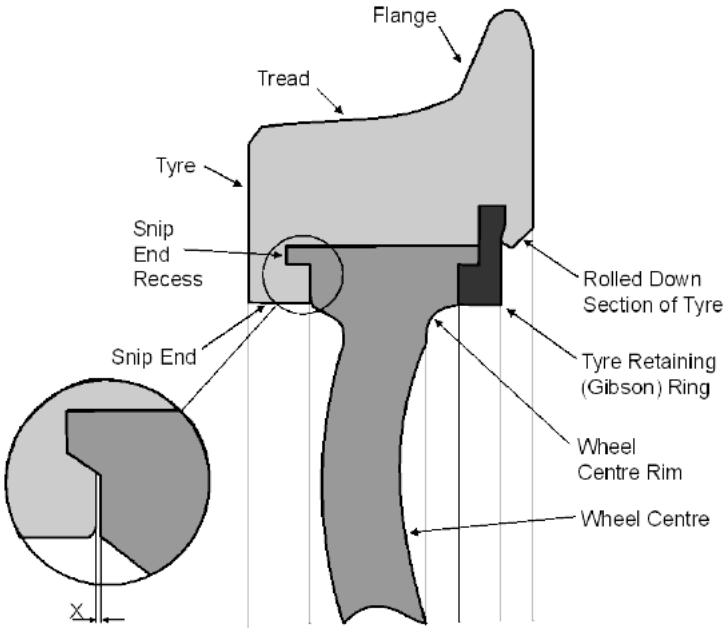

Figure 1: Carriage and coaching stock derivative wheels

3.3.4.4 Locomotive wheels with tyres, except where fitted with coaching stock derivative wheels, shall have no gap.

3.3.4.5 Tyred wheels shall be marked with white lines across the tyre / wheel centre interface (see BS EN 15313 Annex D.1).

Rationale

G 3.3.4.6 This requirement helps to reduce the risk of tyre movement on wheels due to loss of retaining ring pieces.

G 3.3.4.7 White line marking provides a simple means of identifying when a tyre has moved on the wheel centre and helps to reduce the risk of derailment.

Guidance

G 3.3.4.8 The traditional GB practice for marking and monitoring tyre movement uses three equally-spaced 20 mm wide white lines 175 mm long radially on the tyre and on the centre of the wheel. BS EN 15313 specifies four equally spaced 20 mm wide white lines 150 mm long radially.

3.3.5 Wheelset dimensions

3.3.5.1 The assembled wheelset shall comply with the geometric requirements set out in the relevant assembly standard.

3.3.5.2 The tread profiles shall be inspected for conformity to the design tread profile (as set out in EN 13715 or GMRT2466).

Rationale

G 3.3.5.3 These requirements confirm that the wheelset has been correctly manufactured or overhauled and ensure that the wheelset wheel tread profiles, back-to-back dimension, radial and axial run-out are all within prescribed limits in order to maintain compatibility with the vehicle to which is to be fitted and the infrastructure.

3.4 Wheelset testing

3.4.1 Wheelset NDT after assembly

3.4.1.1 Wheelsets shall be subject to NDT testing after assembly.

3.4.1.2 For each wheelset / axle type there shall be a dedicated NDT procedure.

3.4.1.3 Axles found to be opaque to ultrasound, when tested in accordance with the regime defined in the maintenance plan, shall be rejected from use.

Rationale

G 3.4.1.4 This requirement reduces the risk of failure due to the initiation and propagation of fatigue cracks.

Guidance

G 3.4.1.5 All fully assembled wheelsets are subject to NDT examination to ensure the axle satisfies the requirements of the specified NDT procedure; there are to be no spurious signals from interference fits and other features on the axle.

G 3.4.1.6 Dedicated NDT procedures for each wheelset / axle type will ensure clear instructions and reliable inspection.

G 3.4.1.7 Requirements for NDT procedures and validation are set out in RIS-2701-RST.

G 3.4.1.8 Certain material conditions can restrict the transmission of ultrasound such as the larger grain structure in normalised steels. The grain size of axles in the normalised condition can affect the material's ability to transmit ultrasound and the effectiveness of UAT, causing interference to the signal.

G 3.4.1.9 The following factors have an effect on the NDT regime applied:

a) Design calculations and recommendations for similar recently developed designs, where these are available.
b) Service conditions / environment of the wheelset design and its specific use.
c) Service history of the similar wheelset design, regarding fatigue, damage, corrosion, cracking and testing problems of specific NDT regimes.
d) Access to apply NDT techniques regarding the particular design.
e) Validated minimum defect detection and probability of detection capabilities of the NDT techniques being considered.
f) Defect identification criteria, either:
    i) The minimum which can be detected using a particular technique both for the axle body and for specific critical axle areas; or

ii) That set by the design and fatigue consideration when the wheelset is designed.

G 3.4.1.10 Aspects that influence the facilitation of NDT testing regimes include:

a) Access required to apply the NDT equipment.
b) The wheelset equipment to be removed to gain access for testing.
c) Bearing arrangements.
d) Disc brake installation.
e) Drive installations on the axle, such as a gearbox.
f) Risks introduced when dismantling or reassembling, such as contaminants, damage of sealing and incorrect assembly.

3.4.2 Wheelset electrical continuity

3.4.2.1 The wheelset shall be tested to demonstrate compliance with the requirements of the respective standard, that is, one of:

a) BS 5892 Part 6 clause 4.2.2;
b) BS 5892 Part 8 clause 4.3; or
c) BS EN 13260 clause 3.2.3.

Rationale

G 3.4.2.2 This ensures compatibility with the existing train detection systems used on the GB mainline network.

Guidance

G 3.4.2.3 The wheelset electrical resistance is measured to ensure that the wheelset is capable of transmitting the small electrical current produced by track circuits and larger traction return currents.

3.5 Wheelset balancing

3.5.1 Wheelsets shall be balanced in accordance with the requirements of the relevant standard, that is, one of:

- BS EN 13260:2020;
- BS 5892-6:1992;
- BS 5892-8:2012; or
- AAR standards (see *2.1*).

3.5.2 Wheelsets that physically cannot be dynamically balanced, typically due to axle mounted drives, shall be shown to have the equivalent imbalance within the permitted tolerance by calculation.

Rationale

G 3.5.3 Unbalanced wheelsets have the potential to damage the infrastructure and affect vehicle stability. Out-of-balance forces impose additional cyclic loadings on

suspension components, affecting the fatigue behaviour of track components, the wheelset, bearings and the vehicle suspension. These requirements ensure that the risks associated with out-of-balance forces exerted on the track by the wheelset are controlled within acceptable limits.

Guidance

G 3.5.4 It is good practice to minimise the radial run-out for wheelsets that cannot be physically balanced to compensate for the dynamic radial forces that might occur.

G 3.5.5 Methods for elimination of residual imbalance are set out in BS EN 13262 clause F.6 and BS 5892-3 clause 5.8.

G 3.5.6 When assembling wheelset components, the position of their imbalance can affect the total imbalance of the complete wheelset.

G 3.5.7 Existing wheel designs that are balanced by the attachment of rim balance weights may continue to use this method.

G 3.5.8 Typical examples of when it is not feasible to balance wheelsets is when limited dismantling takes place or where significant axle mounted equipment remains in place, for example re-profiling or when no other components are removed.

3.6 Wheelset identification

3.6.1 Branding

3.6.1.1 All wheelsets and components of wheelsets shall be branded in accordance with the requirements of either:

a) Appendix *A* of this document; or
b) BS EN 13260, BS EN 13261 and BS EN 13262.

3.6.1.2 Wheelsets shall not have labels or bands attached as a means of identification as an alternative to branding.

3.6.1.3 Any markings on reused components which refer to the original wheelset shall be erased and the wheelset records endorsed.

3.6.1.4 Illegible or obscured brandings shall be erased and the component shall be re-branded in accordance with the requirements of this document.

Rationale

G 3.6.1.5 These requirements ensure the traceability of wheelsets, axles and wheels throughout their lives.

Guidance

G 3.6.1.6 Cold stamping is the preferred method for branding.

G 3.6.1.7 An example of a means of identification that is not permitted is the option contained in UIC 813 (withdrawn), clause 4.2.5.2, paragraph 2, where the markings could be punched into a steel band placed round the axle.

3.6.2 Unique identification of axles

3.6.2.1 Each new axle shall be branded with a unique serial number, allocated from the wheelset assembler's own series of numbers or from the details generated and supplied by the entity in charge of maintenance (ECM).

3.6.2.2 Axles shall not be given the number of:

a) An axle it replaces.
b) A previously scrapped axle.

3.6.2.3 The wheelset assembler's code shall be included in the unique axle serial number.

Rationale

G 3.6.2.4 This requirement ensures the traceability of axles.

Guidance

G 3.6.2.5 Each axle has a unique serial number that is used with other markings to identify the axle / wheelset throughout its life when subject to activities such as testing, inspections. The serial number is not a duplicate of other serial numbers used in the past or present.

3.6.3 General stamping requirements

3.6.3.1 Wheelset branding shall be in accordance with the appropriate standard.

3.6.3.2 The branding shall be of a size and depth such that the information is clearly legible when the appropriate surface coating or protection is applied at any stage of the wheelset life.

Rationale

G 3.6.3.3 This requirement ensures the traceability of wheelsets, axles and wheels.

Guidance

G 3.6.3.4 The stamping indentations can cause a stress raiser if allowed to infringe the machined tread chamfer or last turning groove. Good practice is to ensure the location of branding marks is clear of such features, including when in the fully worn condition.

G 3.6.3.5 Sharp corners and notches create stress raising features that can initiate fatigue fractures in the material. Good practice is to use stamps with a rounded profile.

G 3.6.3.6 Automated processes can be used for marking wheelset components.

3.7 Handling and care of wheelsets

Guidance

G 3.7.1 Requirements for wheelset handling and storage are set out in RIS-2704-RST.

Part 4 Requirements for Wheelset Maintenance

4.1 Introduction of wheelset maintenance

4.1.1 Maintenance plan

4.1.1.1 BS EN 15313 clause 4 contains requirements for a wheelset maintenance plan. These requirements shall be used, except where alternative requirements are specified in this document.

4.1.1.2 The maintenance plan shall identify all specifications, procedures and processes, including examination, inspection and testing, for wheelset maintenance, which are applied at a frequency adequate to ensure that the wheelset is at all times in compliant condition.

4.1.1.3 For any given wheelset design type within its scope the maintenance plan shall set out any specific processes, tools, gauges, wear or defect limits that are required for its maintenance.

Rationale

G 4.1.1.4 Wheelsets are safety-critical components and it is therefore essential that all maintenance activities are controlled and documented to ensure that their condition in service is maintained within safe limits and that records are sufficient to ensure traceability so that service problems or incidents can be investigated and rectified.

Guidance

G 4.1.1.5 RIS-2004-RST includes requirements for vehicle maintenance, which are supplemented by the maintenance requirements set out in Part 4 of this document.

G 4.1.1.6 Railway undertakings define, as part of their safety management system, the provisions by which the wheelsets are maintained within the specified limits in the maintenance plan.

G 4.1.1.7 Additional inspections and NDT can be applied to wheelsets manufactured to earlier standards than those included in this document. Such wheelsets were manufactured to earlier standards using materials and processes that were not as consistent and reliable as those produced today. In addition, these wheelsets could have accumulated a considerable fatigue history during their service lives. Previously, axles over 40 years old were required to be identified with an 'X' stamped in front of the manufacturing contractor's code and were required to be inspected at half of the normal inspection interval. This is no longer required but it is still expected that the design life is considered in the maintenance plan and appropriate measures are applied to axles that remain in service beyond their intended design life.

G 4.1.1.8 Regular monitoring and recording of wheel wear can enable the prediction of maintenance attention and permit economic re-profiling to be undertaken. Such a monitoring method can allow the identification of abnormal wear conditions within a vehicle or fleet of vehicles.

G 4.1.1.9 To ensure that wheelsets remain within the safety limits set out in this document more restrictive criteria may be established that will allow planning of maintenance activities within the maintenance schedule.

G 4.1.1.10 BS EN 15313 gives additional information and guidance on wheelset defects, which can be used to adjust inspection regimes according to service experience.

G 4.1.1.11 For this part, a wheelset comprises an axle with wheels mounted, which can be tyred or resilient wheels and includes wheelsets which can also be fitted with axle journal bearings, axleboxes, brake discs, final drives, transmissions and noise damping systems.

G 4.1.1.12 Requirements on the identification of roller bearing defects are set out in RIS-2709-RST.

G 4.1.1.13 Wheelsets conforming to AAR standards require a different maintenance regime for safe operation to that required for British or European wheelsets.

4.1.2 Wheelset duty change

4.1.2.1 When a wheelset is subject to a change of duty, the maintenance plan shall be reviewed.

4.1.2.2 A risk assessment shall be undertaken to determine the impact of the change in duty on wheelset maintenance requirements, and shall consider factors that affect its service life, including, but not limited to, the following;

a) Axle load.
b) Route change / mileage.
c) Speed.
d) Duty cycle.
e) Track forces.
f) Change of gearing / tractive effort.
g) Transporting of corrosive commodities.

Rationale

G 4.1.2.3 The inspection intervals and wear patterns are strongly influenced by the duty performed. A change in duty therefore requires the maintenance plan to be reviewed to ensure the inspection regime for a wheelset continues to be appropriate.

4.1.3 Maintenance processes

4.1.3.1 During maintenance, wheelsets shall be handled and stored in accordance with RIS-2704-RST.

4.1.3.2 To prevent damage the following shall not be permitted except as allowed by the individual sub-clause limitations:

a) The use of power tools on an axle or component or any part of the wheelset which is 'ready for assembly' or at any time other than as part of an approved process.
b) Welding, brazing or other thermal process, except where it is set out in a validated procedure. Welding or grinding spatter and sparks can damage the surface of the

wheelset causing localised imperfections on the material surface that could subsequently develop into a fracture.

c) Action in the vicinity which would cause flame cutting debris or weld spatter to fall on a wheelset or component.
d) Attachment of an electrical connection or current return, not allowed for by the wheelset design, other than those needed to carry out MPI or welding using a validated procedure or electrical resistance testing.
e) Use of any tool, other than in accordance with a validated procedure, which could cause notches, pits or other markings on the axle or wheelset component.
f) The application of grease to axle and suspension tube bearings to any extent until they have been assessed for smooth rotation without grease.
g) Hand-grinding to remove sharp flanges except to facilitate recovery of the vehicle.
h) Processes accidentally or inappropriately applied in the vicinity of the wheelset that would mechanically or thermally affect the wheelset.

4.1.3.3 Where there is evidence that any of these has been applied to a wheelset, then the wheelset shall be removed from service and sent for overhaul, with the cause of rejection clearly identified.

Rationale

G 4.1.3.4 As wheelsets are safety-critical components, there is a need to control or prohibit processes affecting wheelsets which can create stress raisers that can initiate fatigue failure or adversely modify material properties.

4.1.4 Welding on vehicles

4.1.4.1 Electrical welding of a railway vehicle fitted with wheelsets shall only be undertaken with adequate electrical return current bonding to prevent electrical current passing through the wheelset and bearings.

Rationale

G 4.1.4.2 Electrical current can damage the bearing surfaces that could subsequently fail in service.

Guidance

G 4.1.4.3 The return current from electrical welding in adjacent vehicles can pass through the coupling and inter-vehicle jumper arrangements to earth, so damaging the bearings of attached vehicles.

4.2 Wheelset examination

4.2.1 Wheelset maintenance examinations

4.2.1.1 Wheelsets shall be examined during service according to the maintenance plan.

4.2.1.2 In addition, wheelsets shall be examined in the event of:

a) Receipt of an incident report, for example rough riding, striking an object, unusual noise, wheel flats etc.

b) Report of a wheel load impact detector exceedance.
c) Activation of a hot box detector.
d) Brake drag.
e) Identification of other deficiencies associated with wheelsets, for example identified by High Risk Defect Reports, as set out in RIS-8250-RST.
f) The vehicle having been stored for a period of time.

4.2.1.3 Any fasteners removed during maintenance shall be replaced.

4.2.1.4 RIS-2702-RST Appendix A sets out requirements on the in-service examination and reference limits for freight wagon wheelsets.

4.2.1.5 All visual and physical examination results shall be recorded (see Part 5 Requirements for Wheelset Records).

Rationale

G 4.2.1.6 These requirements prevent derailment through the use of potentially defective wheelsets.

Guidance

G 4.2.1.7 In addition to the factors set out above, the maintenance plan can set out limits for other factors that will require the wheelset to be overhauled before refitting to the vehicle.

G 4.2.1.8 The maintenance plan sets out the examination frequency of wheelsets.

4.2.2 Wheelset visual examination

4.2.2.1 Wheelset examinations shall include checks for:

a) Corrosion anywhere on the axle, wheel (other than the tread) or wheel centre (see also *4.2.2.2*).
b) Damage anywhere on the axle, wheel or wheel centre as defined in the relevant maintenance standard, and may include:
    i) Cracks.
    ii) Scoring.
    iii) Burrs or raised edges.
    iv) Sharp indentations.
    v) Impact marks.
    vi) Fretting.
    vii) Damage to protective coatings.
c) Tread damage and flats as defined in *4.6.2* including:
    i) Tread run-out.
    ii) Flange build-up, steps or sharp radii on the flange (toe radius build-up or sharp flange).
    iii) Circumferential steps in the flange profile.
    iv) False flange.
    v) Flange back distortion.

vi) Cavities.
vii) Wheel flats.
viii) Local tread collapse in the form of a rim face bulge.

d) Any signs of overheating anywhere on the wheelset.
e) Cracks in the axle, wheel or wheel centre.
f) Any sign of movement at interference fit interfaces.
g) Checks for damage to, or missing, oil injection hole plug.

4.2.2.2 For wheelsets with tyred wheels, examination shall additionally include:

a) Checks for evidence of movement between the tyre and wheel centre (misalignment of paint mark, disturbed or cracked rust / dirt / paint between wheel centre / retaining ring / tyre, polishing at the interface, slivers of metal close to the interface).
b) Checks for cracks in the tyre.
c) Checks for damage to the retaining ring.
d) Where there is reason to suspect that the tyre has moved, checks with a feeler gauge that the clearance between the tyre snip and the wheel centre rim is within limits.

Rationale

G 4.2.2.3 Drawn from service experience, these requirements set out a list of checks for wheelset defects and indications of possible problems that can affect the integrity or life of wheelsets.

Guidance

G 4.2.2.4 A detailed understanding of a particular wheelset design undertaking a particular duty can lead to additional inspection requirements, which are set out in the maintenance plan.

G 4.2.2.5 The regular maintenance of wheelsets needs to include a visual examination of the wheels to ensure they have not overheated. Overheating is evident by loss of dirt, discolouration and flaking of the paint from the wheel rim and web transition on tread-braked wheels.

G 4.2.2.6 Overheating of the wheel can cause the wheel to expand and relieve the interference fit on the axle. The wheel hub to axle interface is checked for evidence of movement on the axle, indicated by signs of the paint at the wheel / axle interface being broken, metal particles at the interface, measurement of the wheelset back-to-back and wheel axial run-out (wobble).

G 4.2.2.7 Overheated tyres can move on the wheel centre. Tyred wheels can be checked for movements by checking the alignment of the indicator lines.

G 4.2.2.8 Overheated wheels can be caused by the lack of free and correct operation of brake gear causing dragging brakes or, for vehicles with rheostatic braking, if this is not functioning correctly, all wheels might be potentially affected.

4.3 Wheelset measurements

4.3.1 Wheelset wear measurement

4.3.1.1 The maintenance plan shall determine the intervals at which the wheel tread profile (see *4.3.2*) and the wheelset back-to-back shall be measured (see *4.3.3*).

4.3.1.2 Wheelsets shall not operate with a wheel diameter below that specified by design or in the technical specification.

Rationale

G 4.3.1.3 Wheelsets are required to be maintained within safe limits to ensure compatibility with the infrastructure. Wheelsets that deviate from the established limits are at risk of derailment and risk damage to critical track components, in particular those at switches and crossings. Damage to switches and crossings, if not immediately causing derailment, can increase the risk of derailment for following vehicles.

Guidance

G 4.3.1.4 Operation with wheels below their minimum diameter increases the risk of failure through structural overload and can cause an infringement of the loading gauge.

G 4.3.1.5 Minimum wheel diameter may be controlled by a last turning groove to limit the minimum diameter on wheel re-profiling and then the use of flange height limits. Minimum rim, tyre or throat thickness limits can also be applicable.

G 4.3.1.6 It is good practice to check for unusual wear such as uneven wear across the wheelset and local areas of uneven wear circumferentially around the wheel tread.

4.3.2 Wheelset measurement following visual examination

4.3.2.1 The wheelset dimensions shall be checked when a wheelset has been involved in a derailment, or when examined:

a) There is evidence of overheating.
b) The wheel tread wear groove is not visible.
c) There is evidence of unusual wear patterns to the tread or the flange.
d) There is any other reason to suspect that dimensions are at variance with requirements.

4.3.2.2 If required by *4.3.2.1*, the following dimensions shall be checked:

a) Back-to-back dimension (see *4.3.4*).
b) Wheel tread diameters.
c) Wheel tread diameter difference.

4.3.2.3 Where there is reason to suspect that a wheelset is out of round or oval, this shall be checked in accordance with *4.3.5*.

4.3.2.4 In the event that a wheel impact load detection threshold is exceeded, but no visible tread damage is observed, the wheel shall be checked for out-of-roundness.

Rationale

G 4.3.2.5 Wheelsets are required to be maintained within safe limits to ensure compatibility with the infrastructure; see *4.3.1*.

Guidance

G 4.3.2.6 Diameter differences across a wheelset cause the wheelset to operate offset on the track. In severe cases, this can cause the wheelset to yaw within the bogie and result in excessive flange wear of one wheel. This effect can also be experienced if the tread profile is not correctly aligned on the wheel.

G 4.3.2.7 Abnormal readings from wheel impact load detection equipment, and in particular any defect in a wheel that contributes to producing a total vertical force of more than 350 kN per wheel, require the wheelset to be examined.

G 4.3.2.8 This examination should consider all possible causes of the reported vertical forces, including wheel out-of-round or ovality, wheel discontinuities, suspension defects etc.

4.3.3 Wheel tread measurement

4.3.3.1 When required, the wheel tread profile shall be measured using suitable gauges or measuring equipment.

4.3.3.2 The flange height and thickness shall not be outside the limits specified for the wheel profile; see GMRT2466 or EN 13715:2020 as applicable.

4.3.3.3 Where wheelset examination shows that the wheelset requires re-profiling due to defects, measurement of the wheel tread profile may be omitted.

Rationale

G 4.3.3.4 Wheelsets are required to be maintained within safe limits to ensure compatibility with the infrastructure; see *4.3.1*.

Guidance

G 4.3.3.5 The condition of tread profiles can seriously affect the wheelset and vehicle performance.

G 4.3.3.6 The suspension arrangement in some vehicles provides a good steering ability for the wheelsets. These wheelsets predominantly experience wear of the tread with little wear on the flange. As the flange thickness is measured at a constant height above the tread datum point, the flange thickness can appear to increase as the tread wears and flange height increases. Although the flange thickness measurement is greater than in the design condition, the wear is limited by the flange height.

G 4.3.3.7 For established or newly defined GB profiles defined in GMRT2466, the flange thickness is measured at 13 mm above the tread datum, whereas the European profiles specified in EN 13715 are measured at 10 mm above the tread datum.

G 4.3.3.8 In addition to the traditional gauges or the integrated measuring system of a machine for checking tread profiles, there are many alternative systems available,

such as electronic profile measurement tools. Care should be taken that profile surfaces are clean and datum surfaces (such as back of flanges) are not worn.

G 4.3.3.9 The user may use any system providing it achieves the required level of repeatability and accuracy and it is subject to a calibration that conforms to the requirements of BS EN ISO 10012.

G 4.3.3.10 Examples of gauges used to assess the flange thickness and height are shown in Figures *22*, *23*, and *24* of Appendix *B*; however, other systems may be available.

G 4.3.3.11 The gauge shown in Figure *23* is used by opening out both slides. The gauge is held squarely on the flange back and drawn down onto the profile at right angles to the tread surface. The sliders are then moved to make contact with the tread and measurements taken.

4.3.4 Back-to-back measurement

4.3.4.1 The back-to-back dimension of wheelsets using an established or newly defined GB tread profile in accordance with GMRT2466 shall be measured at three equally spaced locations around the wheel circumference when unloaded.

4.3.4.2 The back-to-back dimension of wheelsets subjected to vehicle loads shall be measured at axle height to negate flexing due to load.

Rationale

G 4.3.4.3 The compatibility of GB profiles with the GB network is based on the established measuring technique and tolerances.

G 4.3.4.4 NTSN / EN 13715 profiles are controlled by measurement at the rail when loaded and therefore include axle deflection under load and hence have different tolerances.

Guidance

G 4.3.4.5 It may be necessary to move the vehicle to roll the wheels and ensure all measurements are taken at axle level.

G 4.3.4.6 Assessment of the back-to-back dimension can be obtained with Go / No-Go gauges (set out in Figure *24* of Appendix *B*) and feeler gauges or a calibrated internal micrometer.

G 4.3.4.7 The method of measuring the back-to-back dimension of wheelsets using tread profiles defined by the LOC&PAS and WAG NTSNs at rail level in laden conditions still applies if those profiles are used. This method and the corresponding limits consider deflection under loading.

G 4.3.4.8 The LOC&PAS NTSN or WAG NTSN back-to-back limits have also to be considered with the tread widths and the front-to-front limits prescribed.

4.3.5 Tread run-out (radial misalignment) measured in service

4.3.5.1 When required, the tread run-out shall be measured with the wheel unloaded while the wheel is rotated at the wheel tread datum (70 mm outboard of the flange back).

Vehicle type	Limit of tolerable tread run-out
Any vehicle permitted to operate above 125 mile/h and up to 140 mile/h	0.7 mm
Passenger or personnel vehicles operating at speeds up to and including 125 mile/h	1.3 mm
Non-passenger vehicles, locomotives, power cars, driving van trailers and on-track plant	1.3 mm
Freight vehicles up to 17.5 tonnes axle load	3.0 mm
Freight vehicles equal to or over 17.5 tonnes axle load	2.0 mm
Other vehicles	2.0 mm

Table 4: Limit of tolerable tread run-out

Rationale

G 4.3.5.2 Wheelsets are required to be maintained within safe limits to ensure compatibility with the infrastructure (set out in *4.3.1*). In particular, these run-out criteria place a limit on the excess loads applied to suspensions and infrastructure by affected wheelsets, thereby reducing the risk of damage.

Guidance

G 4.3.5.3 Tread run-out occurs where the wheel tread is no longer circular or concentric with the axle bearing surfaces. A wheel that is no longer circular can take two forms, either out-of-round or oval, although practically all run-out of the wheel tread could be considered to be out-of-round. Generally, defects of this type cannot be found by visual inspection and measurement will be required.

G 4.3.5.4 These measurements can be undertaken by manual measurements of the flange height relative to the tread or wheel tread diameters at numerous positions around the wheel. Alternatively, automated systems are available that measure the degree of out-of-round or wheel impact loads in traffic.

G 4.3.5.5 Where run-out is found during routine examination but which is within the limits given in Table *4*, no immediate action is required. However, consideration can be given to restoring the tread profile at a convenient point as subsequent damage such as out-of-round or shelling may result.

4.3.6 Wheelsets damaged in collisions or derailment

4.3.6.1 Wheelsets that have been involved in a collision, struck an object on the track or become derailed shall be examined in accordance with *4.2.1* and *4.2.2* of this document.

4.3.6.2 For movement from the scene of the incident, the wheelset examination shall determine if a wheelset has damage that is likely to lead to a failure or damage the track on the journey to the depot for rectification and shall, in addition, include measurement of back-to-back dimension and checks to establish that:

a) The axle is not fractured. Providing that there are no suspicions of the axle being cracked, an ultrasonic axle test is not required until the vehicle reaches the registered maintenance site.
b) There is no evidence of wheels having moved on the axle.
c) There is no evidence of loose tyres.
d) Any damage to wheel profiles is accounted for in the conditions applying to the move.
e) There are no parts that may become detached during the move.
f) There is nothing to prevent free rotation of the wheelset.
g) There is no evidence of axlebox bearing degradation.
h) There is no evidence of localised overheating on a wheel to indicate the presence of a wheel flat that is preventing rotation, but is resting on the rail and therefore is not readily obvious.
i) For powered axles, the transmission is free to rotate and has no evidence of degradation.

4.3.6.3 Damage to a wheelset arising from a collision or derailment shall be repaired in accordance with a procedure that includes the use of NDT to prove the repaired area is free of defects.

Rationale

G 4.3.6.4 Wheelsets are required to be maintained within safe limits to ensure compatibility with the infrastructure. After a collision or derailment additional checks are required to ensure that recovery of an affected vehicle does not cause additional incidents.

Guidance

G 4.3.6.5 Wheelsets that have been involved in an accident or derailment require visual examination to determine whether they are suitable to run on the track from the incident site to a maintenance location for further detailed examination, or whether some other means of recovery is necessary. See also EN 15313 clause 9 for additional guidance.

G 4.3.6.6 Wheelsets that have been derailed or struck an object on the track may run on the line, provided the axle is not bent and does not have damage that is likely to lead to failure or damage the track on the journey to the depot for rectification.

G 4.3.6.7 Wheelsets with minor tread damage that is within the criteria specified for wheel tread defects, and with no visible damage to the axle, may be considered not to require an axle NDT examination.

G 4.3.6.8 Wheelsets that have been involved in derailments at speeds in excess of 10 mph, or the distance run while derailed was more than 100 m, or have visual damage are usually subjected to non-destructive testing of the axle before re-entering service.

G 4.3.6.9 The use of a wheelskate could be necessary to recover wheelsets with serious tread damage or other defects that would jeopardise the safe movement of the vehicle. Movement is at reduced speed in accordance with the requirements for the use of wheelskates set out in RIS-2780-RST Part 4.

G 4.3.6.10 When the vehicle has been returned to a suitable location, a detailed assessment and examination can then be undertaken in accordance with the maintenance plan.

4.4 Investigation of wheelset damage

4.4.1 When damage or defects are reported relating to vehicle suspensions or underframe equipment, the wheelsets shall be examined for signs of damage. Where there is evidence of damage the affected wheelsets shall be examined according to *4.2.2*.

Rationale

G 4.4.2 Wheelsets do not operate in isolation and may be damaged by defects elsewhere. Conversely, damaged wheelsets may lead to damage to bearings and suspension components.

Guidance

G 4.4.3 Defects identified in the bogies and suspensions could have resulted in damage to the wheelset or, conversely, resulted from a defect on the wheelset. It is good practice to ensure that not only is the defect rectified, but also that associated components and equipment are examined for consequential damage. Table *5* identifies possible defects and causes or effects.

Defect	Cause or effect
Tread damage, ovality, flats	Suspension damage, springs, dampers, pivot bushes, axlebox structural damage, bearings, wheel slide protection installations, drive mechanisms, gearcases and suspension tubes. Seized traction motor / final drive gearbox
Loose / broken safety straps or component that can fall onto the wheelset	Damage and scoring of the axle or other component
Loss of motor bogie axle protective cover	Scoring of the axle by debris being retained in space between axle and motor

Defect	Cause or effect
Loose / defective bearing retaining rings	Damage and scoring of the wheelseat to journal transition and contamination of the journal bearing
Defective current return brush	Scoring and damage to brush track
Defective equipotential bonding and traction return connection	Bearing damage, overheating and potential failure
Seized brake mechanism	Overheated brake disc or brake drag, moved wheel / tyre
Defective primary damper	Rough riding
Defective suspension location	Unusual wear pattern on the wheel tread, high flange wear
Loose balance weights	Damage to the wheel, cracks in the wheel
Loose bearing end caps	Bearings become loose, subsequently overheat and fail in short period

Table 5: Defects and consequential damage

4.5 Wheelset NDT

4.5.1 The maintenance plan shall include requirements that are set out in the wheelset technical specification for NDT during maintenance, repair and overhaul of wheelsets.

4.5.2 The results of all tests shall be recorded and reported.

4.5.3 All wheelsets found by NDT to be defective shall:

a) Be referred for overhaul and further investigation; and
b) Be subject to further NDT examination before being scrapped; and
c) When found to be defective and therefore to be scrapped, be mutilated to prevent inadvertent reuse.

4.5.4 Axles with identified transverse (circumferential) cracks shall be withdrawn from service.

4.5.5 Axles fitted with suspension tubes that are not removed at overhaul shall have the earth return tracks examined using an approved NDT technique.

4.5.6 All axles shall be subject to MPI, or an equivalent NDT technique, at overhaul to ensure they are free of surface breaking defects. This technique is applied when the

axles are generally stripped of components to allow access to most surfaces of the axle.

4.5.7 During overhaul, the NDT examinations of the assembled wheelset shall be proven to be as sensitive and reliable at detecting the same size flaws as the in-service NDT regime. Where no other NDT scanning methods are used, the wheelset axles shall be tested as a minimum application of far end, near end, or high angle techniques to a validated procedure.

4.5.8 Journal surfaces, wheel seats, gear wheels, suspension tubes and other interference fit components shall be subject to MPI, or an equivalent technique, when exposed. Although it is not necessary to remove all components at overhaul, consideration shall be given to exposing the entire axle surface for testing.

4.5.9 Axles shall be subject to MPI or equivalent process during overhaul; however, this does not apply to hollow axles subject to internal NDT inspection.

4.5.10 In addition to the MPI, axles that are subject to a UAT regime in service shall also be examined in accordance with the validated in-service procedure during the overhaul, to avoid a suspect signal being recorded once returned to service.

4.5.11 When a change to the NDT requirements is being considered, a risk assessment shall be undertaken to determine if its impact is likely to consider factors that affect the fatigue life, including, but not limited to, the following:

a) Loadings;
b) Duty cycle;
c) Axle material properties;
d) Suspension design;
e) NDT inspection period;
f) Fracture propagation prediction;
g) Defect size;
h) Probability of detection (NDT method used and flaw detection capabilities);
i) Freight vehicles carrying corrosive or reactive product.

4.5.12 The NDT procedure shall include measures to prevent any couplant used in NDT examinations, particularly hollow axle ultrasonic testing, entering into bearings.

Rationale

G 4.5.13 The objective of subjecting wheelsets to NDT is to prove they are defect free to a level of confidence consistent with the application. At the design stage, the NDT frequency is determined to ensure that defects do not propagate to failure between NDT inspections. These criteria are set to ensure that if a defect in the axle is just below the detectable size, then it does not grow to failure before the subsequent inspection.

Guidance

G 4.5.14 Requirements for NDT procedures and validation are set out in RIS-2701-RST.

G 4.5.15 Axle NDT usually comprises ultrasonic testing (near end, far end and high angle scans for solid axles or using a probe inside a hollow axle), eddy current testing or when the axle is stripped of components at repair or overhaul, MPI.

G 4.5.16 The NDT periodicity is specific to the vehicle type, wheelset type and duty. The arrangements for NDT are defined by the design of the wheelset and form part of the maintenance plan.

G 4.5.17 Typically, axle design depends on axles being free of:

a) Surface breaking transverse (circumferential) cracks or crack-like indications.
b) Surface breaking longitudinal cracks or crack indications in excess of the limits set out in the maintenance plan.
c) Non-surface breaking defects greater than defined in the respective standards: BS 5892, BS EN 13261 or AAR standards.
d) Any characteristic that causes the axle to be opaque to ultrasound.

G 4.5.18 Where an axle is found to contain defects in excess of the design limits, then it is good practice to conduct further metallurgical and physical investigation to determine the origin and any additional information that can be obtained from the investigation.

G 4.5.19 The couplant for UAT can adversely affect the function of bearing lubricant, leading to premature bearing failure.

G 4.5.20 The internal automated ultrasonic test of a hollow axle will include a complete test of the axle using approved equipment and procedures for the particular design of axle.

G 4.5.21 Whatever tests are carried out on wheelsets or wheelset components during repair or overhaul, it is good practice for every wheelset that is subject to a UAT regime to undergo a full UAT in accordance with the appropriate procedure after assembly and before being fitted to a vehicle or sent for storage.

G 4.5.22 The objective of further NDT before scrapping is to determine the proportion of the axle population being scrapped for fractures, the fracture origin and whether there are any trends in the failure rate or detection methods. Where the defect is greater than a specified size the axle should be subject to further metallurgical examination. This requirement has been included as a recommendation of the Rickerscote enquiry (a derailment and subsequent collision with a travelling post office train at Rickerscote, Stafford, March 1996, caused by a broken axle).

G 4.5.23 Where bearings are fitted which cannot be demagnetised in situ, MPI is not typically suitable.

G 4.5.24 After MPI it is good practice that the residual magnetism in the axle is measured and rectified, as appropriate.

G 4.5.25 It is good practice for motor axles with suspension tubes that remain on the axle throughout overhaul to have their centre earth return track inspected by an approved NDT technique. This recommendation was introduced following the failure of a motor axle that was initiated from electrical arc damage on the axle earth return track.

G 4.5.26 An alternative equivalent process will be one for which the probability of detection of the minimum crack size, for the NDT inspection periodicity of the axle, is at least as good as that of the procedure being replaced or MPI, whichever is better.

G 4.5.27 The principles set out in RIS-2700-RST can be used to evaluate the suitability of the alternative equivalent process.

G 4.5.28 Where the technical specification includes a machining allowance, surface defects can be removed by skimming within the allowance. NDT is used to prove any machined surface is free of defects.

G 4.5.29 The maintenance plan will set out the criteria for rectification of longitudinal defects in addition to BS 5892, Part 1, sections B3 and B4 or BS EN 13261. Non-destructive testing is used to prove any machined surface is free of defects.

G 4.5.30 Records of all examinations and inspections of the wheelsets are retained to comply with Part 5 of this document, including the measurements recorded, NDT results and the defects identified. This information permits railway undertakings to plan attention to worn or defective wheelsets before mandatory limits are reached.

4.6 Wheelset defects

4.6.1 Wheelset cracks

4.6.1.1 Wheelsets shall not be used with cracks:

a) In the outer chamfered edge of the wheel or the flange (see Figure 2).
b) On the wheel rim.
c) Within any tread roll-over or toe-radius build-up.
d) On the tread surface beyond the limits set out in the maintenance plan for the wheelset or in this document.

4.6.1.2 The maximum length of multiple or isolated cracks in wheel tread or web shall be measured and recorded.

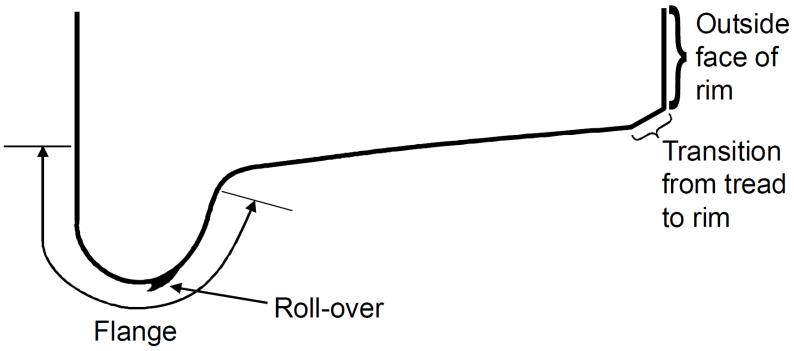

Figure 2: Critical areas for cracks in wheel tread

Rationale

G 4.6.1.3 These requirements define and prioritise the zones on the wheel where cracks could compromise structural integrity of the wheel and result in failure.

4.6.2 Wheel tread defects

4.6.2.1 Thermal crazing and rolling contact fatigue cracks in the centre of the tread surface shall be within the limits set by the requirements of the appropriate maintenance specification.

4.6.2.2 Tread conditions in excess of the criteria specified shall be rectified by re-profiling.

4.6.2.3 Wheel tread roll-over as shown in Figure 3 shall not exceed 5 mm.

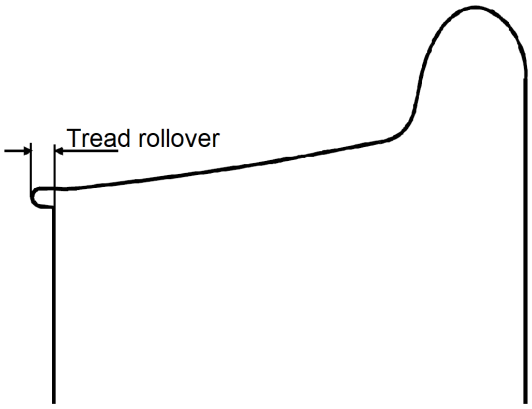

Figure 3: Wheel tread roll-over

4.6.2.4 There shall not be a false flange (as shown in 4) greater than 2 mm.

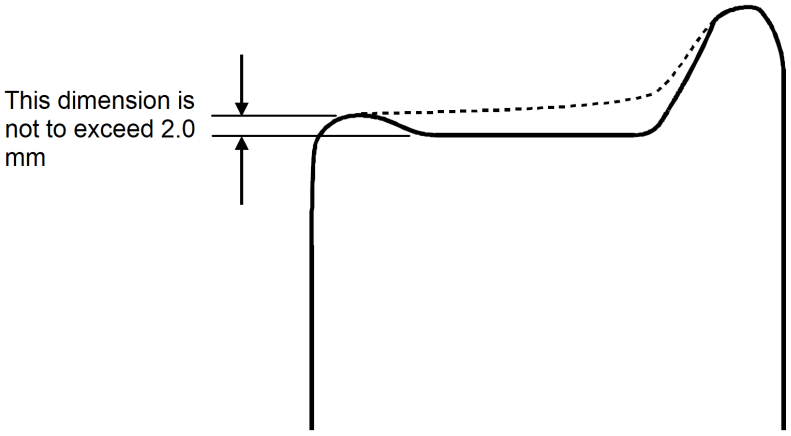

Figure 4: Definition of false flange

4.6.2.5 There shall not be any circumferential step in the flange profile greater than 1.5 mm in depth.

4.6.2.6 There shall be no sharp flange (as shown in Figure 5) or toe radius build-up (as shown in Figure 6), steps or sharp radii on the flange (toe radius build-up or sharp flange).

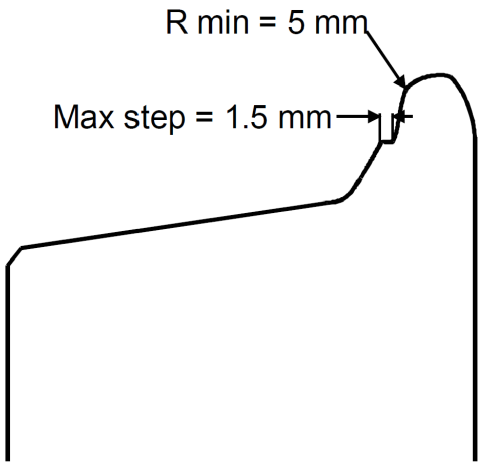

Figure 5: Definition of a sharp flange

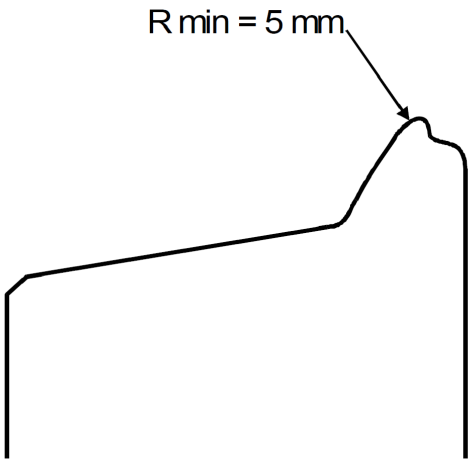

Figure 6: Toe radius build-up

4.6.2.7 Assessment for toe radius build-up or sharp flange shall be made using a 5 mm radius arc over a 7 mm chord length. With the end points of the chord in contact with the flange, then, between these points, the flange shall either only just touch the arc or there shall be a clearance. This may be demonstrated using CAD and a measured profile.

4.6.2.8 For measurement with a gauge (see Appendix *B*), for an acceptable flange, it shall be shown that the gauge can be placed without rocking on any discontinuity or radius on the flange, as shown in Figure *7*.

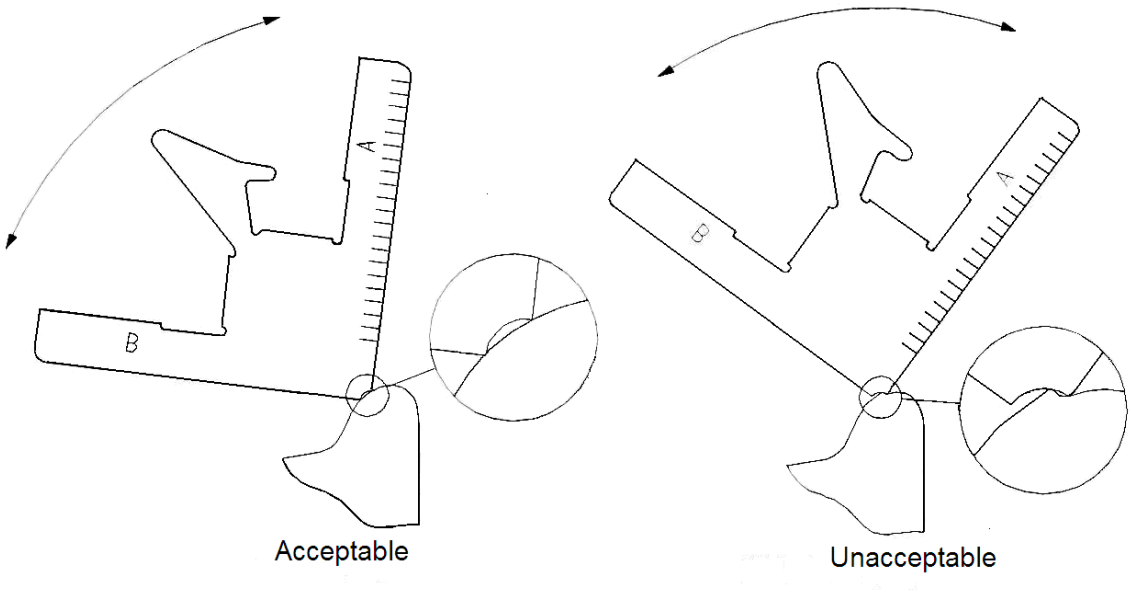

Figure 7: Flange toe radius assessment using a flange height and thickness gauge

4.6.2.9 Flange back blend distortion - any point in the flange back blend shall not be closer to the vehicle centre-line than the flange back as shown in Figure *8*.

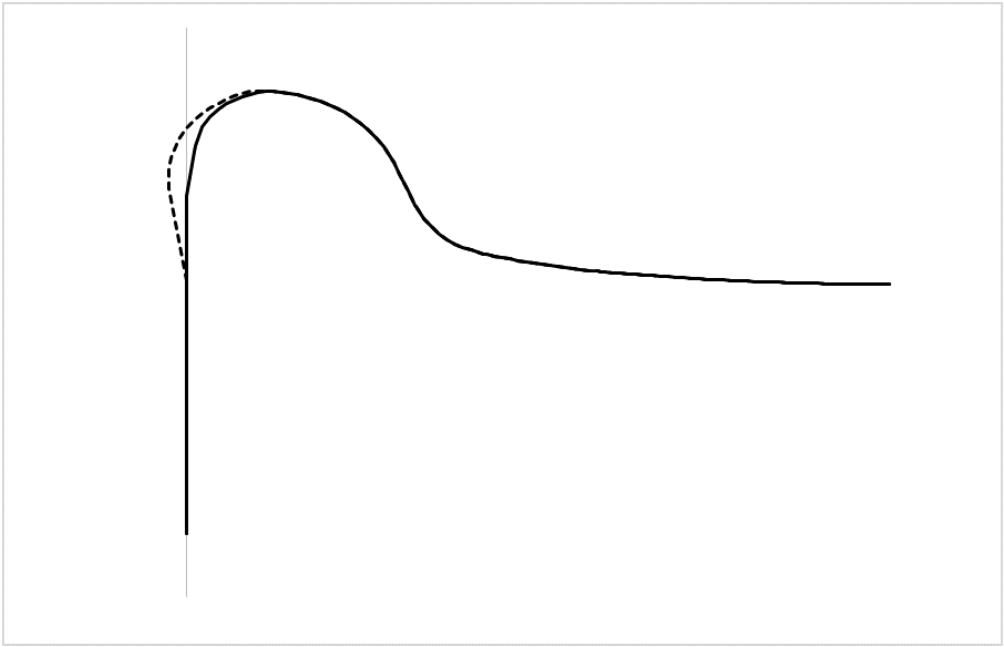

Figure 8: Example of flange back distortion

4.6.2.10 In-service local tread collapse in the form of a rim face bulge shall not exceed 2 mm (see Figure *9*) and such a feature shall cause the wheelset to be removed from service within 24 hours of the fault being identified.

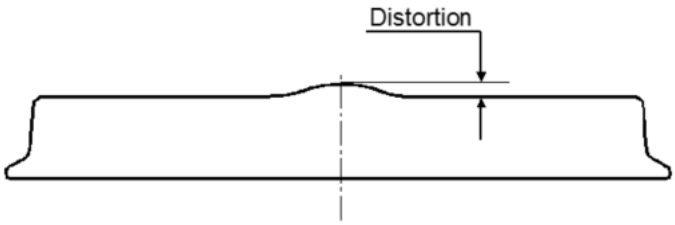

Figure 9: Wheel rim distortion

Rationale

G 4.6.2.11 The defects described clearly represent a risk to the safe operation of a wheelset.

Guidance

G 4.6.2.12 Tread roll-over is caused by metal flow. The metal flow that forms the tread roll-over is susceptible to the formation of cracks that can propagate into the wheel parent material, which can present a safety hazard.

G 4.6.2.13 A circumferential step in the flange profile usually occurs either:

a) When a vehicle is operating over a route where the curve population is such that the flange spends a considerable amount of time in hard contact with the rail side face; or
b) When the wheel diameters are unequal so that one wheel is constantly making excessive contact with the rail gauge face during steering of the wheelset.

G 4.6.2.14 Flange back distortion can be the result of wear, material flow or damage that could result in part of the back of the wheel flange creating a back-to-back dimension less than the specified minimum.

4.6.3 Axle defects

4.6.3.1 The maintenance plan shall determine if wheelsets can continue to be used where axle defects have been observed during visual examination (see *4.2.2*).

4.6.3.2 The maintenance plan shall set acceptable limits and define requirements for repair, overhaul or scrapping.

Rationale

G 4.6.3.3 Wheelsets, in particular axles, experience a large number of cyclic loads when in operation. Damage to the axle, although only minor, can rapidly lead to failure in service. This loading environment can initiate fatigue fractures from small imperfections that could propagate to fracture with the consequential risk of derailment.

Guidance

G 4.6.3.4 The maintenance requirement for the protective coatings applied to certain axles is rigorous and may require the wheelset to be removed in the event of damage to the surface coating. This ensures that corrosion of the axle surface does not occur.

4.7 Actions required when unacceptable defects are identified

4.7.1 Unacceptable defects identified in service

4.7.1.1 For axle defects, the maintenance plan shall determine when and how the affected vehicle is removed from service; see *4.6.3*.

4.7.1.2 Where multiple small cracks are found in the tread and one of the cracks exceeds 40 mm in length the wheelset shall be removed from service within 24 hours of the fault being identified.

4.7.1.3 Where an isolated crack longer than 30 mm is found in the tread, the vehicle shall be removed from service immediately. Where an isolated crack longer than 20 mm is found in the tread, the wheelset shall be removed from service within 24 hours of the fault being found.

4.7.1.4 Where cracks are found in the transition between tread and rim on the outside face of the rim, in the flange or in any roll-over (see Figures *3* and *33*), then the wheelset shall be removed from service immediately. Any move to a repair facility shall be at a speed restricted to 45 mile/h or less.

4.7.1.5 If wheel tread run-out is identified on a vehicle in service, the affected vehicle shall be taken out of service in accordance with Table *6*.

Vehicle type	Tread run-out	Vehicle to be taken out of service	Speed restriction
Any vehicle permitted to operate above 125 mph and up to 140 mph	Above 1.3 mm	Immediately	See Table *8* to clear running line
	0.7 mm to 1.3 mm	Within 24 hours of the fault being found	None
Passenger or personnel vehicles operating at speeds up to and including 125 mph	Above 3.0 mm	Immediately	See Table *8* to clear running line
	1.3 mm to 3.0 mm	Within 24 hours of the fault being found	None
Non-passenger vehicles, locomotives, power cars, driving van trailers and on-track plant	Above 3.0 mm	Immediately	See Table *8* to clear running line
	1.3 mm to 3.0 mm	On completion of the journey	None

Vehicle type	Tread run-out	Vehicle to be taken out of service	Speed restriction
Freight vehicles up to 17.5 tonnes axle load	Above 5.0 mm	Immediately	See Table *8* to clear running line
	3.0 mm to 5.0 mm	On completion of the journey	60 mph
Freight vehicles equal to or over 17.5 tonnes axle load	Above 4.0 mm	Immediately	See Table *8* to clear running line
	2.0 mm to 4.0 mm	On completion of the journey	60 mph
Other vehicles	Above 4.0 mm	Immediately	See Table *8* to clear running line
	2.0 mm to 4.0 mm	On completion of the journey	60 mph

Table 6: Tread run-out limits and actions applicable to vehicles in traffic

4.7.1.6 If wheel flats are identified on a vehicle in service the affected vehicle shall be taken out of service in accordance with Table *7*.

Vehicle type	Wheel flat length	Vehicle to be taken out of service	Speed restriction
Any vehicle permitted to operate above 125 mph and up to 140 mph	Above 60 mm	Immediately	See Table *8* to clear running line
	Above 40 mm to 60 mm	On completion of the journey	The speed shall be limited to 125 mph until the vehicle is taken out of service
	30 mm to 40 mm	Within 24 hours of the fault being found	Discretion of railway undertaking
Passenger or personnel vehicles operating at speeds up to and including 125 mph	Above 60 mm	Immediately	See Table *8* to clear running line
	40 mm to 60 mm	Within 24 hours of the fault being found	Discretion of railway undertaking

Vehicle type	Wheel flat length	Vehicle to be taken out of service	Speed restriction
Non-passenger vehicles, locomotives, power cars, driving van trailers	Above 60 mm	Immediately	See Table 8 to clear running line
	40 mm to 60 mm	On completion of the journey	Discretion of railway undertaking
Freight vehicles up to 17.5 tonnes axle load	Above 80 mm	Immediately	See Table 8 to clear running line
	60 mm to 80 mm	On completion of the journey	60 mph
Freight vehicles equal to or over 17.5 tonnes axle load	Above 70 mm	Immediately	See Table 8 to clear running line
	50 to 70 mm	On completion of the journey	60 mph
Freight vehicles with wheels equal to or less than 630 mm diameter	Above 70 mm	Immediately	See Table 8 to clear running line
	30 to 70 mm	On completion of the journey	60 mph
Other vehicles	Above 60 mm	Immediately	See Table 8 to clear running line
	40 to 60 mm	On completion of the journey	60 mph

Table 7: Wheel flat limits and actions applicable to vehicles in traffic

4.7.1.7 Vehicles with run-out or wheel flats which require the vehicle to be taken out of service immediately shall be removed from the running line in accordance with Table 8.

Damage	Speed restriction
Flat length longer than 100 mm or tread run-out greater than 8.0 mm	A vehicle shall not be moved except to clear the running line and at a maximum speed of 10 mph or with the use of a wheelskate. Further movement shall be with the authorisation of the infrastructure manager

Damage	Speed restriction
Flat length 70 mm to 100 mm long or tread run-out 5.0 mm to 8.0 mm	Speed restriction of 35 mph
Flat length up to 70 mm long or tread run-out 3.0 mm to 5.0 mm	Speed restriction of 60 mph

Table 8: Speed limits for recovery of vehicles with wheel flats or tread run-out

4.7.1.8 Wheelsets found with cavities shall be treated in accordance with Table *9* and Table *10*.

4.7.1.9 The railway undertaking shall also apply a suitable speed restriction when recovering vehicles found with cavities above these limits.

Cavities found during an inspection in traffic	Action
Any single cavity greater than 15 mm long circumferentially around the wheel	The wheelset shall be withdrawn from service within 24 hours
Any two cavities, separated by less than 50 mm, having a combined length in excess of 15 mm circumferentially around the wheel	

Table 9: Actions to be taken on discovery of cavities during inspection in traffic

Cavities found during an inspection at maintenance	Action
Any single cavity greater than 10 mm long circumferentially around the wheel	The tread profile shall be restored within two weeks
Any two cavities, separated by less than 50 mm, having a combined length in excess of 10 mm circumferentially around the wheel.	

Table 10: Actions to be taken on discovery of cavities during routine inspection at maintenance

4.7.1.10 Wheelsets with the following defects shall be removed from service within 24 hours of such a fault being identified:

a) Wheel profile wear limits exceeded.
b) Wheel diameter wear limit exceeded.
c) Excess wheel tread roll-over.

d) Flange build-up, steps or sharp radii on the flange (toe radius build-up or sharp flange).
e) A circumferential step in the flange profile.
f) A false flange.
g) Flange back blend distortion.
h) Local tread collapse in the form of a rim face bulge.

Rationale

G 4.7.1.11 When unacceptable defects are found in service, the requirements set out accepted practice for moving the affected vehicles to a suitable location, taking into account the severity of the defect or defects.

4.7.2 Unacceptable defects identified during maintenance

4.7.2.1 The wheelset shall not be allowed to re-enter service unless rectified or replaced.

Rationale

G 4.7.2.2 When unacceptable defects are found during maintenance the requirement preventing re-entry into service is obvious.

Guidance

G 4.7.2.3 Under some circumstances it may be necessary to move an affected vehicle from a maintenance location to another which is equipped for the repairs required, in which case the requirements set out in *4.6* are to be applied.

4.7.3 Rectification

4.7.3.1 A wheelset where there are signs of movement or cracks shall be overhauled before being refitted to a vehicle or scrapped and replaced.

4.7.3.2 For a wheelset where unacceptable defects have been identified, either:

a) The wheelset shall be re-profiled if the defect involves dimensional limits or tread defects that can be machined out; or
b) The wheelset shall be removed and sent for repair or overhaul, and a replacement wheelset shall be fitted.

Rationale

G 4.7.3.3 The requirements for rectification of unacceptable defects found during maintenance or in service prohibit any attempts to rectify a problem without the correct processes being applied.

4.7.4 Re-profiling

4.7.4.1 When a wheelset is re-profiled the limits for the tread profile shall not exceed the limits set out in the relevant standards used during design and manufacture.

4.7.4.2 After re-profiling the tyre or wheel rim thickness shall not be less than the limits for minimum thickness specified in the maintenance plan.

4.7.4.3 Following re-profiling, the tread surface, including flanges, shall be free of visible defects such as cracks, cavities, flats or spalling and have a surface roughness no coarser than 12.5 µm (formerly denoted grade N10 in ISO 1302:1992).

4.7.4.4 Re-profiling shall remove all evidence of wheel tread roll-over.

4.7.4.5 The tread chamfer applied during re-profiling may be in the range of 3 mm × 3 mm to 7 mm × 7 mm.

4.7.4.6 The maximum allowable wheel axial run-out (wobble) after re-profiling is 0.75 mm for all vehicles except those with resilient wheels.

4.7.4.7 The maximum allowable wheel axial run-out (wobble) for resilient wheels is 1 mm.

4.7.4.8 The maintenance plan shall define the maximum permitted variation between wheel diameters following profiling for wheels on the same axle.

4.7.4.9 When re-profiling the wheel treads, the bearings and other components shall be protected from contamination and damage by swarf or other debris produced during the re-profiling process.

4.7.4.10 After re-profiling, tyred wheels shall be checked for the security of the tyre and retaining ring; see *4.2.2*.

4.7.4.11 When setting up and after re-profiling, the wheelset shall be checked for any actual damage or potential for damage, for example damage to wheel rims if a wheelset being re-profiled is driven by means of drive dogs. Any damage shall be repaired in accordance with the maintenance plan.

4.7.4.12 Witness marks of unmachined material, if they occur on the wheel tread when re-profiling, shall be no more than 10 mm wide and 0.5 mm deep and blend in smoothly with the machined area of the tread; see Figure *10*)..

Rationale

G 4.7.4.13 The requirements are to ensure that re-profiled wheelsets are consistent with the original design and that during re-profiling the risk from damage to other components is controlled, such as bearing seals where, if damaged, there is a risk from subsequent contamination and failure of the bearing.

Guidance

G 4.7.4.14 When re-profiling, it is necessary to remove sufficient material consistent with the removal of all cracks, cavities and hard spots and the creation of the profile designated for use on the wheelset / vehicle combination.

G 4.7.4.15 Throat thickness can be used as a means of controlling the minimum tyre or wheel rim thickness, and the minimum value is set by the design strength of the wheel. For monobloc wheels, the throat thickness is the dimension between the root of the radius of the tread profile (flange root), and the underside of the flange-side wheel rim, measured at the narrowest point.

G 4.7.4.16 Gauges used to assess the throat thickness are shown in Figures *28* and *29* of Appendix *B*. Measurements are taken away from areas that have been machined during balancing of the wheel.

G 4.7.4.17 Gauges used to assess the tyre and wheel rim thickness are shown in Figures *26* and *27* of Appendix *B*.

G 4.7.4.18 If defects remain in the wheel tread it is probable that they could develop while in service and require further attention. A crack remaining in the tread may propagate rapidly in the appropriate conditions, resulting in wheel failure.

G 4.7.4.19 Witness marks being work hardened will have a greater resistance to wear than the adjacent turned surface and may result in irregular tread surface. Also, where only a small amount of material has been turned off, the tread sub-surface defects may remain undetected, which can result in tread defects shortly after returning to service.

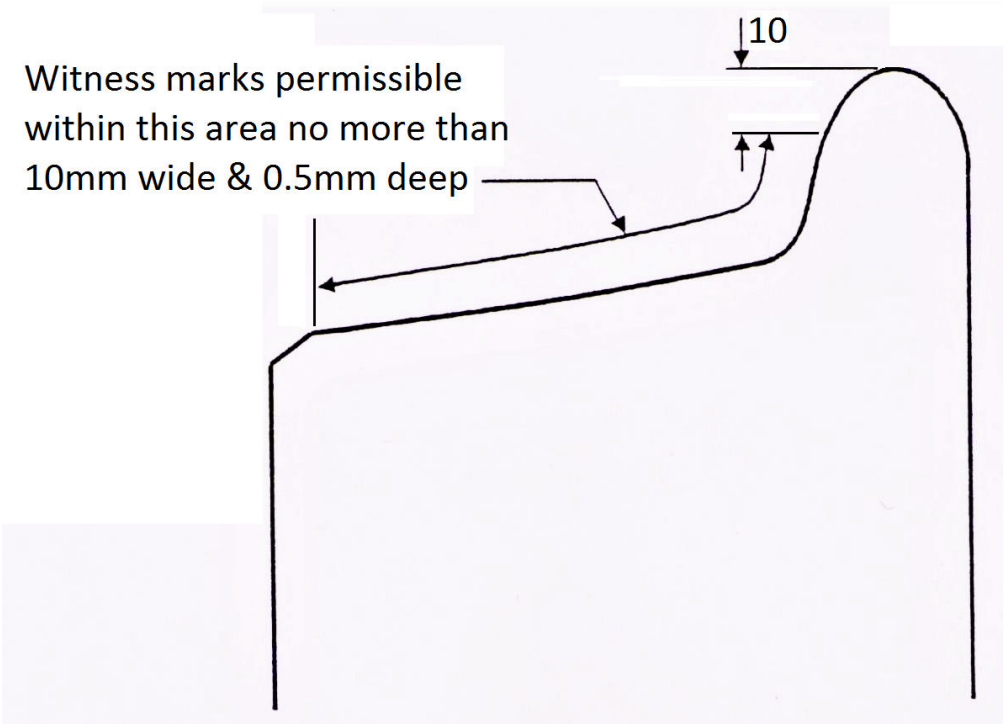

Figure 10: Permissible witness marks on re-profiled treads

G 4.7.4.20 The GB tread profiles included in GMRT2466 are defined with tread chamfers of 6 mm × 6 mm. The range of chamfers permitted is consistent with BS EN 13715.

G 4.7.4.21 The profile alignment on the wheels of a wheelset can have a significant effect on the performance of the vehicle and life of the wheelset. The correct tread profile alignment may be checked using a sliding gauge, as set out in Appendix *B* of this document.

G 4.7.4.22 The maintenance plan may reference the applicable wheelset assembly standard, for example BS 5892 Part 6, Table 2 or BS EN 13260, Table 3. The measurement positions are identical but the criteria used in these standards differ; BS 5892 Part 6 is more demanding.

G 4.7.4.23 Modern wheel lathes have their own in-built measuring system, which provides profile data on the completion of turning and hence no gauging is required, although use of

profile alignment tools may confirm the calibration of the lathe and that the correct profile has been applied.

G 4.7.4.24 Many wheel lathes are imported from the EU and are therefore configured around the TSI and EN controls. Although these are programmed to machine the standard GB profiles, it is important to verify the parameters used to determine flange thickness if the lathe is used to inspect that feature. Unless the lathe has been specifically set to record the flange thickness at 13 mm above the tread datum, it is likely that flange thickness would be reported at 10 mm above the datum and therefore indicate that the flange is thicker than it would be if measured at the correct height.

G 4.7.4.25 Gauges are shown in Figure *22* of Appendix *B* that can be used to assess profile alignment. The profile is checked by assessing the gaps between the tread and gauge at positions K to L and M to N. When the gauge is used on a wheelset carrying the weight of a vehicle, it may be necessary to fit the gauge to the profiles at the same height above the rail as the axle (that is 3 o'clock or 9 o'clock positions) and to release the brakes. This is to avoid errors due to axle deflection under load.

G 4.7.4.26 It is good practice to check the alignment and surface finish of tread profiles produced on a lathe regularly. It is good practice for profiles to be checked at least once a day and on the first wheelset machined after a change to the lathe settings, for example template, program, tooling etc.

4.7.5 Re-profiling - Economic Tread Turning (ETT)

Guidance

G 4.7.5.1 GMRT2466 permits the use of thinner flanges on certain profiles to improve the useful life of wheels before scrapping, and defines the nominal profiles where ETT is permitted and details of the range of subsidiary profiles consistent with the original profile to be used that lie between the new profile and the fully worn condition.

G 4.7.5.2 ETT for use with GB profiles has been developed from the findings of RSSB research projects T641 (2008) , T963 (2013) and Institute of Rail Research report IRR 'and'110/145.

4.7.6 Wheelset replacement

4.7.6.1 The diameter of a replacement wheelset shall be compatible with any requirements in the maintenance plan, which set tolerances for the variation in wheel diameters between wheelsets fitted to a bogie or to a complete vehicle.

Rationale

G 4.7.6.2 Excessive variation in diameter between wheelsets fitted to a vehicle can affect traction and braking performance and can also affect vehicle gauging by causing the vehicle to pitch.

Guidance

G 4.7.6.3 Some diesel multiple unit (DMU) powered bogies, with driven wheelsets on a bogie that are mechanically linked, require a minimal diameter difference between the wheelsets to prevent damage to the drive train.

G 4.7.6.4 The minimum wheel diameter to be fitted to a vehicle following repair or overhaul is specified in the maintenance plan.

4.7.7 Notification of defects

4.7.7.1 When wheelsets with unacceptable defects are identified, the railway undertaking shall advise the infrastructure manager of wheelset damage that may have adversely affected the track over which they have been operating. These are to include wheelsets that have been removed from service for:

a) Wheel flats that exceed criteria for vehicle to be removed from service, as set out in Table *6* of this document.
b) Tread run-out that exceed criteria as set out in Table *4* of this document.
c) False flange exceeding the limits defined in *4.6.2.4* of this document.

Rationale

G 4.7.7.2 This requirement allows the possibility of the infrastructure being damaged by a defective wheelset to be assessed and acting on this information for the risks to be managed and controlled.

Guidance

G 4.7.7.3 The infrastructure manager will need to be advised of the train formation the damaged wheelset had been operating in and the routes on which it had been operating prior to being removed from service.

4.8 Repair and overhaul

4.8.1 Inspection and cleaning

4.8.1.1 Prior to repair or overhaul, wheelsets shall be visually examined before cleaning or dismantling.

4.8.1.2 Cleaning methods shall not be detrimental to the wheelset or attached components and not hinder any tests which may be required. Cleaning methods shall prevent damage from cleaning materials to bearings and other wheelset components by protection and sealing of apertures. Washing sprays shall not be directed at the axlebox / bearing assemblies or seals.

4.8.1.3 Where the wheelset is removed from the vehicle and the axleboxes remain in position on the axle for a repair, a bearing check shall be undertaken. This is to ensure that the bearings in the axlebox are in a suitable condition for when they are returned to service after repair. The bearing check shall include:

a) A rotation test to check for unusual sounds and roughness.

b) An end float test.
c) A check of seals for wear or damage.

4.8.1.4 Where components, such as brake discs, gearwheels and suspension tubes etc are not to be removed as part of the repair or overhaul procedure, they shall be checked for security, integrity, damage and defects.

Rationale

G 4.8.1.5 Careful inspection and cleaning before overhaul can reveal additional information about the condition of a wheelset, which can inform subsequent actions.

Guidance

G 4.8.1.6 Fasteners normally remaining in position may have samples removed to assess corrosion that would otherwise be hidden. Any problems can be dealt with using an applicable procedure.

4.8.2 Wheels, wheel centres and tyres

4.8.2.1 Where the wheelset back-to-back dimension falls outside the acceptable range, both of the wheels or wheel centres shall be changed unless one wheel is clearly distorted.

4.8.2.2 Monobloc wheels and wheel centres that contain balance weight holes in the wheel web shall be inspected at repair and overhaul by MPI or a process with an equivalent level of sensitivity.

4.8.2.3 When accessible, the wheel web and wheel web holes shall be inspected for corrosion, cracks and damage, in particular those wheels that are known to be susceptible to fatigue fractures of the web.

4.8.2.4 The wheel centre to tyre interface shall be maintained to ensure integrity throughout its service life, with particular attention to the inspection and rectification of wheel centre interface surfaces.

4.8.2.5 All wheel centres shall be shown to meet the criteria identified in BS 5892 Part 2 or equivalent criteria prior to re-tyring.

4.8.2.6 During repair or overhaul, examination for security and integrity of tyres shall in addition include:

a) Checking the clearances between the inside vertical face of the tyre and the retaining ring and between the retaining ring and wheel centre to ensure that they are within limits.
b) Checking that the retaining ring ends are not separated by more than the allowable gap and that there is no make-up piece in the retaining ring.

Rationale

G 4.8.2.7 When wheelsets are overhauled or repaired, only components that can be shown to be in an acceptable condition are permitted to be used. Unsatisfactory components are required to be replaced.

Guidance

G 4.8.2.8 The number and spacing of balance weight holes can adversely affect the structural integrity of the wheels. Such holes are consequently not allowed on new wheel designs.

G 4.8.2.9 Wheel web cracks can frequently be initiated from features such as holes in the web, and the point of initiation can be damage or an imperfection in the surface. Fractures in the web can run circumferentially around the wheel web.

G 4.8.2.10 Typically, the criteria for wheel centres deemed acceptable for reuse are:

a) Outside diameter not to be less than nominal diameter minus 5 mm (nominal diameter is recorded in the wheelset database).
b) Centre rim run-out less than 0.6 mm.
c) Surface roughness of all surfaces of the rim less than 3.2 µm.
d) Width of rim not less than nominal minus 2.5 mm.
e) Machined rim profile to comply with the relevant drawing.
f) No corrosion, after any shallow corrosion up to 0.2 mm deep has been removed by an approved process.
g) No indentations greater than 2.5 mm across.
h) No raised edges or burrs. Material standing proud of the surface is to be removed using an approved process. Material below the surface is not to be removed.

G 4.8.2.11 To achieve the above criteria, machining with a minimum depth of cut may be necessary providing that minimum dimensions, as shown on the relevant drawing, are achieved. Welding, using a validated procedure, is permitted in the wheel centre bore.

4.8.3 Repair and overhaul of axles

4.8.3.1 The maintenance plan shall specify the criteria for maintaining axles to ensure they can be maintained for safe operation or identified for scrapping.

4.8.3.2 When stripped of components, axle seats shall be free of all scores, burrs or sheared metal.

4.8.3.3 The axle body run-out shall be measured.

4.8.3.4 If the run-out is greater than the values specified for the design the axle shall be considered to be bent and shall be scrapped.

4.8.3.5 To avoid scrapping, where the technical specification includes a machining allowance, surface defects may be removed by skimming within the allowance. MPI can be used to determine that there are no residual defects.

4.8.3.6 Axles shall be scrapped where copper penetration has occurred due to the migration of copper from an overheated plain bearing into the steel micro structure.

4.8.3.7 Where the axle and wheelset component protective coating has suffered significant damage, then consideration shall be given to removing the whole surface coating before replacing it, with detailed requirements set out in the maintenance plan.

4.8.3.8 Protective coating shall not be applied over corroded surfaces.

4.8.3.9 For axles which are protected by a surface coating, even where MPI or an equivalent technique shows that the axle is clear, the corrosion shall still be unacceptable where it:

a) Is located in any transition area.
b) Is concentrated at a particular point that is a corrosion pit, particularly where it has a ring of red / brown staining.
c) Is greater than 1 mm deep or longer than 30 mm circumferentially or 50 mm axially.
d) Cannot be removed by polishing up to 1 mm deep.
e) Cannot be removed by hand-polishing a sample area with 360 grit paper.

4.8.3.10 The axle end shall be normal to the axle centre-line.

Rationale

G 4.8.3.11 When wheelsets are overhauled or repaired, only components that can be shown to be in an acceptable condition are permitted to be used. Unsatisfactory components are required to be replaced.

Guidance

G 4.8.3.12 When assessing axle corrosion the extent and depth of corrosion is taken into account. Corroded areas can be inspected by MPI or an equivalent technique to help identify cracks and decide upon appropriate action, such as application of an appropriate procedure to keep the axle in serviceable condition or whether to scrap the axle.

G 4.8.3.13 Damage to the axle surface can initiate fatigue fractures; the following list sets out typical examples of such initiators:

a) Weld spatter – causing small imperfections in the surface that cause irregularities and stress concentrations.
b) Electric arc damage – can result in local high thermal gradients sufficient to transform a small area of the surface to martensite, a hard, brittle phase of steel that can form cracks during cooling and subsequent operation, which can develop into fatigue fractures.
c) Sharp indentations – that can form a stress concentration at the axle surface and initiate fatigue fracture.
d) Circumferential damage – scoring around the axle.

G 4.8.3.14 Damaged protective surface coatings can produce localised pitting corrosion and also allow corrosion to propagate beneath the coating. Axle fatigue fractures can initiate from surface corrosion; therefore, to minimise this risk, good practice is to remove the whole of the damaged surface coating for examination, and to rectify any damage.

G 4.8.3.15 Historically, the most common cause of axle fracture in GB has been fatigue failure emanating from surface imperfections. Corrosion pitting can, therefore, pose a significant risk due to the possibility of crack propagation from the base of a pit due to the stress concentration effect. Pitting arises from chemical attack from atmospheric content (for example, salt or sulphur dioxide) or corrosive product carried if this comes into contact with the axle.

G 4.8.3.16 Cleaning methods used are unlikely to remove corrosive deposits from the bottom of corrosion pits. Additionally, measurement of pit depth is problematic and the presence of cracks initiating at the base of deep pits may be undetectable. Therefore, axle skimming is the only certain method of removing these pits. This effectively 're-lifes' the axle but can, of course, be undertaken only where tolerances permit.

G 4.8.3.17 To reduce the possibility of initiation of corrosion pitting, protection by surface coating (for example, painting) has generally been applied on traditional British axle designs. Where this regime is in force, good coating adherence is important since if water penetrates beneath the paint it may not dry out and can therefore initiate localised corrosion. Similarly, damage to the surface protection can give rise to similar problems.

G 4.8.3.18 Although general, even surface corrosion arising from the formation of iron oxide due to oxygen and moisture present in the air is in itself thought unlikely to pose a particular fatigue initiation risk, this needs to be removed before any specified surface coatings are reapplied at wheelset maintenance to ensure that optimum integrity of protection is achieved. There is also the possibility that surface corrosion may aid the initiation of corrosion pits given the right conditions.

G 4.8.3.19 The use of surface coatings to provide corrosion protection is not generally specified on low stress axle designs (for example, AAR axles) since the lower working stress levels result in lower sensitivity to corrosion pitting effects.

G 4.8.3.20 Fretting staining arises where minute relative movement between interference fit surfaces occurs, such as at axle wheelseat and bearing interfaces. A fine oxide layer is created which appears as a surface stain. Easily removed dark brown dust (like 'cocoa') deposits may be present and it is possible that a very slight ridge may be apparent at the edge of the stain when the interference fit components are separated. At overhaul it is thought good practice to remove the dark brown dust but it is not essential to remove the surface staining.

G 4.8.3.21 The axle end flatness and surface condition can have an influence on the reliability of UAT. Therefore, it is important that the axle end faces shall be flat with no burrs, free of indentations, sharp edges or grooves in the surface, other than permitted identification. An oilstone is effective in removing burrs and sharp edges.

G 4.8.3.22 The surface condition of axle ends has typically been manufactured and maintained to the following:

a) Surface roughness of the end face less than 3.2 µm.
b) Where the end face is re-machined to accommodate an axial thrust pad, the surface roughness has typically been reduced to a value less than 0.8 µm and the complete geometry of the axle end reinstated.
c) Flatness / run-out of end face less than 0.08 mm.

G 4.8.3.23 Axial score marks on axle seats are defined as those with raised edges, burrs, sheared metal or excessive depth, sufficient to cause suspect defects on ultrasonic examination or loss of oil injection pressure on subsequent wheelset overhaul/ dismantling. This excludes raised edges or burrs that have been dressed off using an oilstone (or similar) or superficial scoring rectified using fine abrasive paper (finer than 360 grade).

4.8.4 Reassembly

4.8.4.1 Dismantled wheelsets shall be reassembled in accordance with the wheelset design and the requirements of Part 3 of this document.

4.8.4.2 Fasteners removed during repair or overhaul shall be discarded and replaced by new items, or may be re-used subject to:

a) Design assessment on the potential for re-use considering the known or probable service duty of the fastener.
b) Inspection of the fastener according to defined procedures and standards to ensure that the fastener is fit for re-use considering mechanical damage or corrosion.

Rationale

G 4.8.4.3 This is intended to ensure that the wheelset is correctly reassembled after overhaul.

Guidance

G 4.8.4.4 Discarding fasteners during maintenance or overhaul eliminates the uncertainty of whether a fastener is fit for re-use.

G 4.8.4.5 The suitability of a given fastener for re-use varies depending on the loading on the fastener, the environment in which it operates (exposed to corrosive elements or within a sealed enclosure), and any potential damage caused by prior mis-assembly (such as cross-threading).

G 4.8.4.6 Prevailing torque fasteners (such as nyloc), tab washers and plates, and single-use gaskets (paper or cork) are not suitable for re-use.

G 4.8.4.7 Gaskets made of neoprene with reinforcing washers at the fastener holes can be re-used depending on the environment (temperature and aggressive chemicals) in which they have operated, and need to be inspected for re-use.

4.8.5 Re-profiling at repair and overhaul

4.8.5.1 If required, overhauled or repaired wheelsets shall be re-profiled in accordance with *4.7.4*.

Rationale

G 4.8.5.2 The requirement is to ensure that overhauled or repaired wheelsets are consistent with the original design.

Guidance

G 4.8.5.3 None.

Part 5 Requirements for Wheelset Records

5.1 Introduction to wheelset records

5.1.1 Records shall be kept and maintained throughout a wheelset's life cycle.

5.1.2 A wheelset's records shall ensure that the full history of the wheelset, including manufacturing data, inspection records and maintenance activities, including all visual and physical examination results, is available throughout its lifetime.

5.1.3 Wheelset records shall be updated before the wheelset is dispatched for overhaul.

Rationale

G 5.1.4 As safety-critical items it is essential that the full history of wheelsets in service is available and that component histories can be traced. In the event of a failure in service, a manufacturing defect or process problem being identified, robust reliable records will allow identification of the processes applied, by whom, and affected components.

G 5.1.5 The recording of all visual and physical examination results can assist in determining the appropriate level of maintenance to be undertaken. The analysis of robust records can inform decisions on the maintenance and service life of components

5.2 Labelling of wheelsets

5.2.1 Labelling of assembled or overhauled wheelsets

5.2.1.1 When a locomotive or passenger vehicle wheelset has been assembled or when an overhaul or repair has been completed, a durable label shall be attached to the wheelset to provide the following information about the wheelset, to assist traceability:

a) Contractor's identification.
b) Wheelset catalogue number, where applicable.
c) Wheelset serial number (axle unique number).
d) Overhaul / repair date.
e) UAT date or other NDT date.
f) UAT / NDT operator(s) name(s).
g) Warranty expiry date, if applicable.
h) Axle bearing manufacture date *.
i) Axle bearing overhaul date *.
j) Axle bearing fitting date *.
k) Axle bearing serial number *.

Note: *for both bearings on the axle.

Rationale

G 5.2.1.2 Labelling provides an efficient way of managing defective wheelsets, as it provides a consistent form of identification.

G 5.2.1.3 The type of label and its method of attachment to the axle can adversely affect the surface or protective coating. For instance, moisture trapped on the material surface can promote localised corrosion on exposed surfaces. Also, metallic bands can damage any protective coating, so encouraging localised corrosion of the component.

5.2.2 Labelling of defective wheelsets

5.2.2.1 Defective wheelsets shall be labelled with the following information:

a) Catalogue or part number.
b) Wheelset serial number.
c) Reason for removal from vehicle.
d) Requirements for particular tests or examinations.
e) Estimate of miles run since the last NDT examination (where known).
f) The need for quarantine.

Rationale

G 5.2.2.2 Labelling is an efficient way of managing defective wheelsets as it provides a consistent form of identification.

G 5.2.2.3 It is important that feedback is provided to railway undertakings and the maintenance staff, to confirm, or otherwise, the presence of a defect.

G 5.2.2.4 The presence of defects are recorded in accordance with the process set out in the safety management system.

5.3 Traceability of wheelsets

5.3.1 Wheelset records associated with the wheelset shall include the following information:

a) Catalogue or part number.
b) Wheelset serial number.
c) Manufacturing data, including date of manufacture, name of manufacturer, name of assembler and date of assembler.
d) Maintenance inspection history.
e) Maintenance activity record.

Rationale

G 5.3.2 This is to ensure that wheelsets are traceable throughout their life cycle.

G 5.3.3 Good practice is for a wheelset and its components to be traceable throughout its life whether on or off a vehicle. This means systems are in place to ensure the correct processes are applied during repair or overhaul and demonstrate the work has been correctly and competently undertaken.

G 5.3.4 All parties holding wheelset records may be required to make available relevant information upon request of the railway undertaking, entities in charge of maintenance (ECM) or actor investigating an incident. These records can include records of examinations, measurements, tests, work done and assembly details. Also

included are relevant facility certificates, operator certificates and work experience records, calibration evidence and equipment approval documentation.

G 5.3.5 Maintenance inspection history will include records of NDT results.

5.4 Recording of examination results

5.4.1 Records of all examinations and inspections of the wheelsets shall be retained, including the measurements recorded, NDT results and the defects identified.

5.4.2 The examination requirements shall be clearly specified to the repair contractor.

5.4.3 A copy of relevant records identifying the cause of removal from service shall be attached to the defective wheelset when dispatched for repair of overhaul.

5.4.4 Contractors repairing or overhauling wheelsets shall make and retain complete records of examinations, measurements, tests, work done and assembly details.

Rationale

G 5.4.5 Effective records of examinations allow effective repairs and overhaul to be undertaken with supporting evidence to justify the methods and processes used. See also *5.1*.

Part 6 Conformity Assessment

6.1 Conformity assessment

Guidance

G 6.1.1 Conformity assessment is the process of demonstrating that a wheelset or wheelset component satisfies the design specification, standards and is fit for purpose.

G 6.1.2 The LOC&PAS NTSN and WAG NTSN set out conformity assessment requirements in Chapter 6 of the respective NTSNs.

G 6.1.3 RIS-2700-RST sets out a process which can be adopted by organisations that are undertaking projects that require verification of conformity of an engineering change to rail vehicles against applicable requirements and by organisations that carry out the verification work.

G 6.1.4 Conformity assessment helps to ensure that the design requirements of this document are satisfied.

G 6.1.5 Evidence that the requirements of this document have been met forms part of any compliance assessment procedures.

6.2 Assessment of new wheelset designs

Guidance

G 6.2.1 Wheelset designs which embody new, unconventional or novel design features, new materials and / or new manufacturing processes can be assessed by:

a) Evidence of satisfactory service on a major railway system under operating conditions equivalent to those prevailing in GB with evidence to demonstrate that the requirements of this document are met and that the operating conditions are equivalent.
b) Demonstration by testing of new designs of wheelset or components, including testing of new design features, materials or processes to ensure their safety and reliability in service and the operational environment. Demonstration of the suitability of the testing techniques in representing conditions in relation to the component is required.
c) Evidence to demonstrate that equipment that has been used on another railway administration in a similar application and environment to where it is proposed to be used on the GB network.
d) Trials in service before a new wheelset is accepted for regular or service use. Trials are a method of demonstrating that the wheelset design and manufacture meet the requirements of the wheelset standards.

G 6.2.2 Customary validation methods to prove the integrity and suitability of a wheelset design are:

a) Full-scale fatigue tests at the maximum stress ranges used in the design calculations with a load regime no less onerous than that experienced in service.

b) Fatigue life prediction calculations using stress ranges and various effects, including thermal loadings, where appropriate, and the material properties obtained from tests on specimens machined from an actual component or accredited, published data for the same grade of material produced in a manner similar to that of the component, with either:

   i) Strain history under service loads, obtained from strain-gauged tests, used as an input to fatigue life calculations; or
   ii) Service trials to gather stress and strain histories for use in fatigue life calculations.

c) Demonstration that the wheel rim remains dimensionally stable and does not exceed the respective axial displacement when subject to maximum thermal braking load.

Appendices

Appendix A Branding

A.1 Axle branding

A.1.1 Forged axle identification

A.1.1.1 Axles in the as forged or rough machined condition shall be branded, as shown in Figure *11*.

A.1.1.2 The stamping shall be at one end only and shall be light but legible.

A.1.2 Axle end branding

A.1.2.1 Before the wheel seat is finish machined the markings, except for the inspector's stamp, shall be recorded for inclusion in the records associated with the finished axle.

A.1.2.2 The branding shall be applied by cold stamping at one end only as soon as the areas to be stamped have been finish machined in the positions shown by:

a) Roller bearing axle, as shown in Figure *12*.
b) Plain bearing axle, as shown in Figure *13*.
c) Roller bearing axle with thrust pads, as shown in Figure *14*.
d) Plain bearing axle with thrust pads, as shown in Figure *15*.

A.1.2.3 The branding shall be applied at the gear wheel end of a driven axle.

A.1.2.4 Axles supplied in the finish machined condition shall have the brandings as required in *A.1.1* and Figure *11* stamped onto the axle end.

A.1.2.5 This branding shall be identified by the use of '&' either side of the additional information, for example '& SP 95 SC5761 &'.

A.1.3 Axle end additional branding

A.1.3.1 Assembled axles shall have the axle end additionally branded as shown in:

a) Figure *14*.
b) Figure *15*.

A.1.3.2 The branding shall be dressed to remove any raised burrs.

A.1.3.3 For hollow axles, where the end cap is not removed for ultrasonic inspection of the axle, it is permissible to etch additional branding inside in the bore.

A.2 Monobloc wheelset branding

A.2.1 Monobloc branding

A.2.1.1 Monobloc wheels shall be branded by stamping during manufacture, as shown in Figure *16*; wheel rims that have been ultrasonically tested shall include 'UT' in the branding.

A.2.1.2 The cast identity shall be stamped.

A.2.1.3 Where practicable the oil injection plug shall be machined on the same radial line as the branding.

A.2.2 Monobloc wheelset branding

A.2.2.1 When assembled onto an axle, both monobloc wheels shall be branded on the inside face of the wheel, as shown in Figure *17*.

A.2.2.2 Where inside face branding is not practicable, because of the proximity of a gear wheel, for example, then it is permissible to stamp on the outside of the wheel only, at the same radial and circumferential location.

A.2.2.3 The branding shall be diametrically opposite the branding on the rim applied during manufacture.

A.3 Tyred wheelset branding

A.3.1 Wheel centre branding

A.3.1.1 Wheel centres shall be branded during manufacture, as shown in Figure *18*.

A.3.1.2 When machined, the oil injection plug shall be located diametrically opposite the branding.

A.3.2 Tyre branding

A.3.2.1 Tyres shall be branded during manufacture, as shown in Figure *19*.

A.3.2.2 The branding shall be below any last turning groove which may be present and shall not intrude into the chamfer machined at the edge of the wheel tread.

A.3.2.3 The edge of the wheel tread shall not contain any notches or other stress raising features.

A.3.3 Assembled tyre branding

A.3.3.1 When a tyre is fitted to a wheel centre the additional information, as shown in Figure *20* (items 12, 11 and 5) shall be cold stamped onto the tyre in the position shown.

A.3.4 Tyred wheelset branding

A.3.4.1 When assembled onto an axle, both tyred wheels shall be additionally branded on the inside face of the wheels, as shown in Figure *20*.

A.3.4.2 Where inside face branding is not practicable, because of the proximity of a gear wheel, for example, it is permissible to brand the outside face adjacent to the brands applied during manufacture.

A.3.4.3 The branding shall be diametrically opposite the branding on the tyre.

A.3.5 Material grades

A.3.5.1 The grade of material codes set out in Table *11* shall be used when branding wheels, wheel centres and tyres. The branding requirements are as set out in this document.

Grade of material	Code
BR Spec 107	A
BR SPEC. 100/108B	B

Grade of material		Code
BR SPEC. 100/108C		C
BR SPEC. 100/108D		D
BR SPEC. 100/108E		E
BR SPEC. 167(C52TS)		F
BR SPEC. 118A		H
BS 5892 Pt 4	Grade B5	5
ISO 1005 Pt 1		
UIC. 810-1		
BS 5892 Pt 4	Grade B6	6
ISO 1005 Pt 1		
UIC 810-1		
BS 5892 Pt 3	Grade R7E	7E
ISO 1005 Pt 6	Grade R7T	7T
UIC 810-3		
BS 5892 Pt 3	Grade R8E	8E
ISO 1005 Pt 6	Grade R8T	8T
UIC 810-3		
BS 5892 Pt 2	Untreated	U
	Normalised	N

Table 11: Wheelset unique identification codes

A.3.5.2 At overhaul and reassembly of wheelsets:

a) The axle serial number shall be checked to establish that it is not duplicated.
b) The branding shall conform to the requirements of this document.

A.3.5.3 Where the number is not unique, has no assembler's code or is in any way deficient, railway undertakings or ECMs shall require the latest assembler to allocate an axle serial number from its own number series. The number shall be branded on the axle according to the requirements of this document. The wheelset records shall be endorsed, recording both the new serial number and the replaced serial number.

A.3.6 Removal of branding codes

A.3.6.1 When it is necessary to erase the existing branding on a wheel, the marks shall be peened out and erased by filing.

A.3.6.2 The new or reinstated data shall be cold stamped in the relevant location, as required by this document.

A.3.7 Assembler's identification

A.3.7.1 When the wheelset is repaired or overhauled by a different contractor from the original assembling contractor, then on reassembly the latest assembler's code shall be stamped on the axle end (see Figures *14* and *15*), or stamped to comply with AAR requirements, as appropriate.

A.3.8 Wheel branding

A.3.8.1 On reassembly the monobloc wheels shall be branded in accordance with one of the following: as set out in *A.3.5* or UIC or AAR requirements, as appropriate.

A.3.8.2 Tyred wheels shall be branded, as set out in *A.3.6* or UIC requirements, as appropriate.

A.3.8.3 The latest assembler's code shall be added where the wheel is not new and where the wheelset has been repaired or overhauled by a different contractor from the original assembler.

A.3.9 New tyre branding

A.3.9.1 When a wheel centre is re-tyred the new tyre shall have the branding completed, as shown in Figure *20* (items 11, 12 and 5), or as set out in UIC requirements.

A.3.10 Axle geometry codes

A.3.10.1 The axle geometry codes set out in Table *12* shall be included in the axle branding for the following axles:

a) Axles reclaimed by modifying their geometry.
b) Replacement axles where the geometry of the new axle differs from the original, due to the inclusion of transition radii, stress relief grooves etc.

Code	Reclaimed axle geometry
R	Re-profiled
G	Stress relieving grooves added
G1	25 mm (1 inch) stress relieving grooves added
WG	Wide stress relieving grooves added

Table 12: Axle geometry codes

A.3.10.2 Table *13* gives the description of codes used in Figures *11* to *20*.

Code	**Description**
1	Grade of material.
2	Manufacturing contractor's code.
3	Year of manufacture.
4	Cast identity.
5	Inspector's stamp (optional).
6	For ready identification of 140 mm diameter journals from 5½" diameter journals (freight vehicles only): • Stamp the number 140 on both ends • Paint both ends with white paint to BR Catalogue NO 28/44300
7	Axle serial number (from assembling contractor's number allocation).
8	Axle geometry code, if applicable, to be cold stamped after the serial number.
9	Original assembling contractor's code. See *A.3.11*
10	Tyre tread profile.
11	Date of assembly of tyre or wheel centre as applicable.
12	Latest subsequent assembling contractor's code. To be used when a wheelset has been repaired or overhauled by a different contractor from the original assembling contractor.
13	Ultrasonic code, wheel rims that have been ultrasonically tested shall be stamped UT.

Table 13: Branding codes for axles

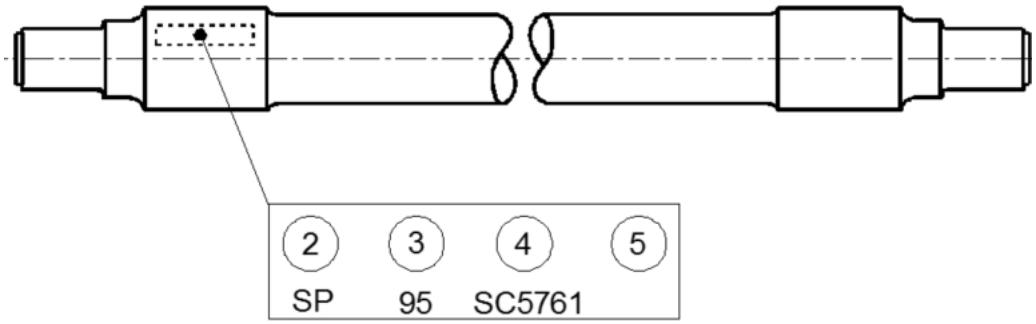

Figure 11: As forged condition axle markings

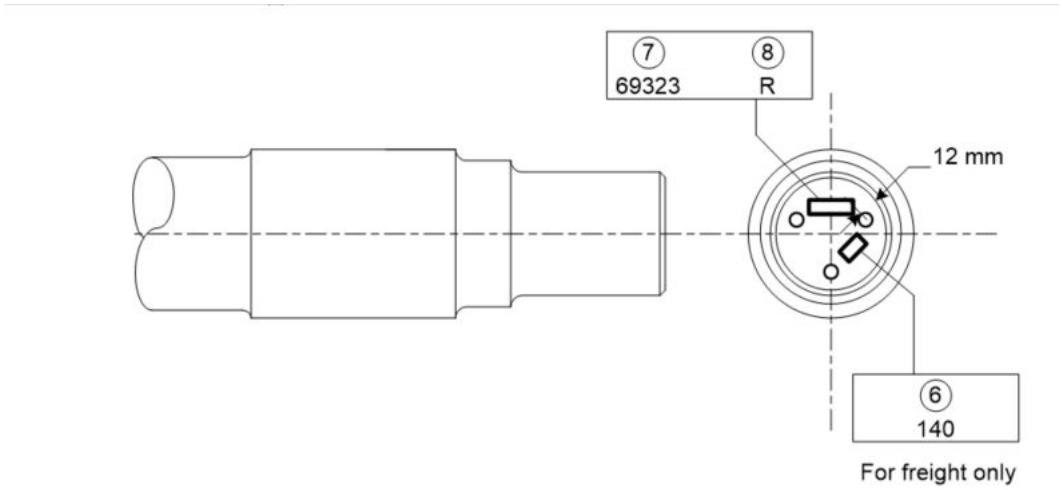

Figure 12: Branding on finish machined roller bearing axles

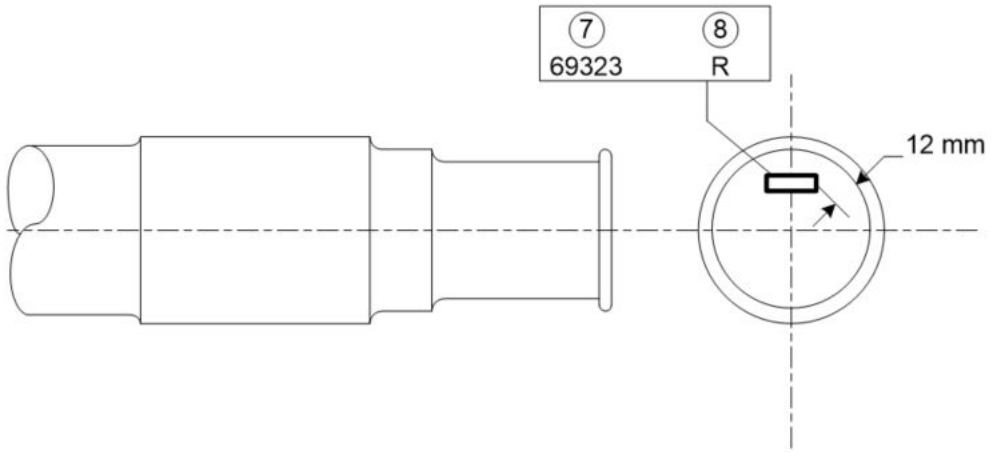

Figure 13: Branding on finish machined plain bearing axle

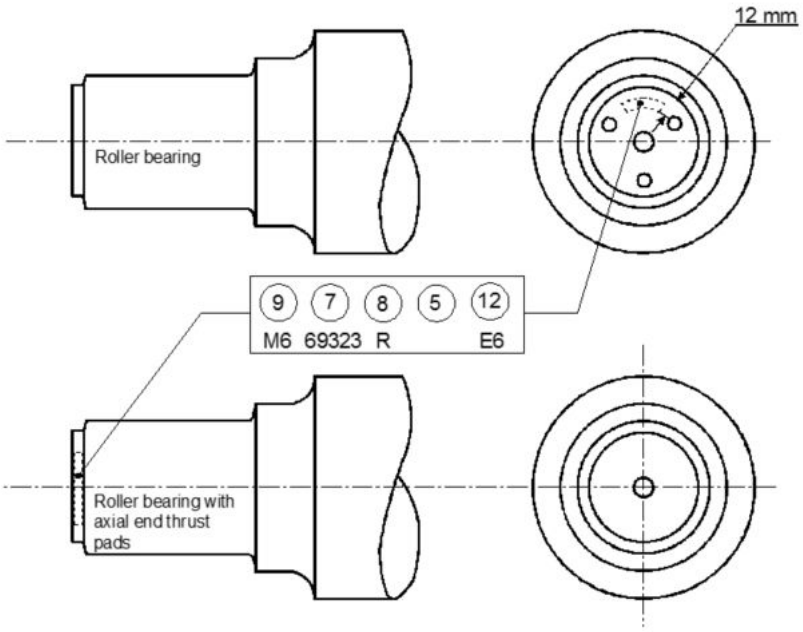

Figure 14: Axle end branding of roller bearing axles

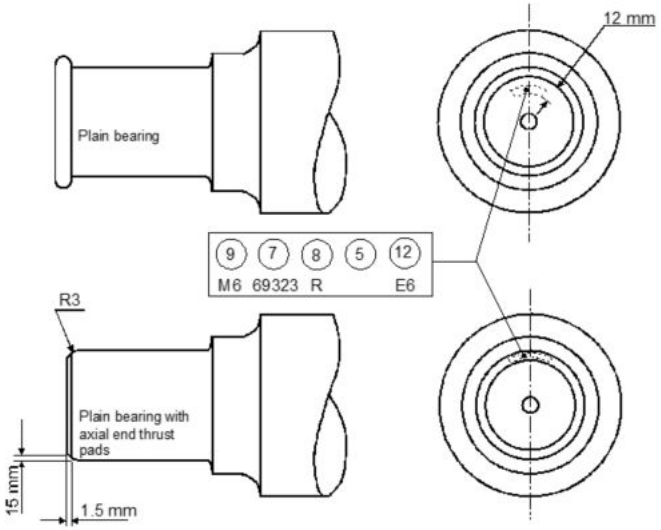

Figure 15: Axle end branding of plain bearing axles

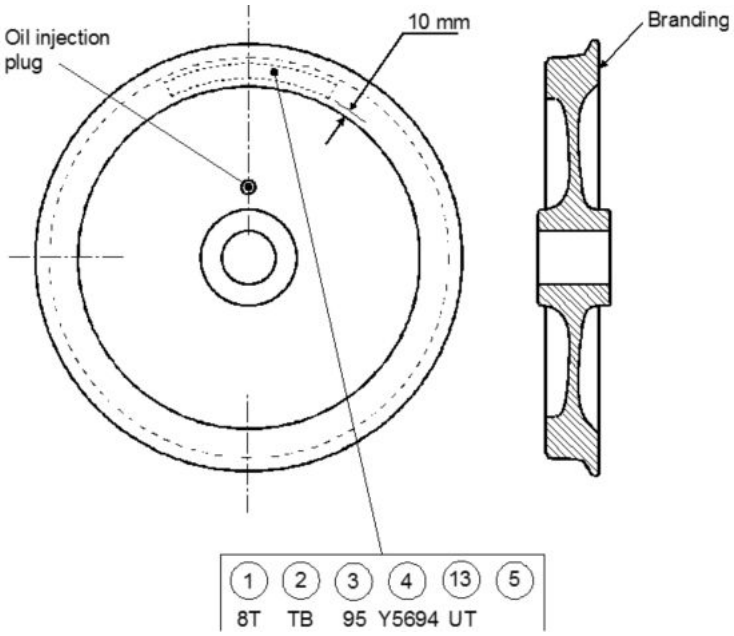

Figure 16: Branding on monobloc wheels during manufacture

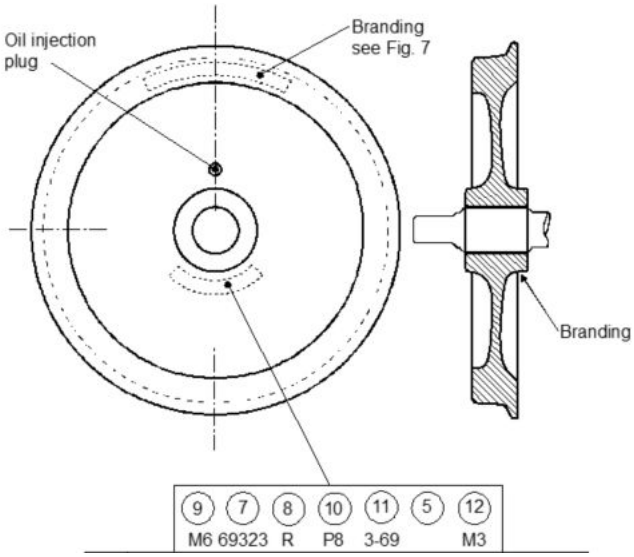

Figure 17: Branding on monobloc wheels after assembly

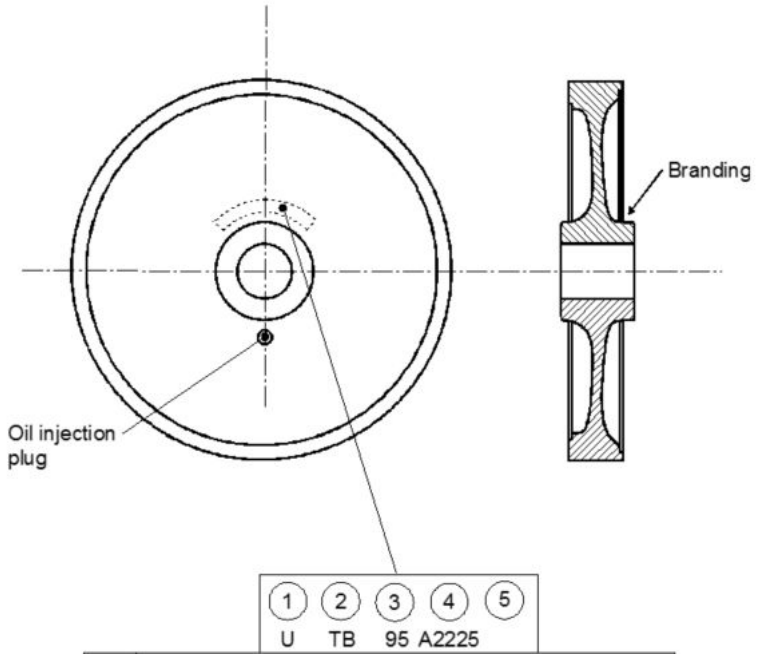

Figure 18: Branding on wheel centre during manufacture

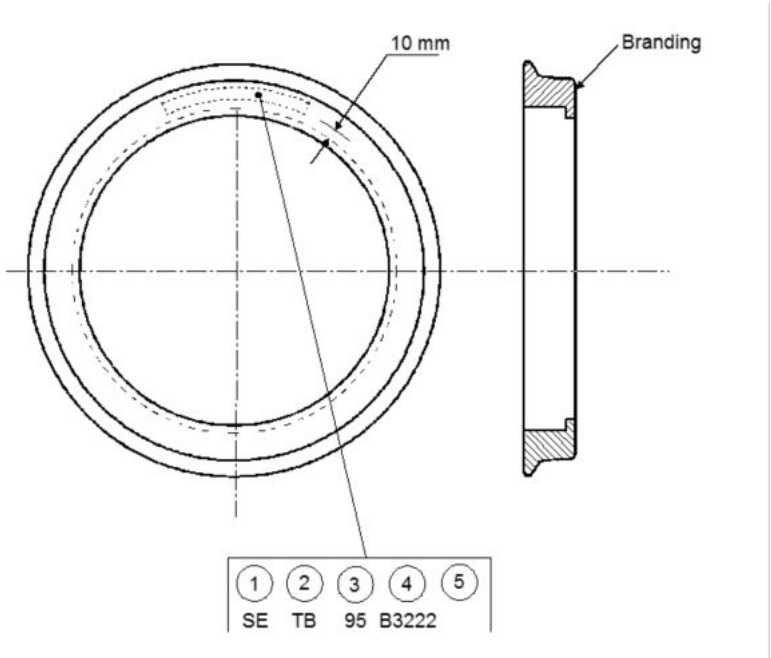

Figure 19: Branding on tyres during manufacture

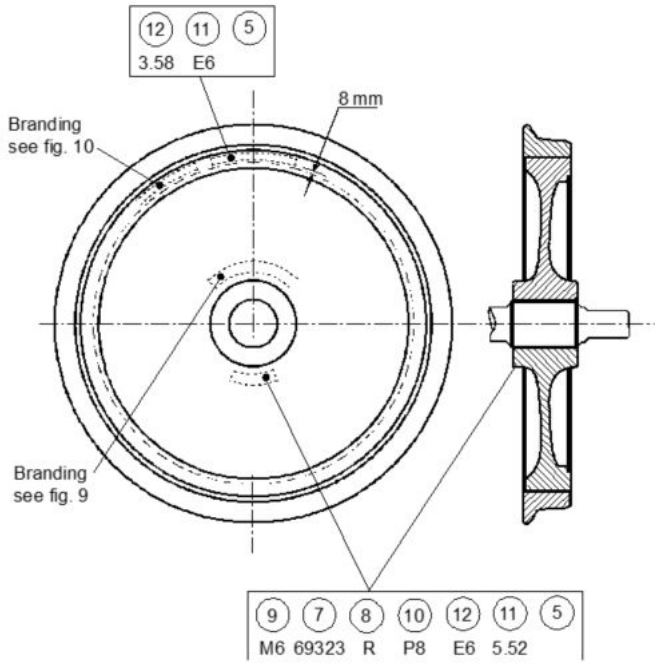

Figure 20: Branding on tyres and wheels following assembly

A.3.11 Manufacturing contractor codes

Guidance

G A.3.11.1 Table *14* lists the known wheelset manufacturing contractors' codes with their associated companies and sites. The list exists only as a register of codes to allow identification of wheelsets in accordance with Appendix *A*. The list has been compiled of all known companies and sites with existing codes and inclusion in the list does not imply that a given site is currently operational or that the site has approval or accreditation.

G A.3.11.2 Codes for other companies / sites may be added by revision to this table and can be requested by contacting RSSB through the RSSB Customer Self-Service Portal.

Branding code	Company	Site	Previous name
AB	Wabtec Rail Scotland	Kilmarnock, UK	
AF	Arlington Fleet Services	Eastleigh, UK	
AX	Axiom Rail Ltd.	Stoke, UK	
BT	Bahntechnik Brand-Erbisdorf GmbH	Brand-Erbisdorf, Germany	
BTB	Bahntechnik Brand-Erbisdorf GmbH	Brand-Erbisdorf, Germany	
BTS	Alstom	Siegen, Germany	Bombardier Transportation

Branding code	Company	Site	Previous name
BV	Bochumer Verein Verkehrstechnik GmbH	Bochum, Germany	
CHT	Jinxi Axle Company Ltd.	Shanxi Province, China	
CM	Matisa Materiel Industriel SA	Crissier, Switzerland	
CSC	Comsteel	Waratah, Australia	
CW	Masteel Co. Ltd.	Maanshan City, China	
E6	Wabtec Rail Limited	Doncaster, UK	
FY	Valdunes Dunkerque	Dunkerque, France	
GE	General Electric Traction	Eire, USA	
GHH	Gutehoffnungshutte Radsatz GmbH	Oberhausen, Germany	
JW	Nippon Steel and Sumitomo Metal Corporation	Osaka, Japan	
KLW	KLW Wheelco Interpipe	Dnepropetrovsk, Ukraine	
LCR	Alstom Le Creusot	Le Creusot, France	
LH	LH Group Services	Barton-under-Needwood, UK	
LP	Lucchini Poland	Warszawa, Poland	
LU	Lucchini Sidermeccanica RS SpA, Lovere	Lovere, Italy	
M3	Knorr-Bremse Rail Services (UK) Ltd	Wolverton, UK	Railcare, BRML
M6	Alstom	Crewe, UK	Bombardier Transportation
MAST	MA Steel Rolling Stock Company	Maanshan City, China	
MRF	Standard Forged Products Inc.	Pennsylvania, USA	
MW	MWL Brazil	San Paulo, Brazil	
MWSP	Meridian Rail	Lewiston, USA	
PT	Plasser & Theurer	Linz, Austria	
PU	Pullman Rail	Cardiff, UK	
QW	C.A.F.	Beasain, Spain	

Branding code	Company	Site	Previous name
R & S	Riley and son (E) Ltd.	Bury, UK	
RI	BVV Ilsenburg	Ilsenburg, Germany	
ROB	Robel Bahnbaumaschinen GmbH	Freilassing, Germany	
RR	DCD Ringroller	Vereeniging, South Africa	
SC	Knorr-Bremse RailServices (UK) Ltd	Springburn, UK	
SDRE	South Devon Railway	Buckfastleigh, UK	
SM	Siemens Bogie Service Centre	Lincoln, UK	
SP	Firth Rixson Rings Limited	Rotherham, UK	
SPG	Siemens Mobility	Graz, Austria	
SSD	Standard Steel LLC	Burnham, USA	
SW	SWASAP (PTY) Ltd.	Gauteng, South Africa	
SWG	SWG	Gröditz, Germany	
SWI	Nippon Steel and Sumitomo Metal Corporation	Osaka, Japan	Sumitomo Metal Industries Ltd
TB	Lucchini UK Ltd, Wheel Systems Division	Manchester, UK	Taylor Brothers
TWM	DB Regio Tyne & Wear Ltd	Newcastle, UK	
TZ	Taiyuan Heavy Industries (TYHI)	Taiyuan City, China	
UV	Valdunes Valenciennes	Trith-St-Leger, France	
ZB	BONATRANS GROUP, a.s.	Bohumin, Czech Republic	

Table 14: Manufacturing contractor codes

Appendix B Wheelset and Tread Profile Gauging Systems

B.1 Wheelset and tread profile gauging systems

B.1.1 Gauges that have traditionally been used for checking many of the conditions identified in this document and have a British Rail Catalogue Number (BR Cat No). allocated are identified in the Table below. Figures *21* to *31* inclusive show typical gauges.

B.1.2 Many of the Go / No Go gauges are set at the safety limit and so their use at routine examinations will not ensure that the wheels do not exceed these limits at all times.

B.1.3 Other more recently developed gauging systems that fulfil the requirements of this standard may be available.

B.1.4 The profile machining limit gauges for fitting into the profile sliding gauge assembly BR Cat No. 39/28048 are shown in Table *15*.

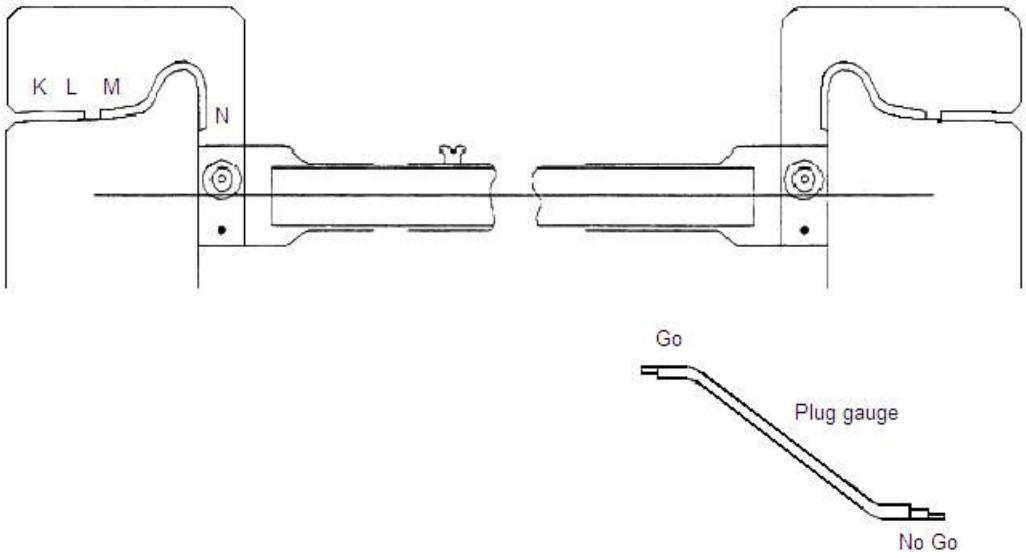

Figure 21: Profile sliding gauge

Gauge type	Tread profile	Drawing No.	Cat. No.
Profile sliding gauge assembly	All	90039352/01	39/28048

Gauge type	Tread profile	Drawing No.	Cat. No.
Profile machining limit gauge (Sliding gauge)	P1	B-A1-002331	39/28045
	P5	B-A1-002334	39/28042
	P6	B-A1-002332	39/28044
	P8	B-A1-002161	39/28047
	P9	B-A1-002295	39/28046
	P10	9007982	39/28051
	P11	9016368	39/28049

Table 15: Sliding profile gauges

B.1.5 Profile machining limit gauges that are handheld directly to the wheel pan and used for checking tread tolerance and permissible flange back wear are shown in Table *16*.

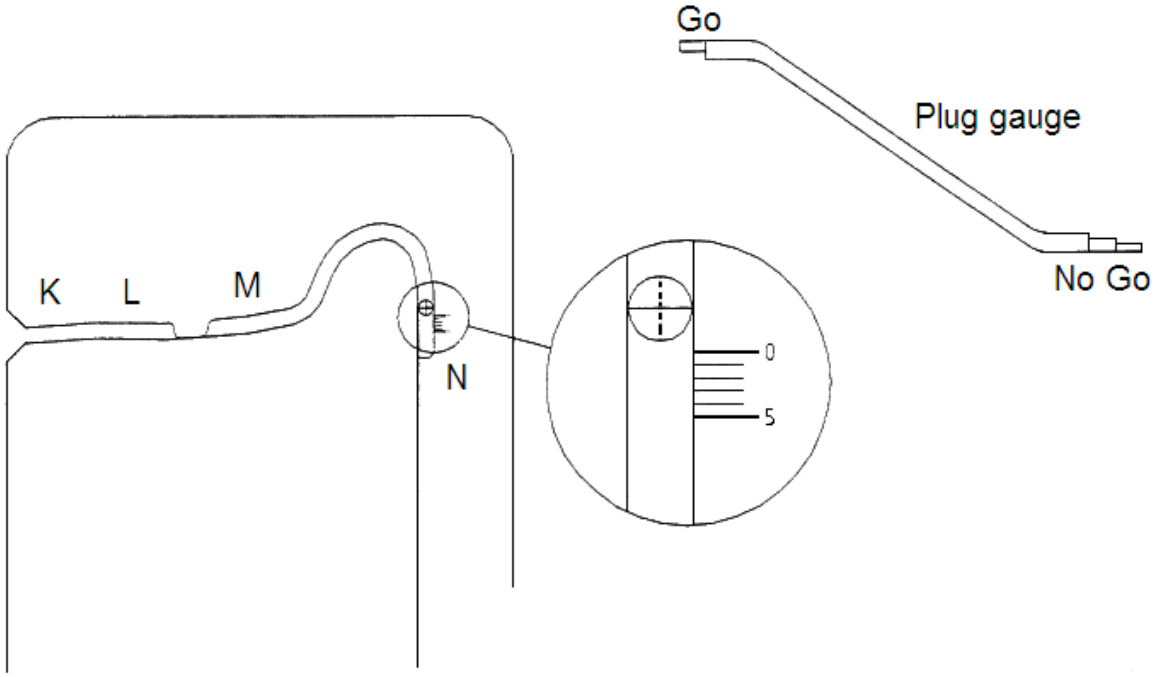

Figure 22: Profile limit machining gauge and plug gauge

Tread profile	Drawing No.	Cat. No.
P1	B-A1-1324/01	39/29823

Tread profile	Drawing No.	Cat. No.
P5	F-A2-4201	39/29792
P6	F-A2-4203	39/29786
P8	L-A1-10593	39/29827
P9	L-A1-10592	39/29825
P10	C1-A1-9007981	39/27968
P11	C1-C1-9016367	39/27972
RD9	B2-C1-9035015	39/29846

Table 16: Profile machining limit gauges

Gauge type	Drawing No.	Cat. No.
Plug gauge	F-A3-4909/01	39/29763
Plug gauge (back flange wear)	B-A1-1324/02	39/29826
Flange height and thickness gauge	F-A2-41	39/29967
Go / No Go back-to-back gauge:		
New and overhauled (1360 to 1362)	B-A1-1286/01	39/29832
Re-profiled (1360 to 1363.3)	B-A1-1286/02	39/28114
Tread diameter comparison gauge	F-S-4545	39/29975
Tyre thickness gauge	F-A2-5748	39/79929
Rim thickness gauge (without magnet)	B2-C1-9038482/02	39/28032
Rim thickness gauge (with magnet)	B2-C1-9038482/03	39/28033

Gauge type	Drawing No.	Cat. No.
Throat thickness gauge 30 mm	F-A2-47/01	39/29968
Throat thickness gauge 36 mm	F-A2-47/02	39/29969
Adjustable throat thickness gauge (P1, P5, P6, P8, P10)	B2-C2-9038488/02	39/28038
Surface finish sample profile	Rubert & Co. No.120	39/29006

Table 17: Other gauges

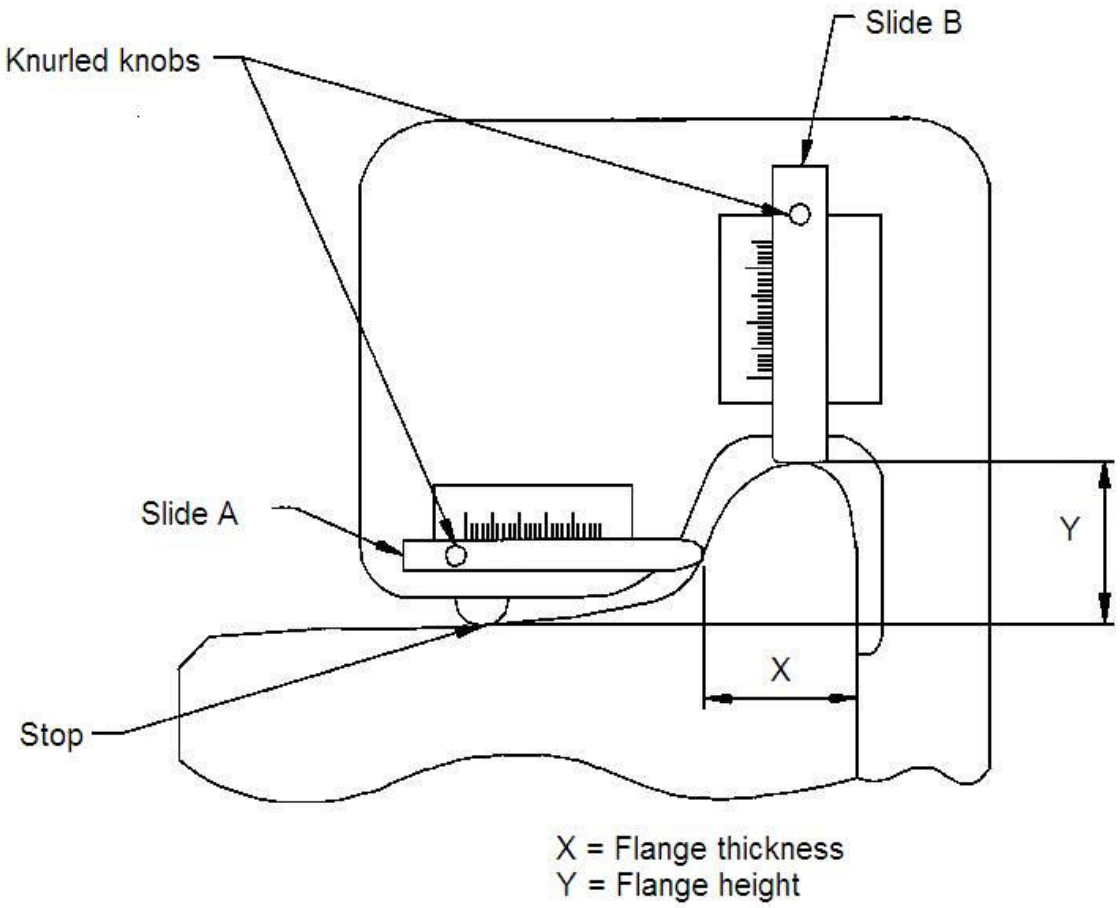

Figure 23: Adjustable flange thickness and height gauge

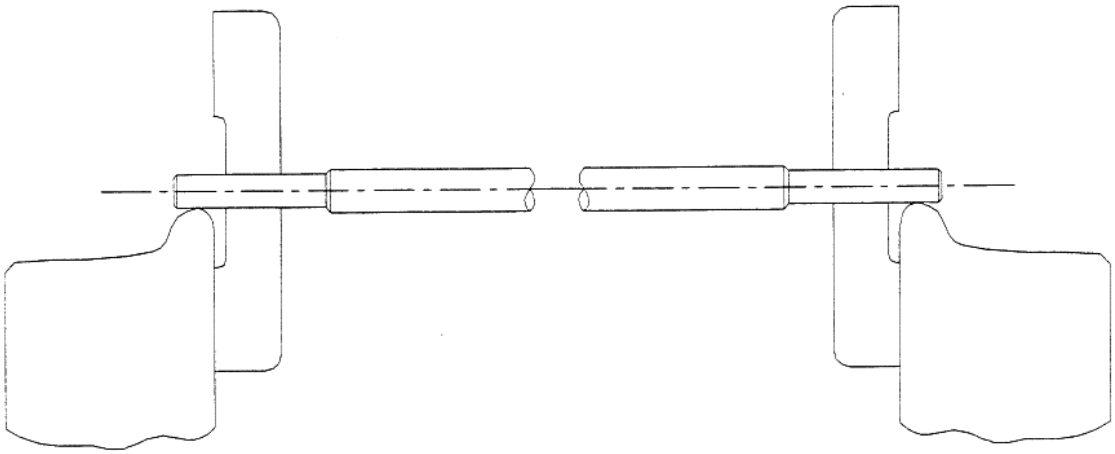

Figure 24: Go / No Go back-to-back gauge

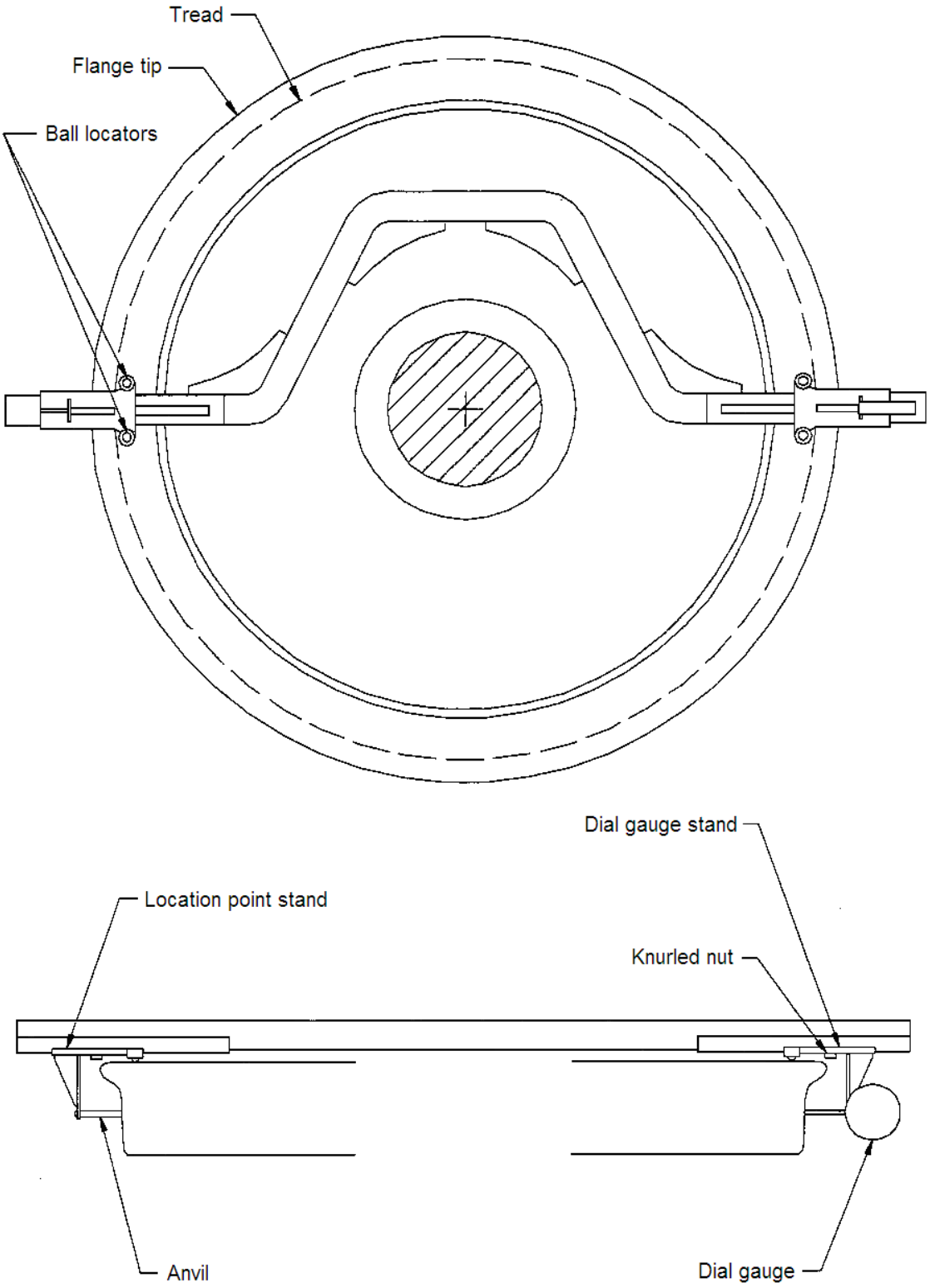

Figure 25: External tread diameter comparison gauge

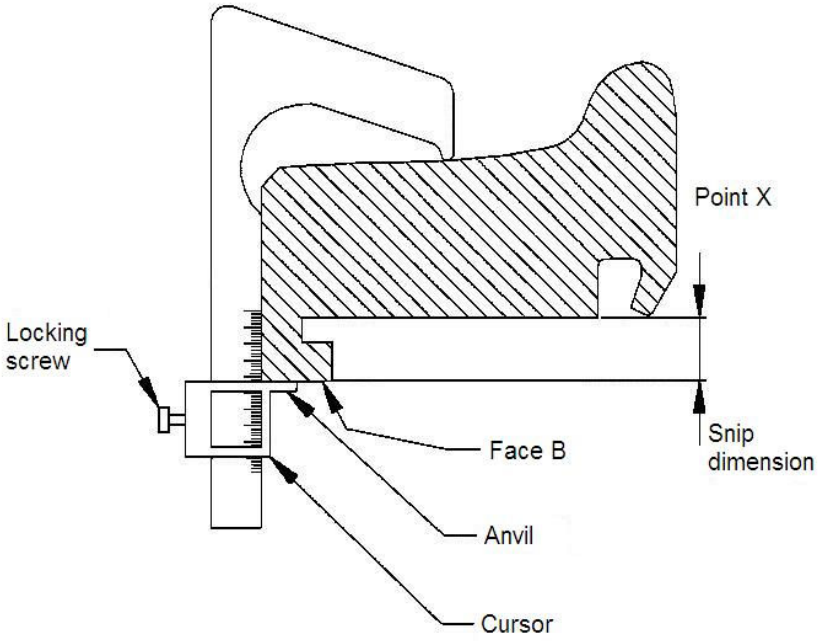

Figure 26: Tyre thickness gauge

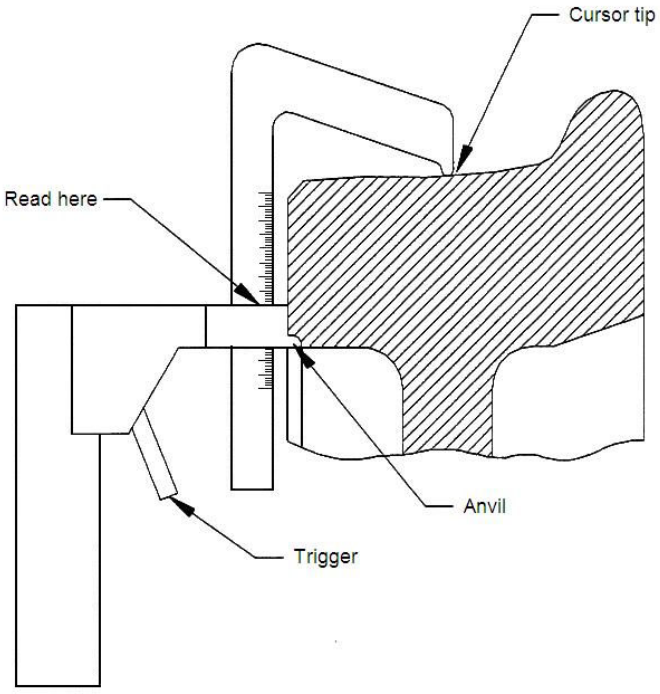

Figure 27: Rim thickness gauge

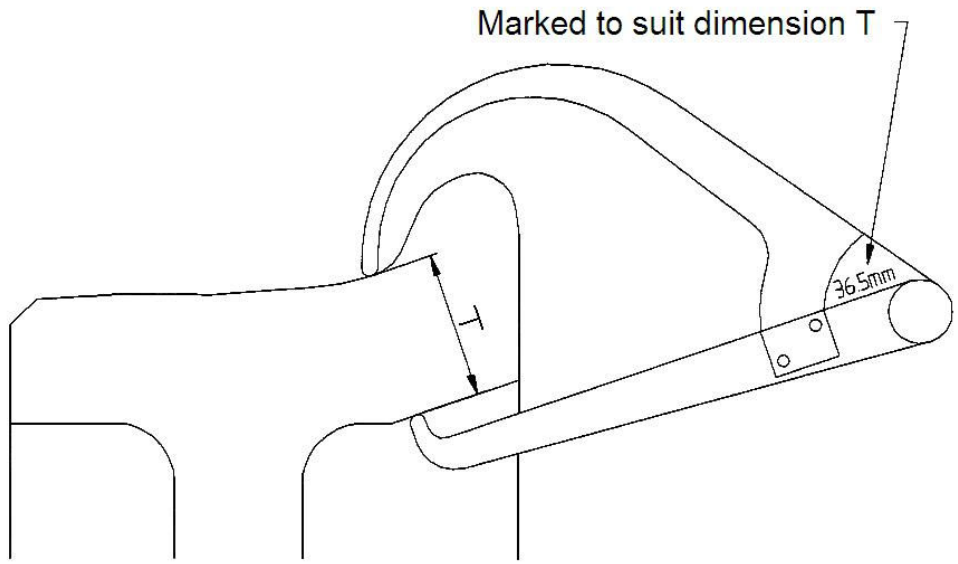

Figure 28: Go / No-Go throat thickness gauge

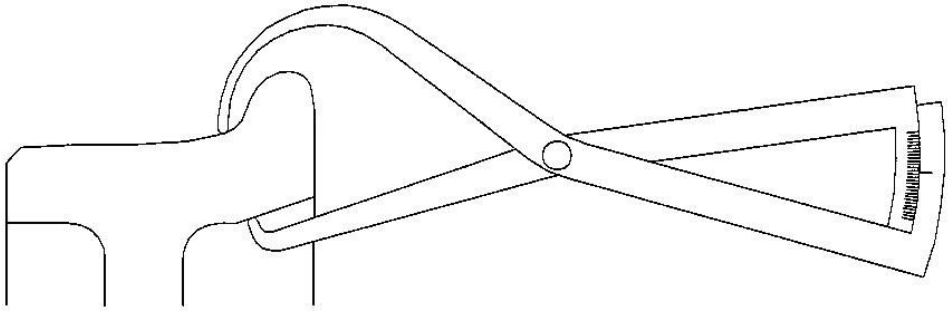

Figure 29: Adjustable throat thickness gauge

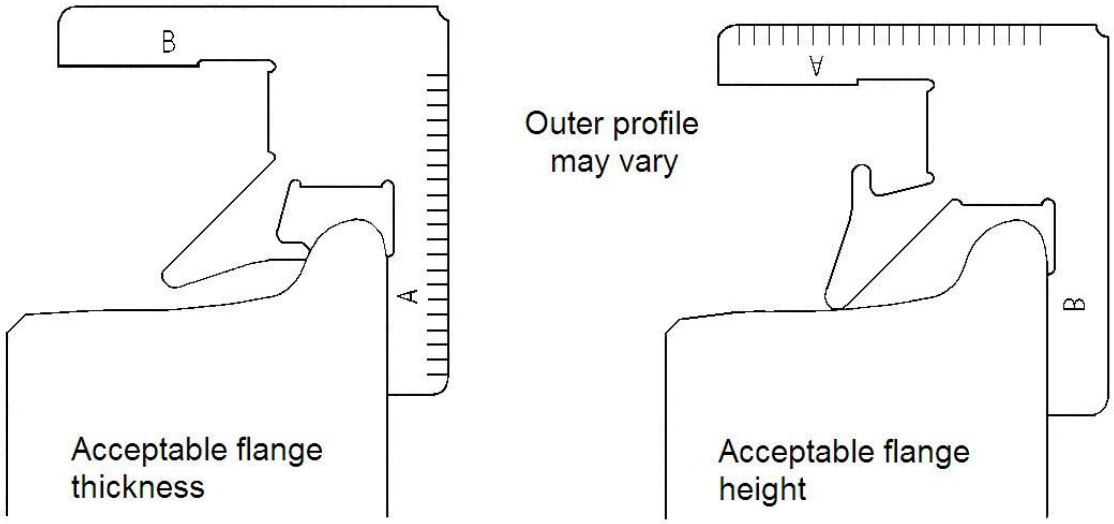

Figure 30: Go / No-Go flange thickness and height gauge

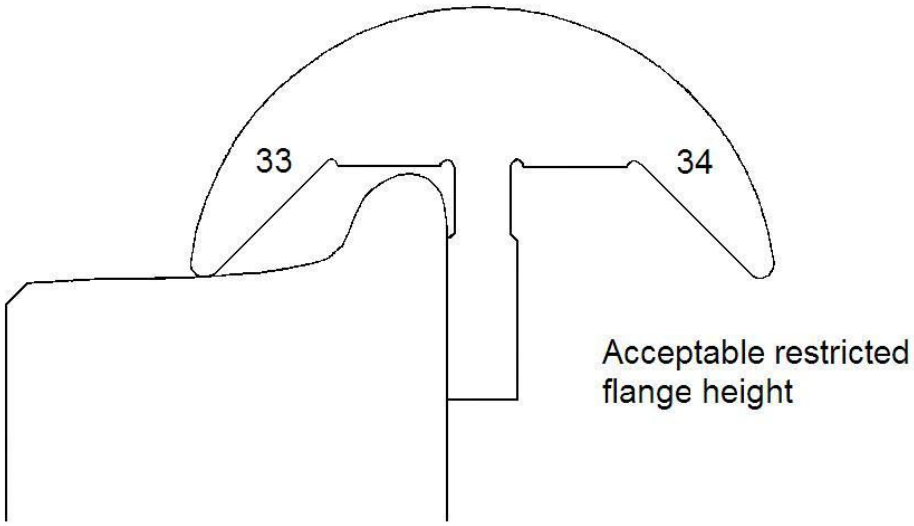

Figure 31: Go / No-Go restricted flange height gauge

Appendix C Wheel Tread Defects

C.1 Wheelset defects

C.1.1 In addition to this appendix, see also BS EN 15313:2016 Annex C which provides numerous examples and illustrations.

C.2 Cracking

C.2.1 Cracking can occur at any position on the wheel surface but is most common in the tread area.

C.2.2 There are three main causes of cracking in the tread:

a) Thermal effects due to tread braking.
b) Rolling contact fatigue.
c) Thermal effects due to sliding.

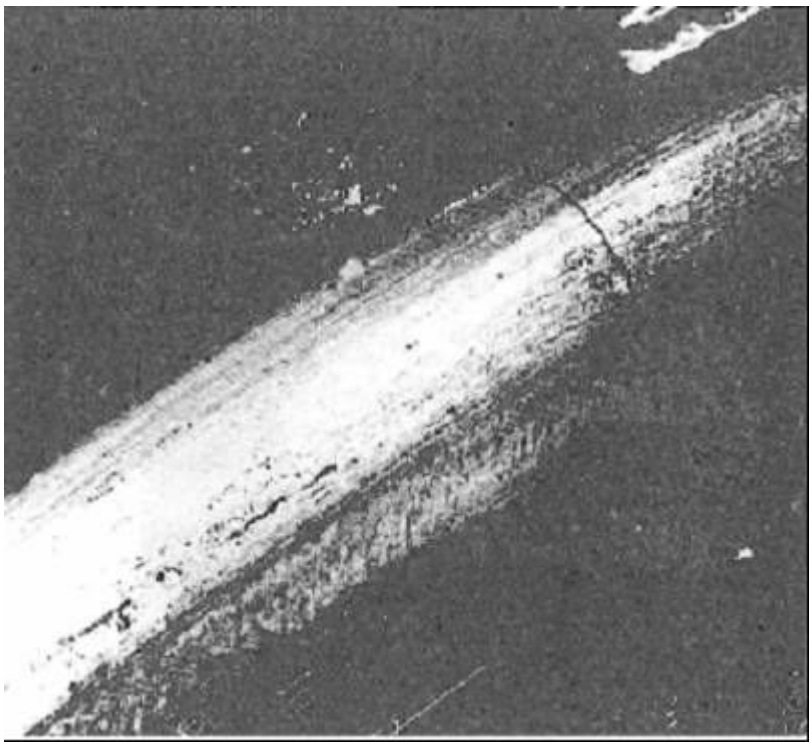

Figure 32: Crack on flange

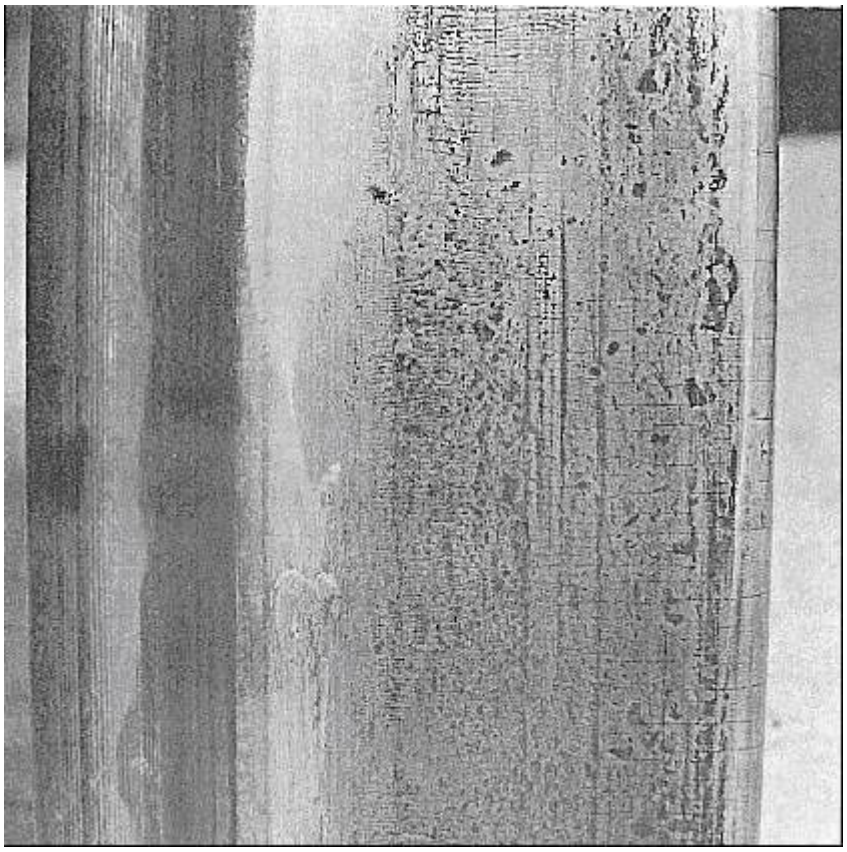

Figure 33: Cracks on wheel tread extending down the chamfer

C.2.3 Thermal cracks will normally be found on the tread where the brake block acts on the tread. Initially, it is seen as a network of fine cracks or 'crazing'. It is similar in appearance to the cracking shown in Figure *33* and is generally disposed laterally across the tread.

C.2.4 Rolling contact fatigue (RCF) occurs due to the repeated loading and unloading of the tread as it both rolls along tangent track and steers around curves. Initially, the damage appears as a network of fine cracks similar in appearance to the thermal effects of tread braking. However, RCF cracks tend to be positioned at an angle across the tread as shown in Figure *34*. Cracking of this type is generally acceptable but it is recommended that regular measurements of the cracks be undertaken to monitor their growth. RCF cracks do not generally result in wheel breakage but will tend to result in the formation of cavities. It is therefore recommended that wheels that exhibit cracks greater than 40 mm long be removed from service for re-profiling.

Figure 34: Light cracking due to RCF

C.2.5 RCF cracks have a tendency to propagate radially and the surface condition may not reflect the crack depth. A typical section through a wheel with RCF cracking is shown in Figure *35*. It can be seen that, although the damage at the tread surface is relatively benign, the cracks extend some way into the rim. It may therefore be prudent to re-profile wheels at regular set intervals, irrespective of the visible surface condition, to avoid the formation of cavities and deep cracks that would necessitate large cuts on a wheel lathe to remove all the cracking.

Figure 35: Section through a wheel with RCF

C.2.6 When a wheel slide occurs, the tread can reach elevated temperatures at the contact patch of slide. Once the wheel starts to rotate again the localised temperature will cool to the wheel bulk temperature. This rapid heating and cooling may result in a change in the steel structure and the formation of martensite. Martensite is very brittle and cracks will be able to develop more readily compared to the unaffected parent material. These cracks will be coarser than those discussed previously and there will probably be a group of them disposed laterally across the tread in the area where the wheel slide occurred. Limited damage of this type is acceptable; that is, up to 40 mm in length, as shown in Figure *36*.

C.3 Cavities

Figure 36: Typical damage associated with a wheel slide showing cracks and spalling

C.3.1 All cracking will eventually lead to the formation of cavities as shown in Figures *36* and *37*. Taking remedial action by re-profiling wheels when the damage is relatively benign may reduce the amount of material that has to be removed to restore the wheel profile. In this way it could be possible to extend the overall wheel life. Scheduling the vehicle on to the wheel lathe due to the presence of cracks may also prevent an out of course machining due to unacceptable cavities.

Figure 37: Long cavity

C.3.2 Limits for cracking in the wheel tread take into account the specific characteristics and application of the wheelset concerned.

C.3.3 It is good practice for wheelsets with integral disc braked wheels to have the friction surfaces examined for thermal cracks as defined by the vehicle maintenance plan.

C.3.4 Further investigation is advisable when a vehicle with cracks exceeding the limit is identified to determine if it is an isolated incident or indicative of a wider problem. Affected wheelsets can be quarantined to preserve the evidence.

C.4 Wheel flats

C.4.1 Under braking or traction where there is insufficient adhesion to allow transmission of the braking and traction force between the wheel and rail, the wheel can 'lock up' and slide under braking, or spin under traction. This can result in the formation of isolated or multiple flats on the wheel surface.

C.4.2 Where an isolated wheel flat is found, as shown in Figure *38*, the length of the flat around the circumference of the tread can be measured, including any regions of discolouration due to heat conditioning. These usually occur on vehicles that do not have a wheel slide protection (WSP) system fitted, or where the WSP system is faulty or inoperative. Where such flats are observed, corresponding damage would be expected to be found on the opposite wheel of the wheelset.

C.4.3 Multiple flats usually occur as a result of the slip / stick type phenomenon seen on early high-speed disc-braked vehicles with a relatively ineffective WSP system. Where

multiple flats within a damaged region are found, as shown in Figure *39*, the lengths of individual flats can be measured.

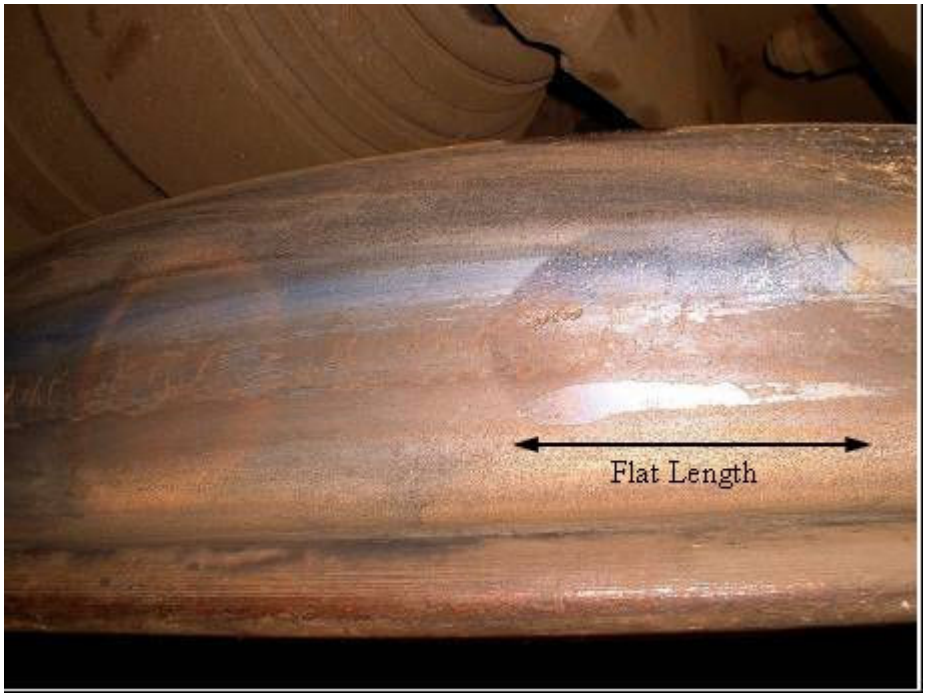

Figure 38: Isolated wheel flat showing measurement of length

Figure 39: Multiple wheel flats

C.4.4 On modern vehicles with a more effective WSP, discernible flats tend not to occur. However, discrete slipping or slides can occur of sufficient duration to generate heat, resulting in localised phase change of the material and the formation of martensite. The martensitic material will eventually fall out leaving a series of small cavities generally arranged circumferentially around an arc of the tread. The cavities can be sufficiently close to become linked if they are allowed to remain in service without remedial action, resulting in a large damaged area on the tread.

C.4.5 Isolated or multiple flats are generally as a result of low adhesion and the lack of a WSP system. Flats on a vehicle fitted with WSP may indicate a WSP system fault. Additionally, but less frequently, wheel flats may be caused by dragging brakes.

C.4.6 Where damage is less than the lower limit no action is required. However, it is suggested that where smaller defects are found, they are monitored and rectified within two weeks. Consideration may also be given to restoring the tread profile at a convenient point as subsequent damage, such as out-of-round or shelling, may result. The most common method for the restoration of the wheel tread profile is by machining on a wheel lathe. However, other methods such as grinding (using purpose-built facilities) are acceptable. Hand techniques are not recommended.

C.5 Tread roll-over (burr)

C.5.1 Tread roll-over is the result of the wheel rolling action squeezing the material at or close to the surface towards the rim face and forming a lip on the outside surface.

Cracks can grow from the flange roll-over and, if propagating into the wheel rim, can rapidly grow under the stresses experienced in the wheel rim and lead to fracture of the wheel and potentially derailment.

C.5.2 An example of tread roll-over in the early stages is shown in Figure *40*.

Figure 40: Tread roll-over

C.6 Flange build-up

C.6.1 See Figures *41* and *42*. This damage usually occurs either:

a) When a vehicle is operating over a route where the curve population is such that the flange spends a considerable amount of time in hard contact with the rail side face; or
b) When the wheel diameters are unequal so that one wheel is constantly making excessive contact with the rail gauge face during steering of the wheelset.

C.6.2 Wear of the back of the flange (flange back wear) can also occur. To avoid excessive removal of wheel material during re-profiling, flange back wear of up to 1 mm is allowed to remain after re-profiling.

Figure 41: Flange toe radius build-up

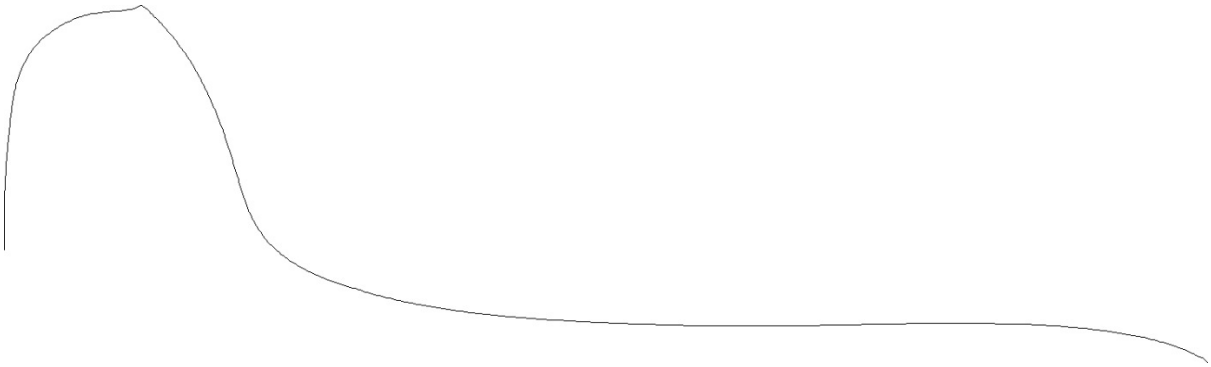

Figure 42: Display of measured wheel profile with flange toe radius build-up

Definitions

axle body run-out	The total radial displacement measured at the centre of the axle when it is rotated on rollers supporting the wheelset bearing journals.
axlebox	The structure, including cartridge bearing adaptor, which houses, or is in contact with, the axle journal bearing and provides an interface with the bogie and/or suspension arrangement.
Cold Stamping	Alpha-numeric stamping performed on the component whilst it is at ambient temperature.
cold stamping	Alpha-numeric stamping performed on the component whilst it is at ambient temperature.
Defect	Any fault(s) in a component, or assembly, which may prevent the component, or assembly, from fulfilling its design purpose.
defect	Any fault(s) in a component, or assembly, which may prevent the component, or assembly, from fulfilling its design purpose.
design life	The total time or distance over which a wheelset is intended to provide a defined standard of performance while subject to a pre-defined regime of maintenance, repair and overhaul.
Economic Tread Turning (ETT)	The practice of re-profiling wheels to the design profile using a thinner flange within wear limits for that profile to extend the useful life of a wheelset
freight vehicle or wagon	Vehicles designed and used for carrying payloads which do not include people.
hollow axles	An axle that has a hole through its centre. Such axles may be tested to a routine, internal, non-destructive testing process.
infrastructure manager (IM)	Has the meaning given to it in the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (as amended), but is limited to those infrastructure managers who hold a safety authorisation issued in respect of the mainline railway. Source: *ROGS*
inspect/inspection	Check condition or conformity of a component or system, typically by visual methods.
interference fit	The shrink or press fit between a wheel centre and a tyre or between the axle and any item, other than a wheelset bearing.
magnetic particle inspection (MPI)	A method of detecting surface, or near surface, discontinuities in magnetisable materials by the generation of a magnetic flux within the material and the application of suitable ferromagnetic particles to the surface, so as to render the discontinuity visible.
maintenance	The routine process of examination, inspection, measurement and lubrication which, together with the completion of identified

	repairs, ensures the wheelset remains safe throughout its current service life.
manufacture	All the processes and assembly operations which culminate in the production of a completely new wheelset.
monobloc wheel	A wheel comprising a hub, a wheel web and rim with the full wheel tread profile manufactured from a single piece of steel as a single entity.
non-destructive testing (NDT)	The process of examination of a component to enable its integrity to be assessed by a means which does not compromise the service life or the design life of the component.
overhaul	Any attention given to the wheelset when it is removed from a vehicle or bogie and when an interference fit is broken (excluding the removal of axle journal bearings).
personnel vehicles	Vehicles used for the carriage of non-operational staff, including contractors.
power cars	A non-passenger vehicle which provides, as its principal function, traction power for a trainset of which it is an integral part.
railway undertaking (RU)	Has the meaning given to the term 'transport undertaking' in the Railways and Other Guided Transport Systems (Safety) Regulations 2006 as amended, but is limited to any private or public undertaking the principal business of which is to provide rail transport services for goods and/or passengers, with a requirement that the undertaking must ensure traction. Source*: ROGS*
repair	The physical attention given to the wheelset to enable it to remain safe throughout its current service life. Such attention does not require the breaking of any interference fit. Re-profiling of wheel treads is not deemed to be a wheelset repair.
retaining ring (Gibson ring)	A split ring of material used to retain the tyre on the wheel centre.
roll-over	A burr of extruded material forming on the outer rim side of the wheel during service by plastic deformation.
rolling contact fatigue	A series of fine, typically closely spaced cracks in the centre of the wheel tread which eventually form a complete circumferential band of cracks but may be more extensive.
service life	The time or distance over which a wheelset safely continues to meet defined technical standards before overhaul is required.
tread run-out	The total radial displacement measured at the wheel tread when the wheelset is rotated on rollers supporting the wheelset bearing journals.
tyred wheel	A wheel which comprises at least a wheel centre and a separately manufactured tyre.

Union Internationale des Chemins de Fer (UIC)	Railway standards organisation now known as The Worldwide Railway Organisation.
ultrasonic testing	A process in which high frequency sound waves are transmitted through materials such that the reflections can be analysed to find imperfections in the material. Ultrasonic axle testing (UAT) is when the process is applied to railway axles.
wheel centre	The wheel hub, web and rim on which a tyre is fitted.
wheel wobble	The total axial displacement (run-out) of the internal wheel face when the wheelset is rotated, measured at the flange back, measured at 60 mm beneath the flange tip.
wheelset	A complete unit comprising an axle and two complete wheels together with any gear wheels, brake discs, etc, but without axle bearings and their end caps, spacers, seals and other associated fittings. The wheels may be either tyred or monobloc.
wheelset component	These are the individual element(s) that when assembled in accordance with the requirements of the requisite standards produce a wheelset. The constituent components vary for different types of wheelset but typically comprise; axle, monobloc wheel, (or wheel centre, tyre, retaining ring), gear wheel, brake disc, etc.
wheelset database	A documented, maintained set of up-to-date data for each wheelset design, and each type of vehicle.

References

The Standards Catalogue gives the current issue number and status of documents published by RSSB. This information is available from http://www.rssb.co.uk/railway-group-standards.

RGSC 01	Railway Group Standards Code
RGSC 02	Standards Manual

Documents referenced in the text

Railway Group Standards

GMRT2100	Requirements for Rail Vehicle Structures
GMRT2466	Railway Wheelsets

RSSB Documents

RIS-2004-RST	Rail Vehicle Maintenance
RIS-2700-RST	Rail Industry Standard for Verification of Conformity of Engineering Change to Rail Vehicles
RIS-2701-RST	Rail Industry Standard for NDT Processes on Rail Vehicles
RIS-2702-RST	In-Service Examination and Reference Limits for Freight Wagons
RIS-2704-RST	Rail Industry Standard for Wheelsets Handling and Storage
RIS-2709-RST	Rail Industry Standard for the Identification of Roller Bearings Defects
RIS-2780-RST	Rail Vehicle Structures
RIS-8250-RST	Reporting High Risk Defects
T641 RSSB (2008)	Cost effective turning of flange worn wheel profiles
T774 RSSB (2017)	Axle End Re-Assembly Human Factors Guidance
T963 RSSB (2013)	Improving wheelset life by better understanding the causes of wheel damage
T1223 RSSB (2022)	Wheelset Coating Systems and Good Practice Guidance: Technical Guidelines for Wheelset Coating

Other References

BASS 503	Design Guide for the Calculation of Stresses in Axles Driven by Axle Hung Traction Motors
BASS 504	Design Guide for the Calculation of Stresses in Non-Driving Axles
BS 5892-1:1992+A3:2009	Railway rolling stock materials — Part 1: Specification for axles for traction and trailing stock

BS 5892-2:1992	Railway rolling stock materials — Part 2: Specification for forged and rolled wheel centres
BS 5892-3:1992+A2:2009	Railway rolling stock materials — Part 3: Specification for monobloc wheels for traction and trailing stock
BS 5892-4:1992	Railway rolling stock materials — Part 4: Specification for forged and rolled tyres
BS 5892-5:1987+A2:2008	Railway rolling stock materials — Part 5: Specification for steel bars for retaining rings for tyred wheels
BS 5892-6:1992	Railway rolling stock materials — Part 6: Specification for wheelsets for traction and trailing stock
BS 5892-7:2014	Railway rolling stock materials — Part 7: Specification for product and technical approval requirements for cast wheels
BS 5892-8:2012	Railway rolling stock materials — Part 8: Railway applications — Wheelsets and bogies — Powered and non-powered wheelsets with inboard bearings — Product requirements
BS 8535:2011	Railway applications. Wheelsets and bogies. Powered and non-powered axles with inboard bearings. Design method
BS EN 13103:2009+A2:2012	Railway applications. Wheelsets and bogies. Non powered axles. Design method (withdrawn)
BS EN 13103-1:2017	Railway applications. Wheelsets and bogies - Design method for axles with external journals
PD CEN/TS 13103-2:2020	Railway applications. Wheelsets and bogies - Design method for axles with internal journals
BS EN 13104:2009+A2:2012	Railway applications. Wheelsets and bogies. Powered axles. Design method (withdrawn)
BS EN 13260:2020	Railway applications. Wheelsets and bogies. Wheelsets. Product requirements
BS EN 13261:2020	Railway applications. Wheelsets and bogies. Axles. Product requirements
BS EN 13262:2020	Railway applications. Wheelsets and bogies. Wheels. Product requirements
BS EN 13715:2020	Railway applications. Wheelsets and bogies. Wheels. Tread profile
BS EN 13749:2021	Railway applications. Wheelsets and bogies. Method of specifying the structural requirements of bogie frames
BS EN 13979-1:2020	Railway applications. Wheelsets and bogies. Monobloc wheels. Technical approval procedure. Forged and rolled wheels
BS EN 15313:2016	Railway applications. In-service wheelset operation requirements. In-service and off-vehicle wheelset maintenance
BS EN 15827:2011	Railway applications. Requirements for bogies and running gears

BS EN ISO 10012:2003	Measurement management systems. Requirements for measurement processes and measuring equipment
BS EN ISO 1302:2002	Geometrical product specifications (GPS). Indication of surface texture in technical product documentation
BS ISO 281:2007	Rolling bearings. Dynamic load ratings and rating life
INF NTSN	Infrastructure National Technical Specification Notice (INF NTSN). Published by the Secretary of State on 1 January 2021 pursuant to regulation 3B of the Railways (Interoperability) Regulations 2011. This NTSN replaces and substantially reproduces the provisions of Commission Regulation (EU) 1299/2014 of 18 November 2014 (the INF TSI) and includes relevant amendments made by Commission Implementing Regulation (EU) 2019/776 which came into force in June 2019.
IRR 110/145	Institute of Rail Research report on Economic Tyre Turning: Wheel Wear Predictions
LOC&PAS NTSN	Locomotive and Passenger National Technical Specification Notice (LOC&PAS NTSN). Published by the Secretary of State on 1 January 2021 pursuant to regulation 3B of the Railways (Interoperability) Regulations 2011. This NTSN replaces and substantially reproduces the provisions of Commission Regulation (EU) 1302/2014 (the LOC&PAS TSI), and includes relevant amendments made by Commission Implementing Regulation (EU) 2018/868 of 13 June 2018, and Commission Implementing Regulation (EU) 2019/776 which came into force in June 2019.
M-107/M-208	AAR Manual of Standards and Recommended Practices - Wheels, Carbon Steel
UIC 510-2	Trailing stock: wheel and wheelset, condition concerning the use of wheel of various diameters
UIC 813	Technical specification for supply of wheelsets for traction and trailing stock – tolerances and assembly
WAG NTSN	Rolling Stock (Freight Wagons) National Technical Specification Notice (WAG NTSN). Published by the Secretary of State on 1 January 2021 pursuant to regulation 3B of the Railways (Interoperability) Regulations 2011. This NTSN replaces and substantially reproduces the provisions of Commission Regulation (EU) 321/2013 of 13 May 2013 (the WAG TSI), and includes relevant amendments made by Commission Regulation (EU) 1236/2013 of 2 December 2013 and Commission Implementing Regulation (EU) 2019/776 which came into force in June 2019.