Railway Group Standard
GMRT2466
Issue: 5 **Draft:** Draft 3
Date: March 2023

Railway Wheelsets

Synopsis

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

Published by RSSB

Issue Record

Issue	Date	Comments
One	June 2003	Original document, superseded: GMT0083 issue one, GMTT0089 issue one, GMTT0120 issue one, GMRT2020 issue one, GMRT2023 issue one, GMRT2025 issue two, GMRT2026 issue two, GMRT2027 issue one, GMRT2028 issue one and GMRT2451 issue one, including compliance dates.
Two	August 2008	Supersedes issue one.
Three	February 2010	Replaces issue two. Small scale change amendment – addition to Table 1 and associated note, together with new clause 2.9.3, correction of reference in 4.9.1.1, revision of 4.18.1, addition of new clause 4.18.2 (following clauses re-numbered), revised drawing number in Table A.1 in Appendix A, new Appendix D and note to identify where drawings can be obtained.
Four	December 2017	Supersedes issue three. Re-written to explicitly define National Technical Rules only. The remainder of the content from issue three has been transferred to RIS-2766-RST issue one.
4.1	07/12/2019	Supersedes issue four. Table 3, Flange height and thickness by tread profile, and Table 39, ETT calculated tread profiles have been clarified to address misinterpretation of 'as new, maximum' column heading. The 'as new, maximum' flange width defined the full width size of the design profile and was not intended to prevent the increase in measured flange width.
Five	March 2023 [Proposed]	Supersedes issue 4.1. References to TSIs replaced by NTSNs Referenced documents updated, maximum in-service flange thickness limits set with guidance to explain why and how they are applied.

Revisions have been marked by a vertical black line in this issue except where "TSI" has only been replaced by "NTSN".

Superseded Documents

The following Railway Group Standard is superseded, either in whole or in part as indicated:

Superseded documents	Sections superseded	Date when sections are superseded
GMRT2466 issue 4.1 Railway Wheelsets	all	June 2023 [Proposed]

Supply

The authoritative version of this document is available at www.rssb.co.uk/standards-catalogue. Enquiries on this document can be submitted through the RSSB Customer Self-Service Portal https://customer-portal.rssb.co.uk/

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Part 1 Purpose and Introduction

1.1 Purpose

1.1.1 This document sets out requirements that meet the characteristics of national technical rules (NTRs) and are applicable to the Great Britain (GB) mainline railway system. Compliance with NTRs is required under the Railways Interoperability Regulations 2011 (as amended).

1.2 Introduction

Principles

1.2.1 The requirements of this document are based on the principles described below.

1.2.2 The NTRs in this document are used for the following purposes:

a) To fill identified open points in NTSNs.
b) To support UK specific cases in NTSNs.
c) To identify and specify alternatives permitted by NTSNs.
d) To set out requirements to maintain compatibility between existing subsystems and / or vehicles that do not conform to the requirements in NTSNs and new, upgraded or renewed subsystems and / or vehicles conforming to NTSNs.

1.2.3 The principal requirements for wheelsets are set out in the Locomotive and Passenger Rolling Stock (LOC&PAS) and Freight Wagon (WAG) NTSNs, and the NTSNs which apply in the following contexts:

a) LOC&PAS NTSN:

i) Equivalent conicity requirements for wheel profiles are set out in LOC&PAS NTSN clause4.2.3.4.3.

ii) Geometrical and conformity assessment requirements for wheelsets, axles and wheels are set out in LOC&PAS NTSN clause 4.2.3.5.2.

iii) For conventional wheelsets with outside journals, the LOC&PAS NTSN requires the application of EN 13103, EN 13104 and EN 13979-1.

iv) The LOC&PAS NTSN assumes the wheel profiles set out in EN 13715 are used, for which there is a presumption of conformity for the equivalent conicity requirements. LOC&PAS NTSN clause 6.2.3.6 (Design values for new wheel profiles) states: *'The requirements for this clause are deemed to have been met by wheelsets having unworn S1002 or GV 1/40 profiles, as defined in the specification referenced in Appendix J-1, index 86 with spacing of active faces between 1420 mm and 1426 mm'*. (Appendix J-1 index 86 is EN 13715).

v) For wheelsets, axles and axle boxes / bearings manufactured according to an existing design, RIS-2766-RST may be applied as permitted by LOC&PAS NTSN clause 6.2.3.7 (8).

b) WAG NTSN:

i) Dimensional characteristics for wheelsets are defined in WAG NTSN clause 4.2.3.6.2.

ii) Dimensional characteristics for wheels are defined in WAG NTSN clause 4.2.3.6.3.

iii) Conformity requirements are defined in WAG NTSN clauses 6.1.2.2, 6.1.2.3 and 6.1.2.4.

iv) For conventional wheelsets with outside journals, the WAG NTSN mandates the application of EN 13103, EN 13260, and EN 13979-1.

v) The WAG NTSN clause 4.2.3.5 specifies dynamic stability requirements, including the application of EN 14363, which affects the choice of wheel profiles. EN 14363 assumes EN 13715 S1002 profiles are the default case but does not exclude other profiles.

Structure of this document

1.2.4 Where relevant, the national technical rules relating to relevant NTSN parameters have been identified together with the relevant clause from the NTSN.

1.2.5 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'.

1.2.6 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'.

Related requirements in other documents

1.2.7 GMRT2400 Engineering Design of On-track Machines in Running Mode requires compliance with this standard.

1.2.8 The INF NTSN specific case 7.7.17.4 identifies this standard as anNTR relating to NTSN point 4.2.5.3 (Maximum unguided length of fixed obtuse crossings) and Appendix J (Safety assurance over fixed obtuse crossings).

Supporting documents

1.2.9 The following Rail Industry Standards support this RGS:

a) RIS-2766-RST Railway Wheelsets.
b) RIS-2701-RST Rail Industry Standard for NDT Processes on Rail Vehicles.
c) RIS-2702-RST In-Service Examination and Reference Limits for Freight Wagons.
d) RIS-2704-RST Rail Industry Standard for Wheelsets Handling and Storage.
e) RIS-2709-RST Rail Industry Standard for the Identification of Roller Bearing Defects.

1.2.10 Much of the content of RIS-2766-RST issue one was derived from the content removed from GMRT2466 issue three.

1.3 Approval and Authorisation

1.3.1 The content of this document will be approved by the Rolling Stock Standards Committee on 9 December 2022 [proposed].

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

Part 2 GB Requirements for Wheelsets

2.1 Wheelsets in scope of NTSNs but restricted to national use

2.1.1 Wheel tread profiles shall be selected from and conform to:

a) BS EN 13715:2020; or
b) An established Great Britain (GB) profile defined in Appendix *A.2* ; or
c) A newly defined profile in accordance with *3.1* of this document.

2.1.2 The wheel rim width for wheelsets restricted to national use shall be in the range 127 mm to 150 mm.

2.1.3 If cast wheels are used, their design and manufacture shall conform to BS 5892-7:2014.

Rationale

G 2.1.4 The specific cases in the NTSNs permit the use of alternative profiles if defined within NTRs. These may be established GB wheel tread profiles or alternatives demonstrated to achieve a similar level of running integrity. The objective is to ensure that the permitted options and potential limitations to use are correctly identified.

Guidance

G 2.1.5 Profiles compliant with *2.1.1 b)* and *2.1.1 c)* are designated within this document as 'GB tread profiles'.

G 2.1.6 LOC&PAS NTSN 7.3.2.6 states '*UK Specific case (Great Britain) ('P') It is permissible for the geometrical dimensions of the wheels to alternatively be established in accordance with the national technical rule notified for this purpose. This specific case does not prevent the access of NTSN compliant rolling stock to the national network*'.

G 2.1.7 For vehicles restricted to national use, wheels that do not conform to BS EN 13979-1 may be used, as specified in the LOC&PAS NTSN.

G 2.1.8 LOC&PAS NTSN 6.1.3.1 (3) states '*Other types of wheels are permitted for vehicles restricted to national use. In that case the decision criteria and the fatigue stress criteria shall be specified in national rules.*' This exemption permits the use of cast wheels.

G 2.1.9 In addition, WAG NTSN 6.1.2.3 b) states '*Other types of wheels are permitted for units in national use. In that case the decision criteria and the fatigue stress criteria shall be specified in national rules.*'

G 2.1.10 WAG NTSN (4.2.3.6.3 table 4) specifies an in-service wheel width of 133 mm to 140 mm, and the LOC&PAS NTSN (4.2.3.5.2.2 table 2) specifies an in-service wheel width of 130 mm to 146 mm. Both are based on a maximum burr width of 5 mm and nominal rim widths of 135 mm or 140 mm as specified in BS EN 13715.

G 2.1.11 WAG NTSN 7.3.2.5, against clause 4.2.3.6.2, states '*UK Specific case (Great Britain) ('P') For units intended to operate solely on the railway network of Great Britain the characteristics of the wheelsets may be in accordance with the national technical* *rules notified for this purpose*'. There is not an equivalent specific case for the LOC&PAS NTSN.

G 2.1.12 WAG NTSN 7.3.2.5, against clause 4.2.3.6.3, states '*UK Specific case (Great Britain) ('P') For units intended to operate solely on the railway network of Great Britain the characteristics of the wheels may be in accordance with the national technical rules notified for this purpose*'.

G 2.1.13 The WAG NTSN sets out requirements for the characteristics of wheelsets (4.2.3.6.2), wheels (4.2.3.6.3) and axles (4.2.3.6.4). While axles are normally essential parts of wheelsets, there is not a specific case for them against clause 4.2.3.6.4 and therefore axles are required to conform to the WAG NTSN.

2.2 Wheelsets outside the scope of the ENs mandated by NTSNs

Guidance

G 2.2.1 LOC&PAS NTSN 6.2.3.7 (7) states '*It is permitted to use other standards where the EN standards do not cover the proposed technical solution*'.

G 2.2.2 Examples of wheelsets outside the scope of the ENs mandated by the NTSNs are:

a) Inside journal wheelsets.
b) Wheelsets with independently rotating wheels, with or without a conventional axle.
c) Variable gauge wheelsets.

G 2.2.3 The most common example where alternative standards are required is for inside journal wheelsets, and for their design and manufacture application of the GB standards set out below is deemed to be NTSN compliant:

a) Axle design BS 8535, manufacture BS EN 13261.
b) Wheel design BS EN 13979-1, manufacture BS EN 13262.
c) Wheelset assembly BS 5892-8.

G 2.2.4 The WAG NTSN does not explicitly acknowledge the possibility of inside journal axles for wagons. However, BS 8535 satisfies the requirements set out in WAG NTSN 6.1.2.4 subject to the application of the criteria specified in clause 7 of BS EN 13103 if these are more stringent than the equivalent criteria in BS 8535.

G 2.2.5 WAG NTSN 6.1.2.4 states '*... the demonstration of conformity of the mechanical resistance and fatigue characteristics of the axle shall be based on clauses 4, 5 and 6 of EN 13103:2009+A2:2012… The decision criteria for the permissible stress are specified in clause 7 of EN 13103:2009+A2:2012*'.

G 2.2.6 Any other wheelset design that does not fall within the scope of the applicable NTSN is expected to conform, as far as practicable, with European, British, American or International standards. Where, due to the features of the particular wheelset, alternative methods are required, these are expected to be supported by technical arguments to demonstrate that an equivalent level of integrity with conventional wheelsets is achieved.

2.3 Existing wheelset designs for new wagons

Guidance

G 2.3.1 To clarify where a new or modified design of vehicle can use existing wheelset design without undertaking the validation required for a new design, existing wheelset designs that conform to the criteria set out below are deemed to satisfy the requirements set out in WAG NTSN 6.2 which states for axles '*… the demonstration of conformity of the mechanical resistance and fatigue characteristics of the axle shall be based on clauses 4, 5 and 6 of EN 13103:2009+A2:2012. The decision criteria for the permissible stress are specified in clause 7 of EN 13103:2009+A2:2012…*'.

G 2.3.2 The following conditions apply to any existing wheelset design to be considered suitable on new vehicles for national use without re-qualification:

a) The design has been previously accepted for use and has an established service history on the GB rail network.
b) The wheelset was designed in accordance with BASS 504 and is manufactured in accordance with all relevant parts of BS 5892 or was designed and manufactured according to the AAR Manual of Standards and Recommended Practices, Part G.
c) The maximum stresses do not exceed the limiting values specified in BS EN 13103.
d) The wheelset loading is not increased.
e) The wheelset materials are not changed unless an improvement in properties can be demonstrated.
f) The braking arrangement and thermal loads are not changed (for example, tread braking duty).
g) The maximum operational speed is not increased.

G 2.3.3 Additional qualification would be required according to the standards applied for the original approval of the design if:

a) The wheelset loading is increased.
b) The wheelset materials are changed (unless an improvement in properties can be demonstrated).
c) The braking arrangement and thermal loads are changed (for example, tread braking duty).
d) The maximum operational speed is increased.

G 2.3.4 The earlier GB BASS design codes address static, dynamic, fatigue and braking loadings using similar methodologies and apply the same engineering principles to geometric transitions and fatigue stresses. It is therefore deemed that such axle designs can be considered to be 'based' on the requirements set out in BS EN 13103.

G 2.3.5 AAR axles are presented as standard designs rather than derived from design rules and represent well-established evolved designs with substantial service experience and, where use has been established under GB conditions, can also be considered to be consistent with, and therefore 'based' on, BS EN 13103.

G 2.3.6 The stress limits are evaluated according to the requirements set out in BS EN 13103 clause 7 and Annex D.

G 2.3.7 When the axle design uses steel A1N or A1T as specified in BS 5892-1, grades EA1N and EA1T may be substituted.

Part 3 Requirements for GB Tread Profiles and Wheelset Geometry

3.1 Newly defined GB tread profile design

3.1.1 In the case of a profile not defined in BS EN 13715:2020 or Appendix *A*:

a) The nominal flange angle shall be in the range 68° to 70°.
b) The flange tip to flange back geometry shall form a smooth convex curve free of irregularities and steps.
c) The flange toe profile shall form a smooth convex curve free of irregularities and steps.
d) Any geometry resulting in a curve radius of less than 10 mm shall be subject to simulation, tests and trials to demonstrate its ability to operate safely and properly over the infrastructure with which it is to be compatible.
e) Conformity shall be demonstrated to the requirements for either:
   i) Equivalent conicity as required by the LOC&PAS NTSN (ref 4.2.3.4.3); or
   ii) Dynamic running behaviour as required by WAG NTSN (ref 4.2.3.5.2).
f) The proposer of the new tread profile design shall obtain a Summary of Compatibility from the infrastructure manager.
g) Wear limits shall be defined to ensure acceptable dynamic running behaviour during the life of the wheel.

Rationale

G 3.1.2 The GB specific cases in the NTSNs permit the use of alternative profiles if defined within NTRs. These may be established GB wheel tread profiles or alternatives demonstrated to achieve a similar level of running integrity. The objective is to ensure that the permitted options and potential limitations to use are correctly identified.

G 3.1.3 For wheelsets restricted to national use the available choices allow optimisation of the vehicle / track interface and wheelset maintenance for particular national conditions. Wheel tread profiles have continued to evolve to optimise dynamic behaviour, and life in terms of wear and contact fatigue, and this clause is intended to support further development.

Guidance

G 3.1.4 These newly defined profiles are designated within this document as 'GB tread profiles' along with established GB profiles defined in *2.1.1 b)* / Appendix *A*.

G 3.1.5 Wheel tread profiles are required to satisfy the conicity requirements set out in the NTSN or conform to NTRs. The characteristics of the wheel / rail interface, vehicle suspensions and dynamics, and wheel / rail wear and maintenance affect tread profile choice.

G 3.1.6 The following factors affect the choice of tread profile:

a) Maintaining vehicle stability on the intended route.
b) The propensity of the profile to initiate rolling contact fatigue, in wheel and rail.
c) Changes in the suspension characteristic throughout its service life.
d) The range of vehicle load conditions.

e) Wheel / rail contact stress levels.
f) Track circuit actuation.

G 3.1.7 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 3.1.8 Some of the early GB tread profiles have flange angles lower than specified in this document, such as the P5 profiles where 60° is used. These were developed to address ride problems of specific suspensions types prevalent at the time.

G 3.1.9 Flange back radius and flange toe radius have historically been profiled to simple radii of 10 mm minimum. Modern computer-controlled wheel lathes can produce any shape of profile, including complex variable radius curves. The P12 profile has a flange back radius of 9.52 mm.

G 3.1.10 The 'Summary of Compatibility' is a document that Network Rail can provide when it is responding as an affected party. RIS-8270-RST sets out requirements and responsibilities for the assessment of technical compatibility at route level for vehicles and infrastructure.

3.2 Wheelset geometry

3.2.1 The back-to-back dimension of wheelsets using a tread profile in accordance with Appendix *A* or a new profile compliant with the rules set out in *3.1*, shall be within the range defined in Table *1*.

Wheelset type	Dimension range
All new, re-wheeled or re-tyred wheelsets with outside bearings	1360.0 mm to 1362.0 mm
Re-profiled and in-service wheelsets with outside bearings	1360.0 mm to 1363.3 mm
Any wheelset with inside bearings	1358.0 mm to 1360.0 mm

Table 1: Wheelset back-to-back dimensions

3.2.2 Back-to-back dimensions of wheelsets with GB tread profiles shall be measured either:

a) At axle height if the wheelset is fitted under a vehicle and is subjected to the mass of the vehicle and any load that the vehicle is carrying; or
b) At three equally spaced locations around the wheel circumference if the wheelset is a free wheelset that is only supporting its own weight.

3.2.3 The method and limits specified in the LOC&PAS and WAG NTSNs shall not be used for wheelsets using GB tread profiles.

Rationale

G 3.2.4 The back-to-back dimension controls the position of the tread profiles on a wheelset with respect to each other and therefore also with respect to the track. This maintains the safe limits to ensure compatibility with the infrastructure. The GB approach is different to the NTSN approach and the GB profiles have been established following the GB approach to geometry.

Guidance

G 3.2.5 The term 'GB tread profiles' relates to established and new profiles restricted to national use as set out in *2.1.1 b)* and *2.1.1 c)*.

G 3.2.6 LOC&PAS NTSN 7.3.2.6 states '*Specific case United Kingdom (Great Britain) ('P') It is permissible for the geometrical dimensions of the wheels to alternatively be established in accordance with the national technical rule notified for this purpose. This specific case does not prevent the access of NTSN compliant rolling stock to the national network*'.

G 3.2.7 There is, however, no specific case for permitting alternative geometry for wheelsets (back-to-back and flange width) but the assumption of conformity set out in this document makes vehicles in the scope of the LOC&PAS NTSN consistent with the GB specific case set out in the WAG NTSN.

G 3.2.8 WAG NTSN Specific case (7.3.2.5) permits the (dimensional) characteristics of wheelsets to be in accordance with NTRs, whereas the equivalent specific case in the LOC&PAS NTSN only explicitly defines wheels. In each NTSN, the permitted profiles are defined in BS EN 13715:2020 and the permitted back-to-back dimensions are the same. This standard does not differentiate between locomotives, passenger vehicles or freight wagons with respect to dimensional definition or control.

G 3.2.9 The geometric dimensions of wheels explicitly defined in the LOC&PAS and WAG NTSNs are compatible with the design profiles and limits defined in BS EN 13715:2020 and BS EN 15313:2016 respectively. Wheelsets with GB wheel tread profiles, as defined in this document and manufactured and maintained to the corresponding GB back-to-back and flange width limits, are deemed to be compatible with the geometrical in-service limits set out in the NTSNs. The GB back-to-back and flange width limits or the BS EN 15313 back-to-back and flange width limits may be used in some cases (for example the P10 profile) but the BS EN and GB measurement methods and limits are not to be mixed.

G 3.2.10 The method of measuring the back-to-back dimension of wheelsets using tread profiles defined by the LOC&PAS and WAG NTSNs (and BS EN 15313) at rail level in laden conditions still applies if those profiles are used. This method and the corresponding limits consider deflection under loading.

G 3.2.11 Wheelsets with profiles conforming to BS EN 13715 are used and maintained in accordance with the methods and limits that are set out in BS EN 15313, unless otherwise specified by the entities in charge of maintenance (ECM) (for example, if maintained in accordance with the GCU Contract).

G 3.2.12 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.

3.3 Re-profiling - economic tread turning (ETT)

3.3.1 Wheel treads shall only be re-profiled with a reduced flange thickness (application of ETT) if the nominal tread profile is set out in Table *2* subject to the following requirements:

a) The resulting wheel tread profile shall be larger than the wear limits for the original profile set out in Table *Table 1*.

b) The resulting wheel tread profile shall conform to the requirements set out in Appendix *B*.

Profile	Generation method
P1	Translated
P5	Translated
P6	Translated
P8	Stretched
P10	Stretched
P11	Stretched
P12	Stretched

Table 2: Permitted profiles for flange width reduction

Note: A Translated profile is one generated by offsetting the flange outer profile along the tread slope, and a Stretched profile is one generated by modifying the flange root to blend with the offset slope. This is explained in more detail in Appendix *B*.

3.3.2 Back-to-back dimensions of wheelsets with ETT tread profiles shall be in accordance with *3.2*.

Rationale

G 3.3.3 The requirements set out the circumstances in which ETT may be used as part of a wheelset wear management regime. ETT is an established method for minimising the amount of material to be removed when reprofiling by allowing a range of subsidiary profiles consistent with the original profile to be used that lie in the range between the new profile and the fully worn condition.

Guidance

G 3.3.4 Detailed guidance is given in Appendix *B*.

G 3.3.5 ETT for use with GB profiles has been developed from the findings of RSSB research projects T641 (2008), T963 (2013) and the Institute of Railway Research report IRR 110/145 (2017).

3.4 Small wheels using GB wheel tread profiles

3.4.1 Vehicles with wheels less than 660 mm in diameter using GB tread profiles shall comply in all loading conditions with the 'low speed rule', as set out in Appendix *C* of this document.

Rationale

G 3.4.2 The ‘low speed rule’ for small wheels manages the risk of derailment at obtuse crossings and satisfies INF NTSN Specific Case 7.7.17.4.

Guidance

G 3.4.3 The term 'GB tread profiles' relates to established and new profiles restricted to national use as defined in 2.1.1 *b)* and *c)*.

G 3.4.4 Where the diameter of a wheel, when fully worn, is 660 mm or greater, and the chosen tread profile is in accordance with 2.1.1*b)* / Appendix *A*, it may be assumed that the Appendix *C* rule is satisfied.

G 3.4.5 For wheel tread profiles to BS EN 13715 the derailment risk is managed by deeper flanges on small wheels and tighter wear tolerances. British Rail Research Report VDYN 155 (1990) concludes that the UIC profile has no features which render it unsuitable for negotiating BR fixed obtuse crossings.

Part 4 Application of this Document

4.1 Scope

4.1.1 The requirements of this document apply to all new and modified equipment (this excludes like-for-like replacement of components) on vehicles.

4.1.2 New, renewed and upgraded vehicles as defined in the Railways (Interoperability) Regulations 2011 (as amended) are required to comply with the LOC&PAS NTSN or the WAG NTSN and all relevant NTRs.

4.1.3 Action to bring existing wheelsets into compliance with the requirements of this document is not required.

4.2 Exclusions from scope

4.2.1 There are no exclusions from the scope defined in section *4.1*.

4.3 General enter into force date

4.3.1 The requirements in this document enter into force from 3 June 2023, except as where specified in *exceptions to general compliance date*. Where the dates specified in *exceptions to general compliance date* are later than the above date, this is to allow sufficient time to achieve compliance with the specified exceptions.

4.4 Deviations

4.4.1 Where it is considered not reasonably practicable to comply with the requirements of this document, permission to comply with a specified alternative should be sought in accordance with the deviation process set out in the Railway Group Standard Code.

4.4.2 In the case where NTSN compliance is required for a new, renewed or upgraded vehicle or structural subsystem, the process for any exemptions needed is set out in the Railways (Interoperability) Regulations 2011 (as amended).

4.5 Exceptions to general compliance date

4.5.1 There are no exceptions to the general compliance date specified in *4.3*.

4.5.2 The Office of Rail and Road (ORR) can be contacted for clarification on the applicable requirements where a project seeking authorisation for placing into service is already underway when this document enters into force.

4.6 Health and safety responsibilities

4.6.1 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.

Appendices

Appendix A Wheel Tread Profile Design

A.1 Wheelset tread profile coordinates

Guidance

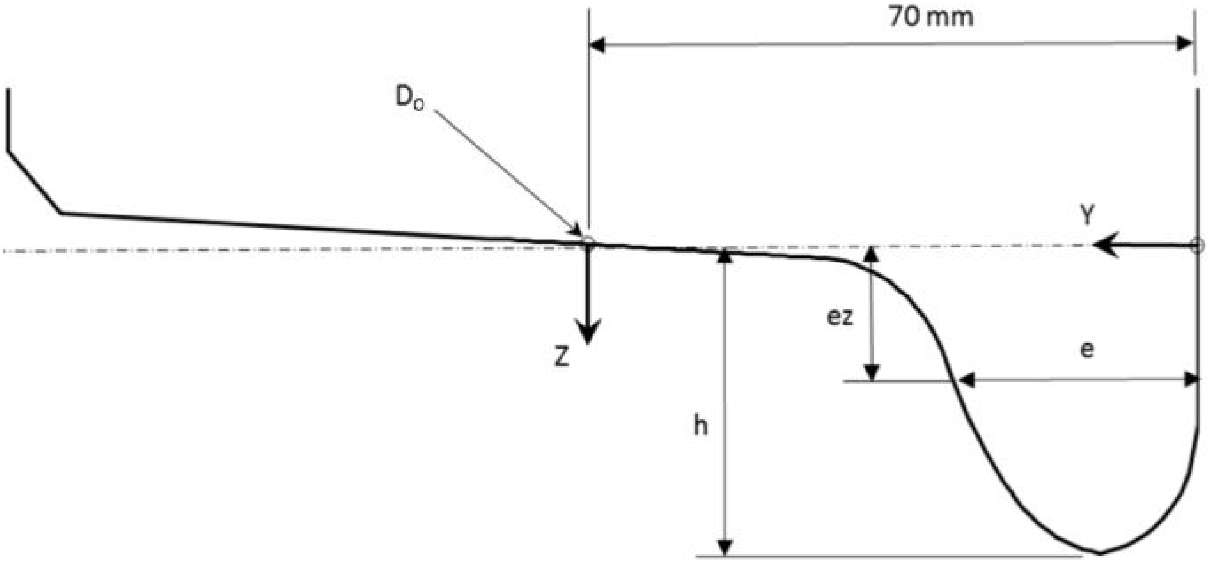


Figure 1: Wheel tread profile coordinate system, flange height and thickness

G A.1.1 The origin of the Z axis is at point D_0, situated 70 mm from the internal face of the wheel. The origin of the Y axis is at the wheel back. In EN 13715:2006 the origin of both axes is at point D_0.

G A.1.2 Flange height, h, is measured from D_0. Flange width, e, is measured at height ez which is defined with respect to D_0.

G A.1.3 For GB wheel tread profiles the flange width measurement height, ez, is 13 mm.

G A.1.4 For EN 13715 wheel tread profiles the flange width measurement height, ez, is 10 mm.

G A.1.5 To describe a profile mathematically each profile is divided into segments which are described as straight lines, curves or, in some cases, tabulated data.

G A.1.6 Segment equations are valid between the start and end values given, for $Ys \geq Y \geq Ye$ (where Ys = start point and Ye = end point).

G A.1.7 For inner curves, $Z = Zc + \sqrt{(R^2-(Y - Yc)^2)}$.

G A.1.8 For outer curves, $Z = Zc - \sqrt{(R^2-(Y - Yc)^2)}$.

G A.1.9 For straight lines, $Z = m.Y + c$.

G A.1.10 The segment equation data is given with a precision that normally exceeds practical requirements but ensures that the segments fit together to a very high level of accuracy. It is good practice to use the values with the precision given for calculation and then round the final values to the appropriate precision.

A.2 GB wheel tread profiles and wear limits

A.2.1 Wheel flange dimensions shall conform to the limits set out in Table 3.

Tread profile	Flange width* (mm)			Flange height (mm)	
	As new	Minimum in-service	Maximum in-service	As new	Maximum in-service
P1	28	24	32	30	36.5
P5	31.5	27	32	29	33
P6	28.5	24	32	30	36.5
P8	28.5	24	32	30	36.5
RD9	26	24	32	30	36.5
P9**	25 (21.5)	21 (18)	32 (29)	30	36.5
P10	31	27	32	28	33
P11	28	24	32	30	34
P12	28.5	24	32	30	36.5
P10/RD9	25.5	24	32	28	33

Table 3: Flange height and thickness by tread profile

Note: * Measured at 13 mm above wheel datum D_0

Note: ** For a P9 profile, the dimensions in brackets are applicable if the inner face of the relieved flange is used as a datum for measurements (see A.15)

Rationale

G A.2.2 These flange dimensions represent the operating limits for each GB tread profile that are considered to be compatible with the network with respect to the interface between the flange and track features such as switches and crossings.

Guidance

G A.2.3 The 'as new' flange height and thickness dimensions set out in Table 3 are nominal values and are subject to a machining tolerance of ±0.25 mm.

G A.2.4 The 'as new' flange height and thickness dimensions set out in Table 3 have been rounded from the dimensions derived from the individual profile definitions and the precise values are given in the dimensional summary table for each profile.

G A.2.5 The P10 profile is geometrically identical to the EN 13715 S1002/h28/e32.5/6.7 % profile (see A.3). The flange width cited is at the GB measuring height. The wear limits are related to the suspension characteristics for the vehicles that use this profile.

G A.2.6 The maximum in-service worn flange thickness condition is intended to ensure compatibility with switches and crossings on worn wheels that have incurred tread wear with no flange wear. This lack of flange wear results in an increase in measured flange width due to the radial movement of the tread datum point with respect to the flange profile. This behaviour was the subject of IRR research project COF-UOH-64, report number IRR 110/239 (2022). The research identified that most tread profiles interact with switches and crossings without abnormal contact up to a maximum flange width of 32 mm.

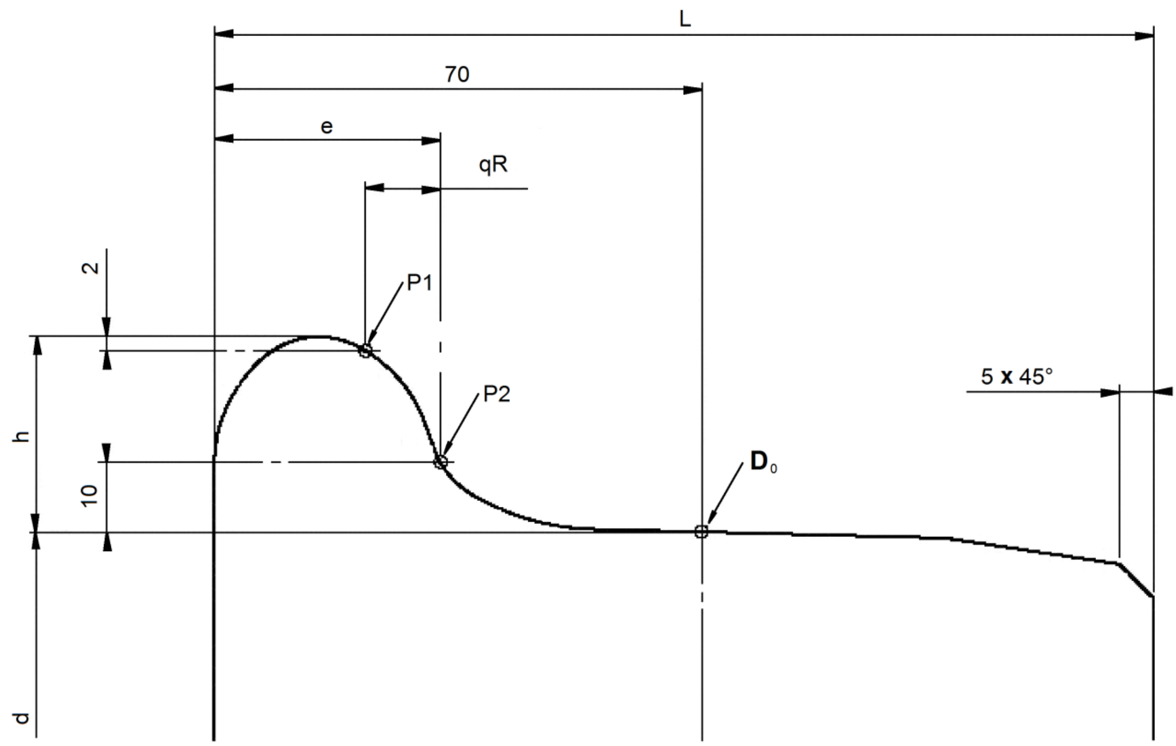
G A.2.7 The maximum in-service flange thickness control only applies in cases with significant uniform tread wear with no flange wear. Hollow wear and the resulting false flange are managed in accordance withthe requirement in 4.6.2.3 of RIS-2766-RST issue 2 that sets a false flange height (and therefore hollow wear depth) limit of 2 mm. Considering the typical flange slope and root radius, 2 mm tread wear equates to approximately 0.9 mm measured flange width increase and therefore warrants no additional controls for flange width for all profiles other than P5 and P10.

G A.2.8 The maximum in-service flange thickness limit provides little scope for flange growth on P5 and P10 profiles but it is not expected that these profiles will be used on vehicles with suspensions that are sufficiently stable to avoid flange contact, and flange wear at the root is more likely with the P5 profile due to the 60˚ flange slope.

A.3 European wheel tread profiles

Guidance

G A.3.1 Wheel profiles selected from EN 13715 comply with NTSN rules and route compatibility is determined in accordance with RIS-8270-RST.



Key

d wheel diameter
D_0 location of the wheel tread, 70 mm from its internal face
h flange height
L rim nominal width
e flange thickness
qR flange angle dimension between P1 and P2
5 x 45° Nominal chamfer

Figure 2: European profile dimensions (from BS EN 15313:2016, Figure 9)

G A.3.2 The wheel tread profiles in EN 13715 are defined using the parameters set out in Figure 2.

G A.3.3 EN 13715 defines three-wheel tread profiles, 1/40, S1002 and EPS. The standard permits a run-out taper in the range 6.7 % to 15 % with a chamfer of 5 mm.

G A.3.4 EN 13715 defines a common design of flange, which can have three heights according to the wheel diameter and a range of widths, which are tabulated in 0.5 mm increments from 32.5 mm down to 28.5 mm.

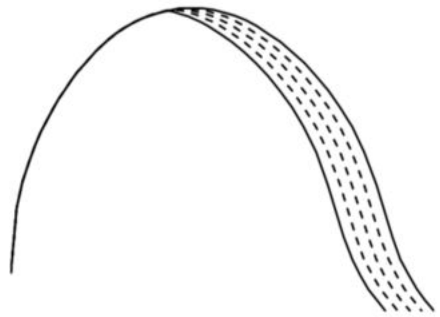


Figure 3: EN 13715 flange variants (1 mm increments shown)

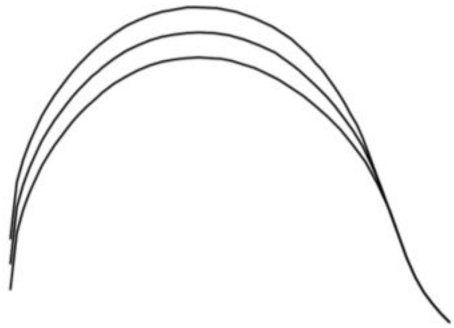


Figure 4: EN 13715 flange height variants, h28, h30, h32

G A.3.5 EN 13715 clause 7 defines profile designations. The letter 'h' denotes the flange height and letter 'e' the flange width measured at 10 mm above the wheel tread datum.

G A.3.6 The 1/40 profile is taken from NF F 01-115, October 1994, superseded by EN 13715. NF F 01-115 also included the UIC 510-2 profiles. This standard indicates that the 1/40 profile is intended primarily for very high speed services (TGVs). The variant shown below has a 32.5 mm wide / 28 mm high flange and is used on Class 373.

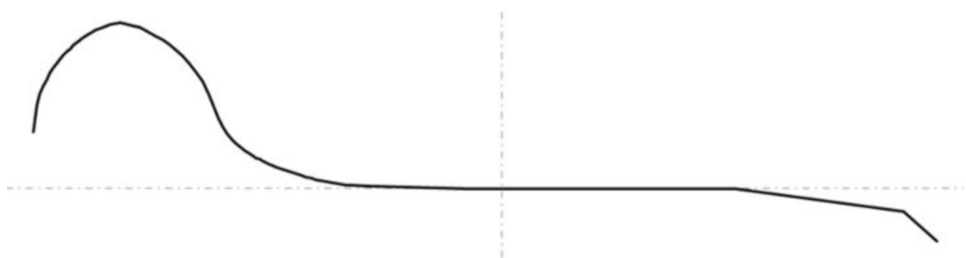


Figure 5: EN 13715 S1002/h28/e32.5/15 % profile

Wheel diameter range (mm)	EN 13715 designation	GB designation
1000 and 760	1/40/h28/e32.5/15 %	Class 373

Table 4: EN 13715 1/40 profile

G A.3.7 The S1002 profile is taken from UIC 510-2 (4th Edition 2004). The variant shown below has a 32.5 mm wide / 28 mm high flange and is identical to the GB P10 profile.

G A.3.8 The S1002 27.5 variation of the S1002 profile is a GB variant of the S1002 profile developed as an alternative to the P10/RD9 hybrid profile for Class 66 freight locomotives for GB operation. This profile follows the EN 13715 method for the flange geometry, except that the flange width in this case is 27.5 mm and is therefore below the EN 13715 permitted range of widths. All other parts of the profile are derived according to EN 13715. This profile is accepted for existing applications but not permitted for any new applications.

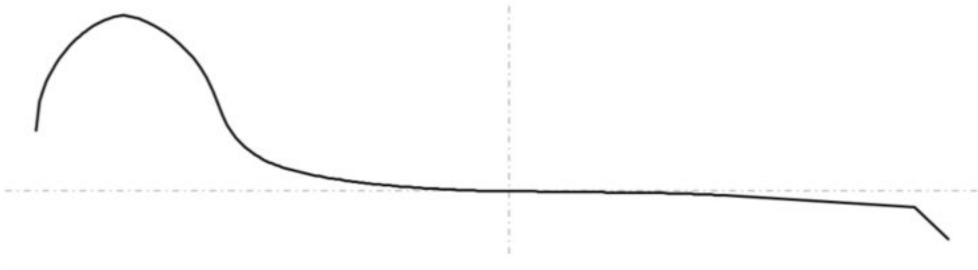


Figure 6: EN 13715 S1002/h28/e32.5/6.7 % profile

Note: The designation S1002 SW is used in some documents relating to freight vehicles.

Wheel diameter range (mm)	EN 13715 designation	UIC 510-2 designation	GB designation
1000 and 760	S1002/h28/ e32.5/6.7 %	Appendix B.1	P10
760 to 630	S1002/h30/ e32.5/6.7 %	Appendix B.2	S1002 SW
630 to 330	S1002/h32/ e32.5/6.7 %	Appendix B.3	n/a

Table 5: EN 13715 S1002 profile

G A.3.9 The EPS profile is described in EN 13715 as ‘equivalent to profile P8 of the United Kingdom with a flange 30 mm thick’. The variant shown below has a 30 mm wide / 30 mm high flange. The flange root and tread areas are similar but the inner flange radius of the P8 profile is tighter than S1002.

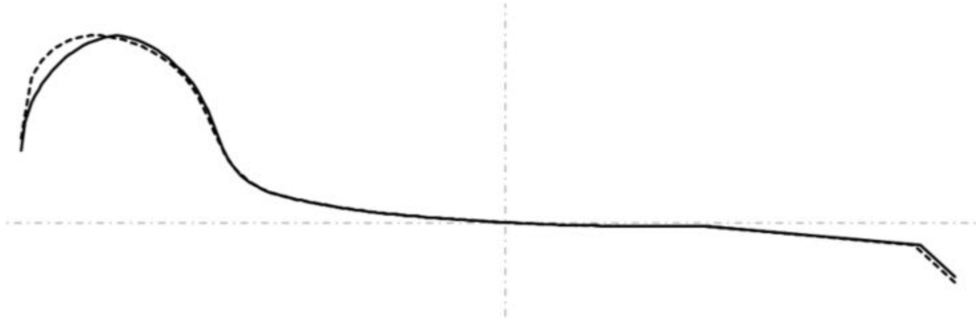


Figure 7: EN 13715 EPS/h30/e30/10 % profile (P8 dashed line)

Wheel diameter range (mm)	EN 13715 designation	GB designation
1000 and 760	EPS/h30/e30/10 %	EPS

Table 6: EN 13715 EPS profile

G A.3.10 An EN 13715 30 mm high / 30 mm wide flange, measured in accordance with GB practice at a height of 13 mm, is 28.21 mm wide.

G A.3.11 Flange width is measured at a height of 10 mm from the reference diameter (D_0) for EN profiles and 13 mm for established GB profiles. This height difference changes the apparent flange width for the same profile whereby the measured flange width is less when measured at the GB height compared to the EN height for a given profile. The equivalent flange width at 10 mm is given along with nominal qR values for reference below the coordinate table for each profile in this appendix.

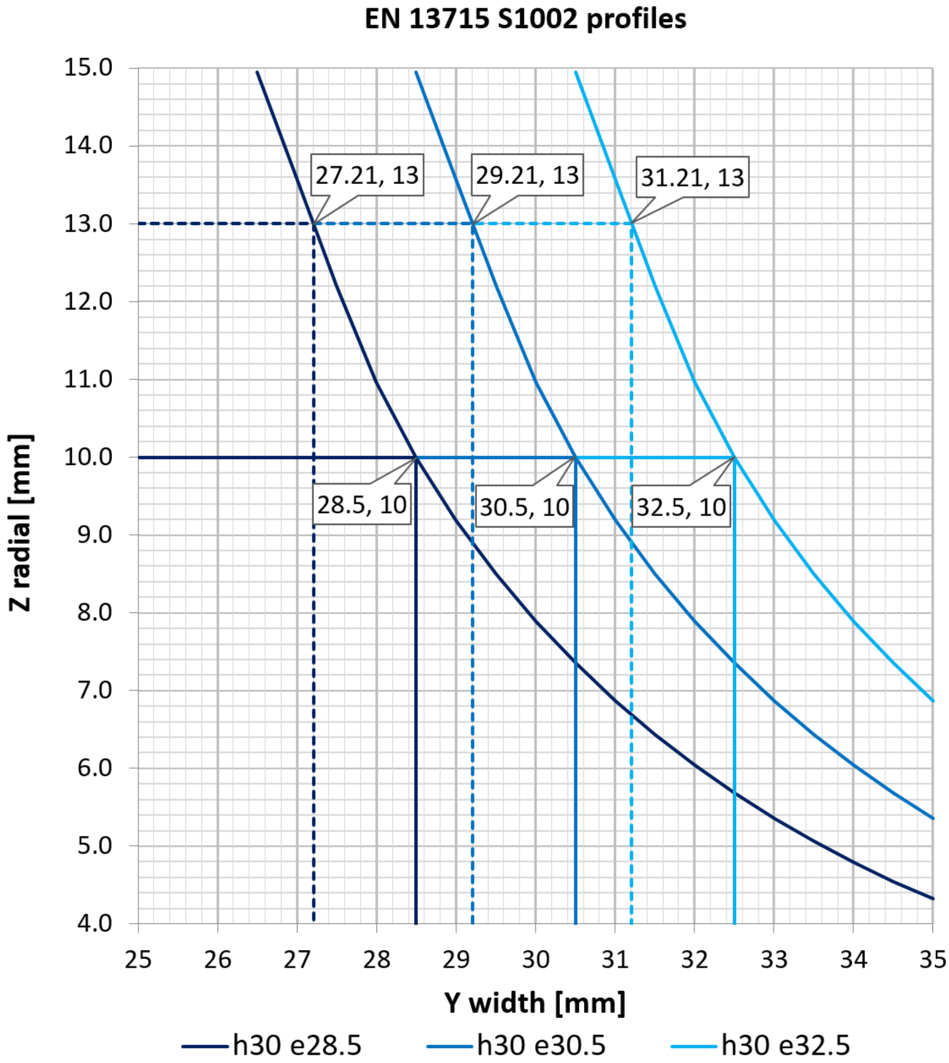


Figure 8: Difference in measured flange width according to GB and EN measuring heights

G A.3.12 This applies to design profiles, as the width difference between the two measuring heights in a worn condition depends on the wear characteristics.

G A.3.13 Equivalent flange widths for S1002 design profiles at 13 mm are given in Figure *8*. The measured flange width difference for all S1002 design variants when measured at 10 mm and 13 mm above the tread datum is -1.29 mm.

G A.3.14 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 A.3.15 The LOC&PAS and WAG NTSNs and EN 15313 give limits for minimum flange width in service. If these limits are applied to a wheelset, the related back-to-back and front-to-front dimensions and qR values shall also be measured and assessment shall be based on the complete set of criteria.

G A.3.16 The 33 mm flange width limit set for the profiles defined in the LOC&PAS and WAG NTSNs measured at 10 mm above the datum point is considered to be comparable with the limit set for GB profiles and therefore still compatible with GB track features.

G A.3.17 A critical aspect for the EN approach is the requirement to determine the back-to-back dimension at rail level for tare and laden conditions:

a) The back-to-back dimension is measured in the worst loading state, laden for a wheelset with outside journals, tare for inside journals; or
b) An unloaded back-to-back dimension is combined with a calculated lateral wheelset displacement determined from the load / deflection characteristics of the wheelset; or
c) An unloaded back-to-back dimension is combined with an assumed worst-case deflection.

G A.3.18 The summation of the back-to-back dimension at rail level and the measured flange thicknesses give the front-to-front dimension, which is required to be within the limits prescribed.

G A.3.19 In addition, the effective flange slope is controlled by the EN requirements for control of the qR value.

G A.3.20 The net result is that, in practice, the minimum flange widths given in the LOC&PAS NTSN and WAG NTSN and EN 15313 cannot be attained unless uneven flange wear is assumed across the wheelset.

G A.3.21 For example, for wheels in the range $760 < D \leq 840$:

a) The maximum permitted back-to-back dimension is 1363 mm.
b) The minimum permitted front-to-front dimension is 1410 mm.
c) The sum of both flange widths is therefore 47 mm.
d) The width of each flange is therefore 23.5 mm - considering even wear.

G A.3.22 A flange significantly thinner than this would be the result of high shoulder wear on that wheel with a steep slope that would then result in an unacceptably low qR value.

G A.3.23 GB practice is to measure either unloaded or at axle height and the back-to-back limits are therefore tighter. GB controls on flange width are independent of the back-to-back dimension.

G A.3.24

GB variants of EN 13715 tread profiles	EN 13715 Profile specification	Flange width (mm) (measured at 13 mm above wheel datum D_0)			Flange height (mm)	
		As new	Minimum in- service	Maximum in-service	As new	Maximum in-service
Class 373	1/40/h28/ e32.5/15 %	32.5	26	32	28	36
S1002	S1002/h28/ e32.5/6.7 %	32.5	24	32	28	36
S1002 SW	S1002/h30/ e32.5/6.7 %	32.5	27.5	32	30	36
EPS	EPS/h30/ e30/10 %	28	24	32	30	36.5

Table 7: European wheel tread profiles - wear limits for wheelsets maintained to GB back-to-back limits

G A.3.25 The recommended wear limits set out in Table 7, are for commonly used EN profiles that are compatible with GB controls and permit the use of these profiles without front-to-front and qR measurements.

G A.3.26 These minimum flange widths are defined to be compatible with existing GB profile gauges and are therefore measured at a height of 13 mm from the tread datum.

G A.3.27 Where applicable to freight wagons, these limits are also defined in RIS-2702-RST.

G A.3.28 The S1002 27.5 variation of the S1002 profile is a GB variant of the S1002 profile developed as an alternative to the P10/RD9 hybrid profile developed for Class 66 freight locomotives for GB operation. This profile follows the EN 13715 method for the flange geometry, except that the flange width in this case is 27.5 mm and is therefore below the EN 13715 permitted range of widths. All other parts of the profile are derived in accordance with EN 13715.

A.4 P1 Wheel tread profile

Guidance

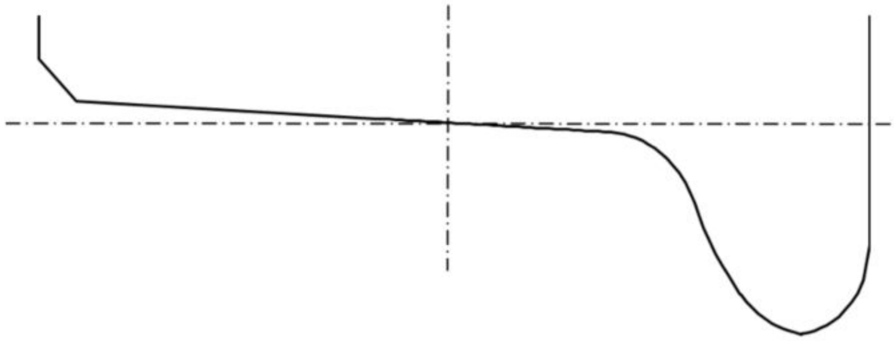


Figure 9: P1 profile

P1 wheel tread profile. From BR drawing S8-C2-8006234				
Flange width, e, mm (measured at 13 mm above wheel datum D_0)		Flange height, h, mm (measured from wheel datum D_0)		Flange angle
As new	Minimum (worn)	As new	Maximum (worn)	
28 (Precise value = 27.84)	24	30 (Precise value = 29.93)	36	Tangent 60˚

Table 8: GB control measurements for a P1 profile

Profile segment	Start, Ys (mm)	End, Ye (mm)	Line Z= mY +c		Arc centre (mm)		Radius (mm)
			Slope, m	Intercept, c	Yc	Zc	
1	0.000	11.113			12.700	17.331	12.700
2	11.113	21.062			8.730	14.237	15.875
3	21.062	28.466			-15.935	-5.758	47.626
4	28.466	42.466			43.259	17.232	15.875
5	42.466	70.000	-0.050	3.500	Taper 1 in 20		
6	70.000	129.000	-0.050	3.500	Taper 1 in 20		
7	129.000	135.000	6 mm 45˚ chamfer				

Table 9: P1 tread profile equation parameters

Y	Z	Y	Z	Y	Z	Y	Z
0	17.33	12	29.77	24	20.19	36	3.11
0.5	20.86	12.5	29.66	24.5	19.41	36.5	2.87
1	22.27	13	29.53	25	18.59	37	2.64
1.5	23.32	13.5	29.38	25.5	17.72	37.5	2.44
2	24.17	14	29.21	26	16.82	38	2.25
2.5	24.90	14.5	29.03	26.5	15.86	38.5	2.09
3	25.53	15	28.82	27	14.85	39	1.94
3.5	26.09	15.5	28.60	27.5	13.78	39.5	1.81
4	26.58	16	28.35	28	12.63	40	1.69
4.5	27.03	16.5	28.08	28.5	11.38	40.5	1.60
5	27.43	17	27.79	29	10.25	41	1.52
5.5	27.79	17.5	27.47	29.5	9.31	41.5	1.45
6	28.12	18	27.12	30	8.50	42	1.41
6.5	28.42	18.5	26.75	30.5	7.79	42.5	1.37
7	28.68	19	26.34	31	7.15	50	1.00
7.5	28.92	19.5	25.90	31.5	6.57	60	0.50
8	29.13	20	25.42	32	6.04	70	0.00
8.5	29.32	20.5	24.89	32.5	5.56	80	-0.50
9	29.48	21	24.31	33	5.12	90	-1.00
9.5	29.62	21.5	23.68	33.5	4.71	100	-1.50
10	29.74	22	23.04	34	4.34	129	-2.95
10.5	29.84	22.5	22.37	34.5	3.99	135	-8.95
11	29.92	23	21.67	35	3.67		

Y	Z	Y	Z	Y	Z	Y	Z
11.5	29.87	23.5	20.95	35.5	3.38		

Table 10: P1 tread profile coordinate data

G A.4.1 European control measurements for a new P1 profile, for reference:

- Flange width, e, at 10 mm above wheel datum D_0, 29.13 mm (P2 Y coordinate).
- Flange tip (P1 coordinates) Y = 16.76, Z = 27.93.
- qR = Y(P2) – Y(P1) = 12.37 mm (see EN 15313 Figure 9 for coordinate definitions).

A.5 P5 Wheel tread profile

Guidance

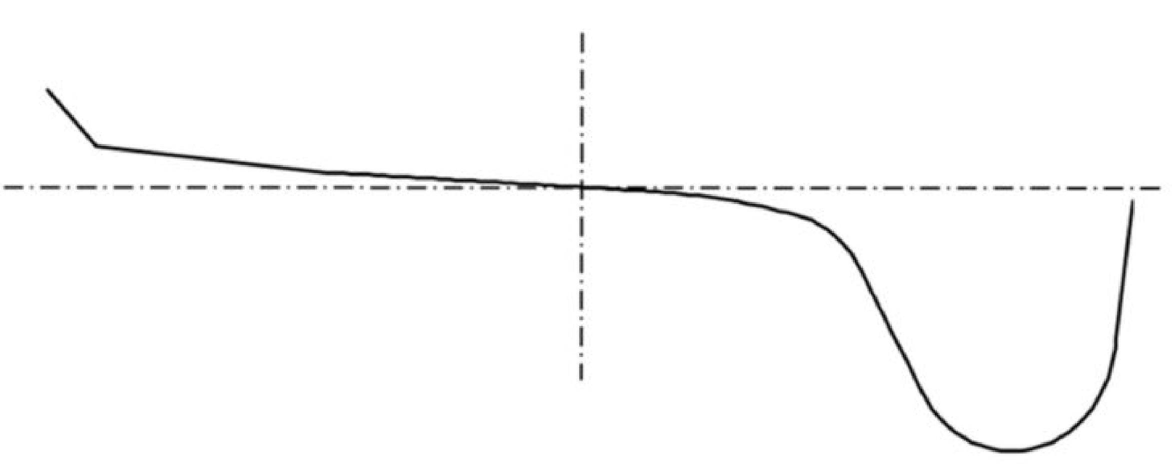


Figure 10: P5 profile

P5 wheel tread profile. From BR drawing S8-C2-8003908				
Flange width, e, mm		Flange height, h, mm		Flange angle
(measured at 13 mm above wheel datum D_0)		(measured from wheel datum D_0)		
As new	Minimum (worn)	As new	Maximum (worn)	
31.5 (Precise value = 31.53)	27	29 (Precise value = 28.63)	33	60˚

Table 11: GB control measurements for a P5 profile

Profile segment	Start, Ys	End, Ye	Line Z= mY +c		Arc centre (mm)		Radius (mm)
	(mm)	(mm)	Slope, m	Intercept, c	Yc	Zc	
1	0.000	2.116	7.435	1.625			
2	2.116	26.251			15.000	15.625	13.000
3	26.251	33.929	-1.732	67.605			
4	33.929	41.501			44.321	14.839	12.000
5	41.501	60.006			65.000	100.375	100.000
6	60.006	100.000	-0.050	3.500	Taper 1 in 20		
7	100.000	129.000	-0.100	8.500	Taper 1 in 10		
8	129.000	135.000	6 mm 45˚ chamfer				

Table 12: P5 tread profile equation parameters

Y	Z	Y	Z	Y	Z	Y	Z
0	1.62	14.5	28.62	29	17.38	45	2.40
0.5	5.34	15	28.62	29.5	16.51	46	2.20
1	9.06	15.5	28.62	30	15.64	47	2.01
1.5	12.78	16	28.59	30.5	14.78	48	1.83
2	16.50	16.5	28.54	31	13.91	49	1.66
2.5	19.20	17	28.47	31.5	13.05	50	1.51
3	20.62	17.5	28.38	32	12.18	51	1.36
3.5	21.69	18	28.27	32.5	11.31	52	1.22
4	22.55	18.5	28.14	33	10.45	53	1.10
4.5	23.29	19	27.99	33.5	9.58	54	0.98
5	23.93	19.5	27.82	34	8.72	55	0.88
5.5	24.50	20	27.62	34.5	7.94	56	0.78
6	25.01	20.5	27.40	35	7.28	57	0.70
6.5	25.46	21	27.16	35.5	6.70	58	0.62
7	25.87	21.5	26.88	36	6.19	59	0.56
7.5	26.24	22	26.58	36.5	5.74	60	0.50
8	26.58	22.5	26.24	37	5.33	70	0
8.5	26.88	23	25.87	37.5	4.97	80	-0.50
9	27.16	23.5	25.46	38	4.64	90	-1.00
9.5	27.40	24	25.01	38.5	4.35	100	-1.50
10	27.62	24.5	24.50	39	4.08	129	-4.40
10.5	27.82	25	23.93	39.5	3.85	135	-10.4
11	27.99	25.5	23.29	40	3.64		

Y	Z	Y	Z	Y	Z	Y	Z
11.5	28.14	26	22.55	40.5	3.46		
12	28.27	26.5	21.71	41	3.31		
12.5	28.38	27	20.84	41.5	3.18		
13	28.47	27.5	19.97	42	3.06		
13.5	28.54	28	19.11	43	2.82		
14	28.59	28.5	18.24	44	2.60		

Table 13: P5 tread profile coordinate data

G A.5.1 European control measurements for a new P5 profile, for reference:

- Flange width, e, at 10 mm above wheel datum D_0, 33.26 mm (EN 15313 Figure 9, P2 coordinate).
- Flange tip (EN 15313 Figure 9, P1 coordinate) Y = 21.93, Z = 26.63.
- qR = P2 – P1 = 11.33 mm.

A.6 P6 Wheel tread profile

Guidance

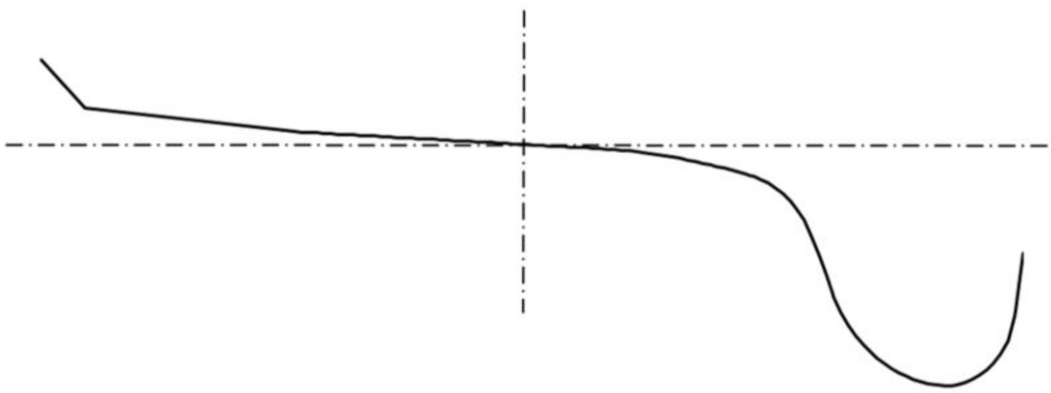


Figure 11: P6 profile

P6 wheel tread profile. From BR drawing S8-C2-8006238				
Flange width, e, mm (measured at 13 mm above wheel datum D_0)		Flange height, h, mm (measured from wheel datum D_0)		Flange angle
As new	Minimum (worn)	As new	Maximum (worn)	
28.5 (Precise value = 28.36)	24	30 (Precise value = 30)	36	68°

Table 14: GB control measurements for a P6 profile

Profile segment	Start, Ys	End, Ye	Line Z= mY +c		Arc centre (mm)		Radius (mm)
	(mm)	(mm)	Slope, m	Intercept, c	Yc	Zc	
1	0.000	1.111	7.116	13.500			
2	1.111	10.500			11.014	20.013	10.000
3	10.500	26.021			9.332	12.038	18.000
4	26.021	28.947	-2.475	83.185			
5	28.947	37.638			41.000	16.410	13.000
6	37.638	58.506			63.500	100.450	100.000
7	58.506	100.000	-0.050	3.500	Taper 1 in 20		
8	100.000	129.000	-0.100	8.500	Taper 1 in 10		
9	129.000	135.000	6 mm 45˚ chamfer				

Table 15: P6 tread profile equation parameters

Y	Z	Y	Z	Y	Z	Y	Z
0	13.50	14	29.42	28	13.88	42	2.79
0.5	17.06	14.5	29.28	28.5	12.65	43	2.57
1	20.62	15	29.12	29	11.41	44	2.37
1.5	23.09	15.5	28.95	29.5	10.35	45	2.18
2	24.34	16	28.76	30	9.48	46	1.99
2.5	25.26	16.5	28.55	30.5	8.74	47	1.82
3	26.00	17	28.32	31	8.10	48	1.66
3.5	26.61	17.5	28.08	31.5	7.54	49	1.51
4	27.14	18	27.81	32	7.03	50	1.37
4.5	27.6	18.5	27.53	32.5	6.57	51	1.23
5	28.00	19	27.22	33	6.16	52	1.11
5.5	28.36	19.5	26.89	33.5	5.79	53	1.00
6	28.67	20	26.54	34	5.46	54	0.90
6.5	28.94	20.5	26.15	34.5	5.15	55	0.81
7	29.17	21	25.74	35	4.88	56	0.73
7.5	29.38	21.5	25.30	35.5	4.63	57	0.66
8	29.55	22	24.83	36	4.41	58	0.60
8.5	29.69	22.5	24.31	36.5	4.21	59	0.55
9	29.81	23	23.75	37	4.04	60	0.50
9.5	29.9	23.5	23.14	37.5	3.89	70	0
10	29.96	24	22.47	38	3.76	80	-0.50
10.5	30.00	24.5	21.73	38.5	3.63	90	-1.00
11	29.96	25	20.90	39	3.50	100	-1.50

Y	Z	Y	Z	Y	Z	Y	Z
11.5	29.91	25.5	19.95	39.5	3.37	129	-4.40
12	29.84	26	18.83	40	3.25	135	-10.40
12.5	29.76	26.5	17.60	40.5	3.13		
13	29.66	27	16.36	41	3.01		
13.5	29.55	27.5	15.12	41.5	2.90		

Table 16: P6 tread profile coordinate data

G A.6.1 European control measurements for a new P6 profile, for reference:

- Flange width, e, at 10 mm above wheel datum D_0, 29.69 mm (EN 15313 Figure 9, P2 coordinate).
- Flange tip (EN 15313 Figure 9, P1 coordinate) Y = 17.65, Z = 28.00.
- qR = P2 – P1 = 12.04 mm.

A.7 RD9 Wheel tread profile

Guidance

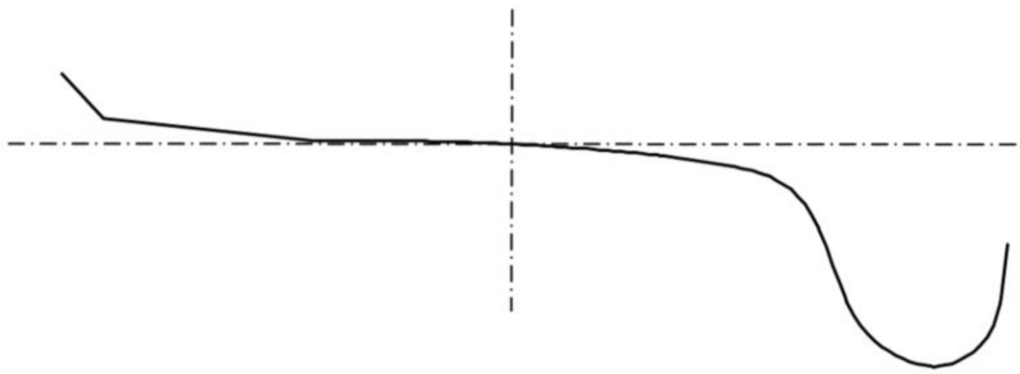


Figure 12: RD9 profile

RD9 wheel tread profile. From BR drawing A1-C1-8700150				
Flange width, e, mm (measured at 13 mm above wheel datum D_0)		Flange height, h, mm (measured from wheel datum D_0)		Flange angle
As new	Minimum (Worn)	As new	Maximum (worn)	
26 Precise value = 26.31	24	30 Precise value = 29.91	36	68˚

Table 17: GB control measurements for a RD9 profile

Profile segment	**Start, Ys**	**End, Ye**	**Line Z= mY +c**		**Arc centre (mm)**		**Radius (mm)**
	(mm)	**(mm)**	**Slope, m**	**Intercept, c**	**Yc**	**Zc**	
1	0.000	1.112	7.116	13.500			
2	1.112	10.560			11.000	19.920	10.000
3	10.560	23.247			9.340	14.960	15.000
4	23.247	26.948	-2.474	78.082			
5	26.948	36.270			39.000	16.300	13.000
6	36.270	49.710			61.500	120.908	120.000
7	49.710	89.000			89.105	399.544	400.000
8	89.000	99.000	Z = -0.457		Cylindrical		
9	99.000	129.000	-0.100	9.444	Taper 1 in 10		
10	129.000	135.000	6 mm 45° chamfer				

Table 18: RD9 tread profile equation parameters

Y	Z	Y	Z	Y	Z	Y	Z
0	13.5	14	29.22	28	9.37	42	2.5
0.5	17.06	14.5	29.04	28.5	8.64	43	2.34
1	20.62	15	28.85	29	7.99	44	2.19
1.5	23.04	15.5	28.64	29.5	7.43	45	2.05
2	24.28	16	28.4	30	6.92	46	1.91
2.5	25.19	16.5	28.14	30.5	6.46	47	1.79
3	25.92	17	27.86	31	6.05	48	1.67
3.5	26.53	17.5	27.55	31.5	5.68	49	1.56
4	27.06	18	27.21	32	5.35	50	1.46
4.5	27.52	18.5	26.84	32.5	5.04	51	1.36
5	27.92	19	26.44	33	4.77	52	1.27
5.5	28.27	19.5	26	33.5	4.52	53	1.18
6	28.58	20	25.51	34	4.3	54	1.09
6.5	28.85	20.5	24.98	34.5	4.1	55	1
7	29.09	21	24.4	35	3.93	56	0.92
7.5	29.29	21.5	23.74	35.5	3.78	57	0.83
8	29.46	22	23.01	36	3.65	58	0.75
8.5	29.6	22.5	22.16	36.5	3.54	59	0.68
9	29.72	23	21.16	37	3.44	60	0.6
9.5	29.81	23.5	19.96	37.5	3.33	70	0
10	29.87	24	18.72	38	3.23	80	-0.35
10.5	29.91	24.5	17.48	38.5	3.13	89	-0.46
11	29.87	25	16.25	39	3.04	99	-0.46

Y	Z	Y	Z	Y	Z	Y	Z
11.5	29.8	25.5	15.01	39.5	2.94	129	-3.46
12	29.72	26	13.77	40	2.85	135	-9.46
12.5	29.62	26.5	12.53	40.5	2.76		
13	29.51	27	11.3	41	2.67		
13.5	29.37	27.5	10.24	41.5	2.59		

Table 19: RD9 tread profile coordinate data

G A.7.1 European control measurements for a new RD9 profile, for reference:

- Flange width, e, at 10 mm above wheel datum D_0, 27.63 mm (EN 15313 Figure 9, P2 coordinate).
- Flange tip, (EN 15313 Figure 9, P1 coordinate) Y = 16.91, Z =27.91.
- qR = P2 – P1 = 10.72 mm.

A.8 P8 Wheel tread profile

Guidance

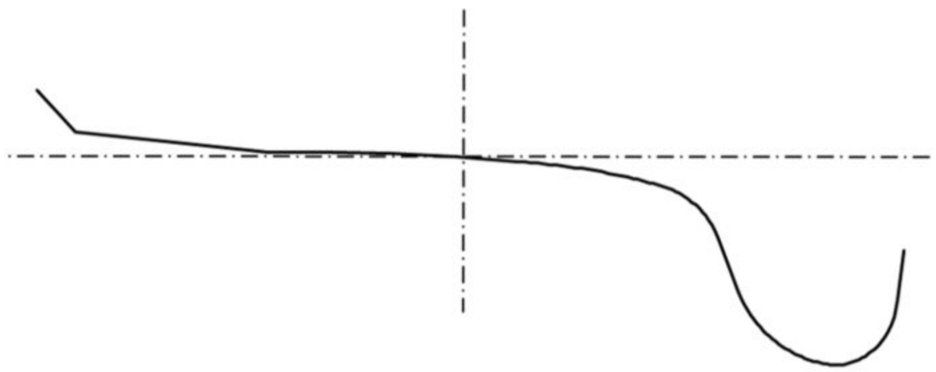


Figure 13: P8 profile

P8 wheel tread profile. From BR drawing S8-C2-8006239				
Flange width, e, mm		Flange height, h, mm		Flange angle
(measured at 13 mm above wheel datum D_0)		(measured from wheel datum D_0)		
As new	Minimum (worn)	As new	Maximum (worn)	
28.5 (Precise value = 28.53)	24	30 (Precise value = 30)	36	68˚

Table 20: GB control measurements for a P8 profile

Profile segment	Start, Ys	End, Ye	Line Z= mY +c		Arc centre (mm)		Radius (mm)
	(mm)	(mm)	Slope, m	Intercept, c	Yc	Zc	
1	0.000	1.111	7.115	13.500			
2	1.111	10.500			11.014	20.013	10.000
3	10.500	26.188			9.5059	12.028	18.000
4	26.188	28.947	-2.475	83.606			
5	28.947	37.639			41.000	16.830	13.000
6	37.639	52.413			63.500	100.871	100.000
7	52.413	89.000			89.000	329.453	330.000
8	89.000	99.000	Z = -0.547		Cylindrical		
9	99.000	129.000	-0.100	9.353	Taper 1 in 10		
10	129.000	135.000	6 mm 45˚ chamfer				

Table 21: P8 tread profile equation parameters

Y	Z	Y	Z	Y	Z	Y	Z
0	13.50	14	29.46	28	14.30	42	3.21
0.5	17.06	14.5	29.32	28.5	13.07	43	2.99
1	20.62	15	29.17	29	11.83	44	2.79
1.5	23.09	15.5	29.00	29.5	10.77	45	2.60
2	24.34	16	28.82	30	9.90	46	2.41
2.5	25.26	16.5	28.61	30.5	9.17	47	2.24
3	25.99	17	28.39	31	8.52	48	2.08
3.5	26.61	17.5	28.15	31.5	7.96	49	1.93
4	27.14	18	27.90	32	7.45	50	1.79
4.5	27.60	18.5	27.62	32.5	6.99	51	1.65
5	28.00	19	27.32	33	6.58	52	1.53
5.5	28.36	19.5	27.00	33.5	6.21	53	1.42
6	28.67	20	26.65	34	5.88	54	1.31
6.5	28.94	20.5	26.28	34.5	5.57	55	1.21
7	29.17	21	25.88	35	5.30	56	1.11
7.5	29.38	21.5	25.45	35.5	5.05	57	1.01
8	29.55	22	24.99	36	4.83	58	0.91
8.5	29.69	22.5	24.48	36.5	4.63	59	0.82
9	29.81	23	23.94	37	4.46	60	0.73
9.5	29.90	23.5	23.35	37.5	4.31	70	0
10	29.96	24	22.70	38	4.18	80	-0.42
10.5	30.00	24.5	21.99	38.5	4.05	89	-0.55
11	29.97	25	21.19	39	3.92	99	-0.55

Y	Z	Y	Z	Y	Z	Y	Z
11.5	29.92	25.5	20.29	39.5	3.79	129	-3.55
12	29.85	26	19.23	40	3.67	135	-9.55
12.5	29.78	26.5	18.02	40.5	3.55		
13	29.69	27	16.78	41	3.43		
13.5	29.58	27.5	15.54	41.5	3.32		

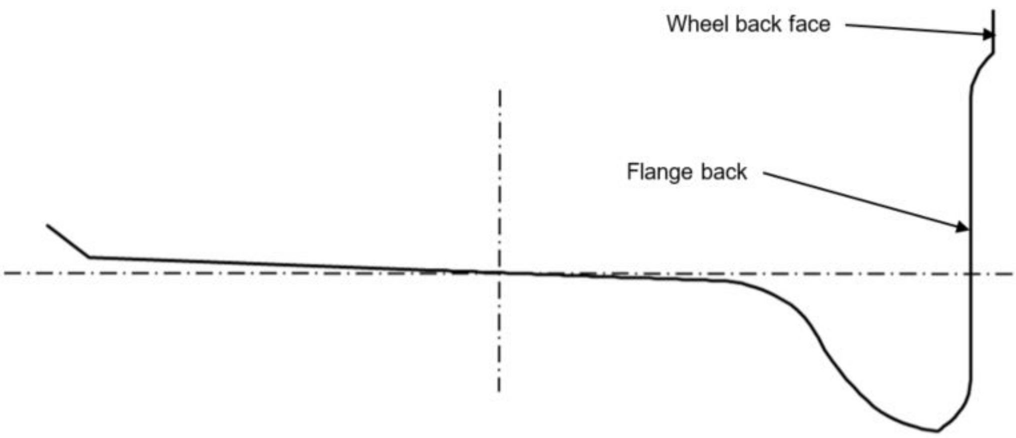
Table 22: P8 tread profile coordinate data

G A.8.1 European control measurements for a new P8 profile, for reference:

- Flange width, e, at 10 mm above wheel datum D_0, 29.94 mm (EN 15313 Figure 9, P2 coordinate).
- Flange tip (EN 15313 Figure 9, P1 coordinate) Y = 17.81, Z = 28.00.
- qR = P2 – P1 = 12.13 mm.

A.9 P9 Wheel tread profile

Guidance



Flange widths are given from the wheel back face. Values in brackets are from the flange back.

Figure 14: P9 profile

P9 wheel tread profile. From BR drawing S8 C2-8006240				
Flange width, e, mm (measured at 13 mm above wheel datum D_0)		Flange height, h, mm (measured from wheel datum D_0)		Flange angle
As new	Minimum (worn)	As new	Maximum (worn)	
25 (-21.5) (Precise value = 24.74)	21 (-18)	30 (Precise value = 30.09)	36	Tangent 60 ˚

Table 23: GB control measurements for a P9 profile

Profile segment	**Start, Ys**	**End, Ye**	**Line Z= mY +c**		**Arc centre (mm)**		**Radius (mm)**
	(mm)	**(mm)**	**Slope, m**	**Intercept, c**	**Yc**	**Zc**	
2	0.000	3.175			-9.525	-33.409	12.700
	3.175	3.175	Z = -33.409 to Z = 20.127		Vertical line		
3	3.175	8.000			15.875	20.127	12.700
4	8.000	18.011			5.619	14.395	15.875
	18.011	25.272			-19.166	-5.449	47.625
5	25.272	39.292			40.084	17.391	15.875
6	39.292	3.175	-0.050	3.500	Taper 1 in 20		
8	129.000	135.000	6 mm 45° chamfer				

Table 24: P9 tread profile equation parameters

Y	Z	Y	Z	Y	Z	Y	Z
0	-41.81	13	28.45	27	8.40	41	1.45
0.5	-41.21	13.5	28.18	27.5	7.71	41.5	1.42
1	-40.52	14	27.88	28	7.10	42	1.40
1.5	-39.71	14.5	27.55	28.5	6.54	43	1.35
2	-38.74	15	27.20	29	6.03	44	1.30
2.5	-37.49	15.5	26.82	29.5	5.56	45	1.25
3	-35.51	16	26.41	30	5.13	46	1.20
3.175	-33.41	16.5	25.95	30.5	4.74	47	1.15
3.175	20.13	17	25.46	31	4.37	48	1.10
3.5	22.98	17.5	24.92	31.5	4.04	49	1.05
4	24.63	18	24.33	32	3.73	50	1.00
4.5	25.77	18.5	23.70	32.5	3.44	51	0.95
5	26.69	19	23.04	33	3.18	52	0.90
5.5	27.45	19.5	22.36	33.5	2.95	53	0.85
6	28.11	20	21.65	34	2.73	54	0.80
6.5	28.69	20.5	20.91	34.5	2.53	55	0.75
7	29.21	21	20.14	35	2.35	56	0.70
7.5	29.67	21.5	19.34	35.5	2.19	57	0.65
8	30.09	22	18.50	36	2.05	58	0.60
8.5	30.01	22.5	17.62	36.5	1.93	59	0.55
9	29.91	23	16.69	37	1.82	60	0.50
9.5	29.79	23.5	15.71	37.5	1.73	70	0
10	29.65	24	14.67	38	1.65	80	-0.50

Y	Z	Y	Z	Y	Z	Y	Z
10.5	29.50	24.5	13.56	38.5	1.59	90	-1.00
11	29.33	25	12.37	39	1.55	100	-1.50
11.5	29.14	25.5	11.12	39.5	1.52	129	-2.95
12	28.93	26	10.07	40	1.50	135	-8.95
12.5	28.70	26.5	9.18	40.5	1.47		

Table 25: P9 tread profile coordinate data

G A.9.1 European control measurements for a new P9 profile, for reference:

- Flange width, e, at 10 mm above wheel datum D_0, 26.03 mm (EN 15313 Figure 9, P2 coordinate).
- Flange tip (EN 15313 Figure 9, P1 coordinate) Y = 13.80, Z = 28.0.
- qR = P2 – P1 = 12.24 mm.

A.10 P10 Wheel tread profile

Guidance

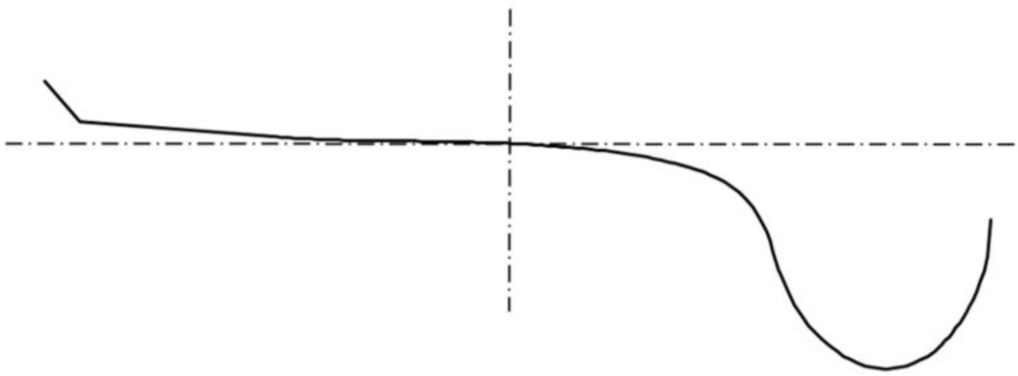


Figure 15: P10 profile

P10 wheel tread profile. From BR drawing F-C-00234				
Flange width, e, mm		Flange height, h, mm		Flange angle
(measured at 13 mm above wheel datum D_0)		(measured from wheel datum D_0)		
As new	Minimum (worn)	As new	Maximum (worn)	
31 (Precise value = 31.21)	27	28 (Precise value = 28)	33	70˚

Table 26: GB control measurements for a P10 profile

G A.10.1 The P10 profile is a direct copy of the UIC 510-2 profile for wheels of diameter 1000 to 760 mm, set out in UIC 510-2 Annex B.1. In turn the UIC profile has been incorporated into EN 13715 as part of the S1002 family of profiles.

G A.10.2 The flange width is 32.5 mm measured at 10 mm from the wheel datum. Therefore, the GB P10 is identical to an EN 13715 S1002/e32,5/h28/6.7 % profile.

G A.10.3 The profile wear limits applied are in consideration of GB conditions and do not represent the actual limits for this profile.

Profile segment	Start, Ys	End, Ye	Line Z= mY +c		Arc centre (mm)		Radius (mm)
	(mm)	(mm)	Slope, m	Intercept, c	Yc	Zc	
1	0.000	7.235			20.500	9.519	20.500
2	7.235	20.337			15.000	16.000	12.000
3	20.337	30.236			11.442	8.835	20.000
4	30.236	31.573	-2.749	98.784			
5	31.573	35.000			43.789	16.446	13.000
6	35.000	102.158	Tabulated data. Identical to UIC 510-2 polynomials				
7	102.158	130.000	-0.050	3.500	Taper 6.7 %		
8	130.000	135.000	5 mm 45˚ chamfer				

Table 27: P10 tread profile equation parameters

G A.10.4 European control measurements for a new P10 profile, for reference:

- Flange width, e, at 10 mm above wheel datum D_0, 32.5 mm (EN 15313 Figure 9, P2 coordinate).
- Flange tip (EN 15313 Figure 9, P1 coordinate) Y = 21.63, Z =26.
- qR = P2 – P1 = 10.86 mm.

Flange					
Y	Z	Y	Z	Y	Z
0	9.52	12	27.62	24	24.40
0.5	14.02	12.5	27.74	24.5	23.98
1	15.84	13	27.83	25	23.54
1.5	17.22	13.5	27.91	25.5	23.06
2	18.35	14	27.96	26	22.55
2.5	19.33	14.5	27.99	26.5	22.00
3	20.20	15	28.00	27	21.40
3.5	20.98	15.5	27.99	27.5	20.76
4	21.68	16	27.96	28	20.05
4.5	22.34	16.5	27.91	28.5	19.28
5	22.94	17	27.83	29	18.41
5.5	23.49	17.5	27.74	29.5	17.43
6	24.01	18	27.62	30	16.29
6.5	24.49	18.5	27.48	30.5	14.95
7	24.95	19	27.31	31	13.58
7.5	25.37	19.5	27.12	31.5	12.20
8	25.75	20	26.91	32	10.97
8.5	26.09	20.5	26.67	32.5	10.00
9	26.39	21	26.40	33	9.19

Flange					
9.5	26.67	21.5	26.12	33.5	8.50
10	26.91	22	25.82	34	7.89
10.5	27.12	22.5	25.50	34.5	7.35
11	27.31	23	25.16	35	6.87
11.5	27.48	23.5	24.79	See A.10.5	

Table 28: P10 tread profile flange coordinate data

G A.10.5 These values may also be calculated using the two 7th and 8th order polynomials set out in UIC 510-2 for the ranges Y = 35 to 44 and Y = 44 to 102.158 in the GB coordinate system.

G A.10.6 If the polynomials are used, the Z values need to be evaluated in the European coordinate system and then the Y values offset for the GB coordinate system (see A.1).

G A.10.7 The tabulated values set out in EN 13715 Annex C for a 32.5 mm wide flange are equally applicable.

Y	Z	Y	Z	Y	Z	Y	Z
35	6.87	53	1.19	71	-0.03	89	-0.30
36	6.04	54	1.08	72	-0.06	90	-0.31
37	5.36	55	0.97	73	-0.09	91	-0.33
38	4.79	56	0.87	74	-0.11	92	-0.35
39	4.32	57	0.77	75	-0.13	93	-0.37
40	3.92	58	0.68	76	-0.15	94	-0.40
41	3.58	59	0.60	77	-0.17	95	-0.43
42	3.27	60	0.52	78	-0.18	96	-0.46
43	3.00	61	0.45	79	-0.20	97	-0.50
44	2.74	62	0.38	80	-0.21	98	-0.54
45	2.51	63	0.32	81	-0.22	99	-0.60

Y	Z	Y	Z	Y	Z	Y	Z
46	2.30	64	0.26	82	-0.23	100	-0.65
47	2.10	65	0.21	83	-0.24	101	-0.71
48	1.92	66	0.16	84	-0.25	102	-0.77
49	1.75	67	0.12	85	-0.26	102.16	-0.78
50	1.60	68	0.07	86	-0.27	130	-2.64
51	1.45	69	0.04	87	-0.27	135	-7.64
52	1.32	70	0	88	-0.29		

Table 29: P10 tread profile tread coordinate data

A.11 P11 Wheel tread profile

Guidance

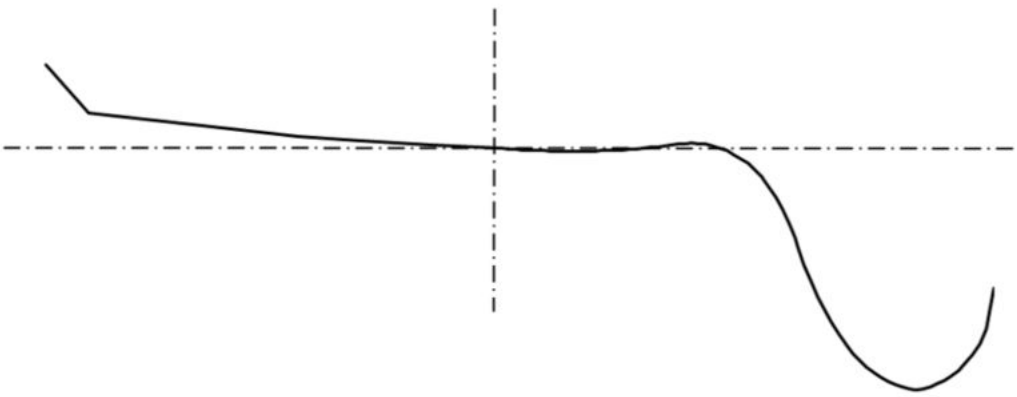


Figure 16: P11 profile

P11 wheel tread profile. From BR drawing C1-C1-9016365				
Flange width, e, mm (measured at 13 mm above wheel datum D_0)		Flange height, h, mm (measured from wheel datum D_0)		Flange angle
As new	Minimum (worn)	As new	Maximum (worn)	
28 (Precise value = 27.59)	24	30 (Precise value = 29.92)	34	Tangent 60˚

Table 30: GB control measurements for a P11 profile

Profile segment	**Start, Ys**	**End, Ye**	**Line Z= mY +c**		**Arc centre (mm)**		**Radius (mm)**
	(mm)	**(mm)**	**Slope, m**	**Intercept, c**	**Yc**	**Zc**	
1	0.000	11.113			12.700	17.320	12.700
2	11.113	21.322			8.730	14.225	15.875
3	21.322	28.318			-16.455	-5.108	47.625
4	28.318	32.801			49.000	18.626	22.000
5	32.801	44.653			43.000	13.331	14.000
6	44.653	66.492			60.000	-129.662	130.000
7	66.492	99.000	-0.050	3.500	Taper 1 in 20		
8	99.000	129.000	-0.100	8.500	Taper 1 in 10		
9	129.000	135.000	6 mm 45° chamfer				

Table 31: P11 tread profile equation parameters

Y	Z	Y	Z	Y	Z	Y	Z
0	17.32	15	28.81	30	7.54	45	-0.53
0.5	20.85	15.5	28.58	30.5	6.72	45.5	-0.44
1	22.26	16	28.34	31	5.98	46	-0.34
1.5	23.31	16.5	28.07	31.5	5.29	46.5	-0.22
2	24.16	17	27.78	32	4.66	47	-0.31
2.5	24.89	17.5	27.46	32.5	4.07	47.5	-0.26
3	25.52	18	27.11	33	3.53	48	-0.22
3.5	26.08	18.5	26.74	33.5	3.05	48.5	-0.17
4	26.57	19	26.33	34	2.61	49	-0.13
4.5	27.02	19.5	25.89	34.5	2.21	49.5	-0.09
5	27.42	20	25.41	35	1.84	50	-0.05
5.5	27.78	20.5	24.88	35.5	1.51	51	0.03
6	28.11	21	24.30	36	1.21	52	0.09
6.5	28.40	21.5	23.66	36.5	0.93	53	0.15
7	28.67	22	22.99	37	0.68	54	0.20
7.5	28.91	22.5	22.29	37.5	0.46	55	0.24
8	29.12	23	21.56	38	0.25	56	0.28
8.5	29.31	23.5	20.81	38.5	0.07	57	0.30
9	29.47	24	20.02	39	-0.09	58	0.32
9.5	29.61	24.5	19.20	39.5	-0.22	59	0.33
10	29.73	25	18.34	40	-0.34	60	0.34
10.5	29.83	25.5	17.43	40.5	-0.44	62	0.32
11	29.91	26	16.47	41	-0.53	64	0.28

Y	Z	Y	Z	Y	Z	Y	Z
11.5	29.86	26.5	15.46	41.5	-0.59	66	0.20
12	29.76	27	14.38	42	-0.63	66.5	0.18
12.5	29.65	27.5	13.23	42.5	-0.66	70	0
13	29.52	28	11.98	43	-0.67	99	-1.45
13.5	29.37	28.5	10.64	43.5	-0.66	129	-4.45
14	29.20	29	9.46	44	-0.63	135	-10.45
14.5	29.01	29.5	8.44	44.5	-0.59		

Table 32: P11 tread profile coordinate data

G A.11.1 European control measurements for a new P11 profile, for reference:

- Flange width, e, at 10 mm above wheel datum D_0, 28.76 mm (EN 15313 Figure 9, P2 coordinate).
- Flange tip (EN 15313 Figure 9, P1 coordinate) Y =16.76, Z = 27.92.
- qR = P2 – P1 = 12.0 mm.

A.12 P12 Wheel tread profile

Guidance

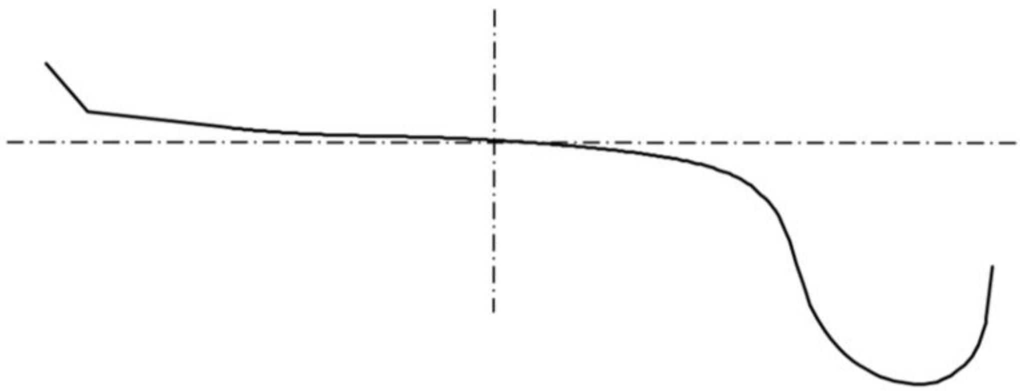


Figure 17: P12 profile

Note: The P12 profile was formerly referred to as WRISA 2

P12 wheel tread profile. From Network Rail drawing RV-C0-2400412				
Flange width, e, mm (measured at 13 mm above wheel datum D_0)		Flange height, h, mm (measured from wheel datum D_0)		Flange angle
As new	Minimum (worn)	As new	Maximum (worn)	
28.5 (Precise value = 28.78)	24	30 (Precise value = 30.11)	36	69.93˚

Table 33: GB control measurements for a P12 profile

Profile segment	**Start, Ys**	**End, Ye**	**Line Z= mY + c**		**Arc centre (mm)**		**Radius (mm)**
	(mm)	**(mm)**	**Slope, m**	**Intercept, c**	**Yc**	**Zc**	
1	0.000	0.893	-7.116	28.266			
2	0.893	10.320			10.320	20.590	9.520
3	10.320	26.720			10.320	12.650	17.460
4	26.720	29.000	-2.737	91.778			
5	29.000	108.690	Tabulated data				
6	108.690	129.000	-0.100	9.281	Taper 1 in 10		
7	129.000	135.000	6 mm 45˚ chamfer				

Table 34: P12 tread profile equation parameters

X	Y	X	Y	X	Y	X	Y
0	15.56	27.5	16.51	55	1.09	82.5	-0.48
0.5	19.12	28	15.14	55.5	1.05	83	-0.49
1	22.53	28.5	13.77	56	1	83.5	-0.5
1.5	24.17	29	12.4	56.5	0.96	84	-0.51
2	25.22	29.5	11.23	57	0.91	84.5	-0.52
2.5	26.02	30	10.23	57.5	0.87	85	-0.53
3	26.68	30.5	9.39	58	0.83	85.5	-0.54
3.5	27.23	31	8.68	58.5	0.79	86	-0.54
4	27.71	31.5	8.08	59	0.74	86.5	-0.55
4.5	28.12	32	7.55	59.5	0.7	87	-0.56
5	28.48	32.5	7.08	60	0.66	87.5	-0.57
5.5	28.8	33	6.66	60.5	0.63	88	-0.58
6	29.07	33.5	6.27	61	0.59	88.5	-0.59
6.5	29.31	34	5.9	61.5	0.55	89	-0.6
7	29.51	34.5	5.57	62	0.51	89.5	-0.61
7.5	29.68	35	5.27	62.5	0.47	90	-0.62
8	29.82	35.5	4.99	63	0.44	90.5	-0.63
8.5	29.93	36	4.74	63.5	0.4	91	-0.64
9	30.02	36.5	4.51	64	0.37	91.5	-0.65
9.5	30.07	37	4.31	64.5	0.33	92	-0.66
10	30.1	37.5	4.12	65	0.3	92.5	-0.67
10.5	30.11	38	3.95	65.5	0.27	93	-0.69
11	30.1	38.5	3.79	66	0.24	93.5	-0.7

X	Y	X	Y	X	Y	X	Y
11.5	30.07	39	3.63	66.5	0.2	94	-0.71
12	30.03	39.5	3.48	67	0.17	94.5	-0.73
12.5	29.97	40	3.34	67.5	0.14	95	-0.74
13	29.9	40.5	3.2	68	0.11	95.5	-0.76
13.5	29.82	41	3.08	68.5	0.08	96	-0.78
14	29.72	41.5	2.96	69	0.06	96.5	-0.79
14.5	29.6	42	2.85	69.5	0.03	97	-0.81
15	29.47	42.5	2.74	70	0	97.5	-0.83
15.5	29.32	43	2.64	70.5	-0.03	98	-0.85
16	29.16	43.5	2.55	71	-0.05	98.5	-0.87
16.5	28.98	44	2.46	71.5	-0.08	99	-0.9
17	28.78	44.5	2.37	72	-0.1	99.5	-0.92
17.5	28.57	45	2.29	72.5	-0.13	100	-0.94
18	28.33	45.5	2.21	73	-0.15	100.5	-0.97
18.5	28.08	46	2.13	73.5	-0.17	101	-1
19	27.8	46.5	2.06	74	-0.2	101.5	-1.02
19.5	27.5	47	1.99	74.5	-0.22	102	-1.05
20	27.18	47.5	1.92	75	-0.24	102.5	-1.08
20.5	26.84	48	1.85	75.5	-0.26	103	-1.12
21	26.46	48.5	1.78	76	-0.28	103.5	-1.15
21.5	26.06	49	1.72	76.5	-0.3	104	-1.18
22	25.63	49.5	1.66	77	-0.32	104.5	-1.22
22.5	25.16	50	1.6	77.5	-0.33	105	-1.26

X	Y	X	Y	X	Y	X	Y
23	24.65	50.5	1.54	78	-0.35	105.5	-1.3
23.5	24.1	51	1.48	78.5	-0.37	106	-1.34
24	23.5	51.5	1.43	79	-0.38	106.5	-1.38
24.5	22.84	52	1.38	79.5	-0.4	107	-1.43
25	22.1	52.5	1.33	80	-0.41	107.5	-1.47
25.5	21.28	53	1.28	80.5	-0.43	108	-1.52
26	20.33	53.5	1.23	81	-0.44	108.5	-1.57
26.5	19.21	54	1.18	81.5	-0.45	129	-3.62
						135	-9.62

Table 35: P12 tread profile coordinate data

G A.12.1 European control measurements for a new P12 profile, for reference:

- Flange width, e, at 10 mm above wheel datum D_0, 30.39 mm (EN 15313 Figure 9, P2 coordinate), value derived by interpolation.
- Flange tip (EN 15313 Figure 9, P1 coordinate) Y = 16.16, Z = 28.11.
- qR = P2 – P1 = 12.62 mm.

A.13 P10/RD9 Wheel tread profile

Guidance

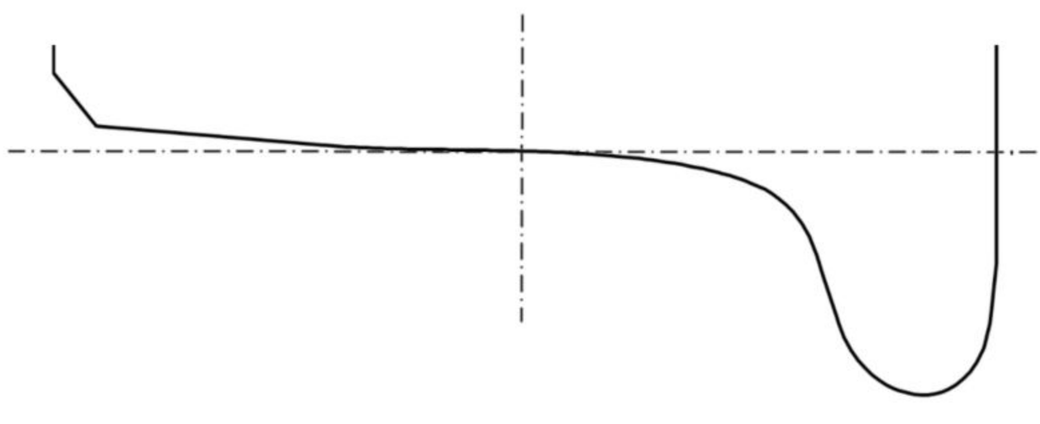


Figure 18: P10/RD9 profile

P10/RD9 wheel tread profile				
Flange width, e, mm (measured at 13 mm above wheel datum D_0)		Flange height, h, mm (measured from wheel datum D_0)		Flange angle
As new	Minimum (worn)	As new	Maximum (worn)	
25.5 (Precise value =25.54)	24	28 (Precise value = 28)	33	68˚

Table 36: GB control measurements for a P10/RD9 profile

Profile segment	Start, Ys	End, Ye	Line Z= mY + c		Arc centre (mm)		Radius (mm)
	(mm)	(mm)	Slope, m	Intercept, c	Yc	Zc	
1	0.000	1.157	7.115	11.590			
2	1.157	10.560			10.564	18.500	9.500
3	10.560	22.820			10.564	14.781	13.218
4	22.821	26.058	-2.475	76.215			
5	26.057	29.322			38.111	16.591	13.000
6	29.322	96.480	Tabulated Data				
7	96.480	137.000	-0.067	5.797			
8	137.000	143.000	6 mm 45˚ chamfer				

Table 37: P10/RD9 tread profile equation parameters

Y	Z	Y	Z	Y	Z	Y	Z
0	11.59	23	19.29	48.3	1.22	77.3	-0.09
1	18.71	24	16.81	49.3	1.11	78.3	-0.10
1.2	19.82	25	14.34	50.3	1.01	79.3	-0.11
1.2	19.82	26	11.86	51.3	0.92	80.3	-0.12
2	22.61	26.1	11.72	52.3	0.83	81.3	-0.13
3	24.25	26.1	11.72	53.3	0.74	82.3	-0.14
4	25.37	27	9.84	54.3	0.67	83.3	-0.15
5	26.20	28	8.42	55.3	0.60	84.3	-0.17
6	26.83	29	7.32	56.3	0.53	85.3	-0.18
7	27.31	29.3	7.01	57.3	0.47	86.3	-0.20
8	27.65	29.3	7.01	58.3	0.41	87.3	-0.23
9	27.87	30.3	6.18	59.3	0.36	88.3	-0.25
10	27.98	31.3	5.50	60.3	0.31	89.3	-0.28
10.6	28.00	32.3	4.94	61.3	0.26	90.3	-0.32
10.6	28.00	33.3	4.47	62.3	0.22	91.3	-0.35
11	27.99	34.3	4.07	63.3	0.18	92.3	-0.40
12	27.92	35.3	3.72	64.3	0.14	93.3	-0.45
13	27.77	36.3	3.41	65.3	0.11	94.3	-0.50
14	27.55	37.3	3.14	66.3	0.08	95.3	-0.56
15	27.23	38.3	2.89	67.3	0.06	96.3	-0.62
16	26.83	39.3	2.65	68.3	0.03	96.5	-0.64
17	26.33	40.3	2.44	69.3	0.01	100	-0.87
18	25.71	41.3	2.25	70.3	-0.01	110	-1.54

Y	Z	Y	Z	Y	Z	Y	Z
19	24.96	42.3	2.06	71.3	-0.02	120	-2.20
20	24.04	43.3	1.90	72.3	-0.04	137	-3.34
21	22.9	44.3	1.74	73.3	-0.05	143	-9.34
22	21.41	45.3	1.60	74.3	-0.06		
22.8	19.73	46.3	1.46	75.3	-0.07		
22.8	19.73	47.3	1.34	76.3	-0.08		

Table 38: P10/RD9 flange and run-out profile coordinate data

G A.13.1 European control measurements for a new P10/RD9 profile, for reference:

- Flange width, e, at 10 mm above wheel datum D_0, 26.91 mm (EN 15313 Figure 9, P2 coordinate), value derived by interpolation.
- Flange tip (EN 15313 Figure 9, P1 coordinate) Y = 17.6, Z = 26.0.
- qR = P2 – P1 = 9.31 mm.

Appendix B Economic Tread Turning

B.1 Economic tread turning

Guidance

G B.1.1 A wheelset's life can be extended by turning the wheels with a thinner flange (compared to the full design profile). The use of thinner flanges in this way is termed Economic Tread Turning (ETT), as by this method the amount of material that is removed to create an acceptable profile is minimised.

G B.1.2 EN 13715 allows a range of flange widths to make ETT possible for the 1/40, S1002 and EPS profiles.

G B.1.3 For coned GB wheel profiles (P1, P5, P6 and P9) a lateral translation is made of the whole profile from flange tip to field side chamfer in order to create thin flange variants and an extension of the tread runout. This method maintains the same relationship between Rolling Radius Differential (RRD) and lateral displacement, in normal tread contact, and therefore results in the same dynamic behaviour.

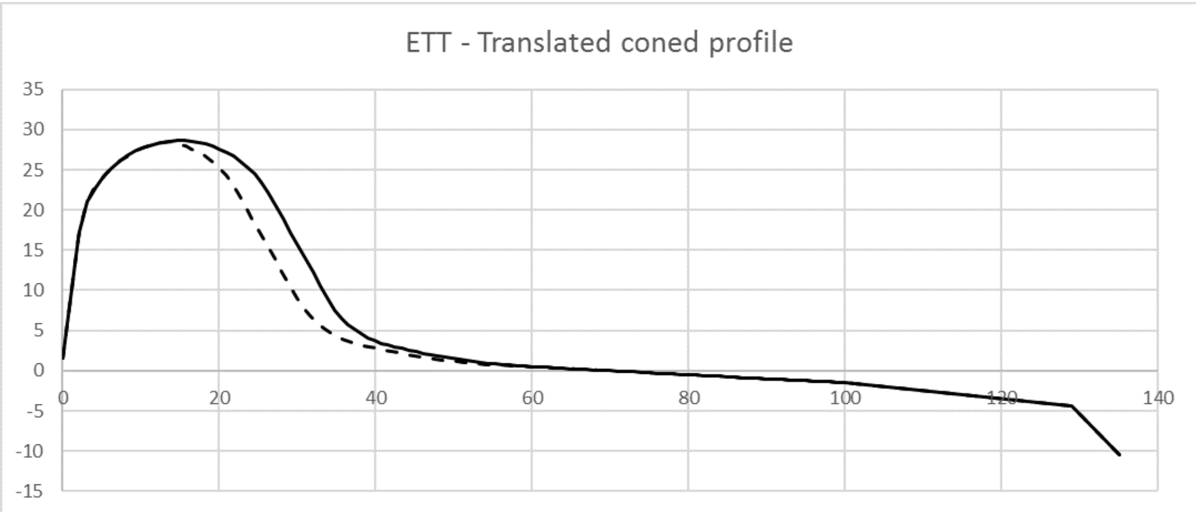


Figure 19: Translated coned profile

G B.1.4 For the GB wheel profiles containing curved treads (P8, P10, P11, P12), a method involving stretching the wheel profiles in the flange root area is used, based on the EN 13715 Annex D approach. This approach means, for these profiles, the relationship between RRD and lateral displacement can also be maintained.

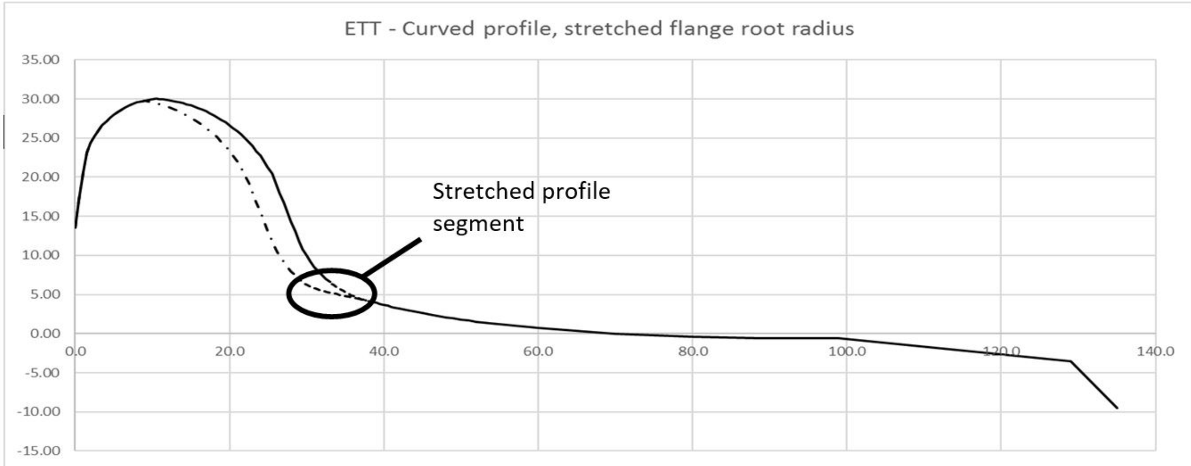


Figure 20: Translated curved profile

G B.1.5 The profile segment numbers in this appendix are the same as those defined in Appendix *A*. Segments that are translated are given the suffix 'T'. If a segment is split, the fixed portion retains the segment number and the translated portion is given the suffix 'T'. A segment that is stretched has the same number as the segment it is taken from, with a suffix 'S'.

G B.1.6 The following sections define the equations and parameters that define the tread coordinates for each profile that permits ETT.

Tread profile	Flange width (mm) (measured at 13 mm)		ETT profile increments (mm)			
	as new	Minimum (worn)				
P1	28.0	24.0	-1.0	-2.0	-3.0	-
P5	31.5	27.0	-0.5	-1.5	-2.5	-3.5
P6	28.5	24.0	-0.5	-1.5	-2.5	-3.5
P8	28.5	24.0	-0.5	-1.5	-2.5	-3.5
P9	21.5	18.0	-1.0	-2.0	-3.0	-
P10	31.0	27.0	-1.0	-2.0	-3.0	-
P11	28.0	24.0	-1.0	-2.0	-3.0	-
P12	28.5	24.0	-0.5	-2.0	-2.5	-3.5

Table 39: ETT calculated tread profiles

Note: The ‘as new’ flange width defines the nominal full-size profile width, before taking into account the reduction by the ETT profile increments.

G B.1.7 Calculated coordinates in selected flange width increments are available in spreadsheet format on the page for this document on RSSB's online Standards Catalogue.

B.2 P1 ETT profiles

Guidance

G B.2.1 For a detailed description of the profile and wear limits, see *A.4*.

G B.2.2 In the following equations ΔY denotes the difference between the standard flange width, 28 mm, and the ETT flange width required. ΔY cannot theoretically be greater than 4 mm, which would take the profile to the wear limit.

G B.2.3 Yi, Zi are calculated according to the method set out in *B.9*. For a full width flange, Yi = 11.113 mm.

G B.2.4 ΔZ is the cone angle multiplied by the offset; ΔZ = ΔY / 20 (see *B.11*).

Profile segment	Start, Y_s (mm)	End, Y_e (mm)	Line Z= mY +c		Arc centre (mm)		Radius (mm)
			Slope, m	Intercept, c	Y_c	Z_c	
1	0.000	Yi			12.700	17.331	12.700
2T	Yi	21.062 - ΔY			8.730 - ΔY	14.237 + ΔZ	15.875
3T	21.062 - ΔY	28.466 - ΔY			-15.935 - ΔY	-5.758 + ΔZ	47.626
4T	28.466 - ΔY	42.466 - ΔY			43.259 - ΔY	17.232 + ΔZ	-15.875
5T	42.466 - ΔY	70.000	-0.050	3.500	Taper 1 in 20		
6	70.000	135.000	-0.050	3.500			

Table 40: P1 ETT Tread profile equations

G B.2.5 Table *40* is to be read in conjunction with *A.4*, Table *9*.

B.3 P5 ETT profiles

Guidance

G B.3.1 For detailed description of the profile and wear limits, see *A.5*.

G B.3.2 In the following equations ΔY denotes the difference between the standard flange width, 28.5 mm, and the ETT flange width required. ΔY cannot theoretically be greater than 4.5 mm, which would take the profile to the wear limit.

G B.3.3 Yi, Zi are calculated according to the method set out in *B.9*. For a full width flange, Yi = 15 mm.

G B.3.4 ΔZ is the cone angle multiplied by the offset; ΔZ = ΔY / 20 (see *B.11*).

Profile segment	Start, Y_s (mm)	End, Y_e (mm)	Line Z= mY +c		Arc centre (mm)		Radius (mm)
			Slope, m	Intercept, c	Y_c	Z_c	
1	0.0	2.116	7.435	1.625			
2	2.1160	Y_i			15.000	15.625	13.000
3T	Yi	26.251 - ΔY			15.000 - ΔY	15.625 + ΔZ	13.000
4T	26.251 - ΔY	33.929 - ΔY	-1.732	8.839 +ΔZ -1.732 x33.929			
5T	33.929 - ΔY	41.501 - ΔY	n/a		44.321 - ΔY	14.839 + ΔZ	-12.000
6T	41.501 - ΔY	60.006 - ΔY	n/a		65.000 - ΔY	100.375 + ΔZ	-100.000
7T	60.006 - ΔY	70.000	-0.050	3.500			
8	70.000	100.000	-0.050	3.500			
9	100.000	135.000	-0.100	8.500			

Table 41: P5 ETT Tread profile equations

G B.3.5 Table *41* to be read in conjunction with *A.5*, Table *12*.

B.4 P6 ETT profiles

Guidance

G B.4.1 For detailed description of the profile and wear limits, see *A.6*.

G B.4.2 In the following equations ΔY denotes the difference between the standard flange width, 28.5 mm, and the ETT flange width required. ΔY cannot theoretically be greater than 4.5 mm, which would take the profile to the wear limit.

G B.4.3 Yi, Zi are calculated according to the method set out in *B.9*. For a full width flange, Yi = 10.5 mm.

G B.4.4 ΔZ is the cone angle multiplied by the offset; ΔZ = ΔY / 20 (see *B.11*).

Profile segment	Start, Y_s (mm)	End, Y_e (mm)	Line Z= mY +c		Arc centre (mm)		Radius (mm)
			Slope, m	Intercept, c	Y_c	Z_c	
1	0.000	1.111	7.116	13.500			
2	1.111	Y_i			11.014	20.013	10.000
3T	Yi	26.021 - ΔY			9.332 - ΔY	12.038 + ΔZ	18.000
4T	26.021 - ΔY	28.947 - ΔY	-2.475	83.1847-2.475 1xΔY			
5T	28.947 - ΔY	37.638 - ΔY			41.000 - ΔY	16.410 + ΔZ	-13.000
6T	37.638 - ΔY	58.506 - ΔY			63.500 - ΔY	100.450 + ΔZ	-100.000
7T	58.506 - ΔY	70.000	-0.050	3.500			
8	70.000	100.000	-0.050	3.500			
9	100.000	135.000	-0.100	8.500			

Table 42: P6 ETT Tread profile equations

G B.4.5 Table 42 to be read in conjunction with A.6, Table 1512.

B.5 P8 ETT profiles

Guidance

G B.5.1 For a detailed description of the profile and wear limits, see A.8.

G B.5.2 In the following equations ΔY denotes the difference between the standard flange width, 28.5 mm, and the ETT flange width required. ΔY cannot theoretically be greater than 4.5 mm, which would take the profile to the wear limit.

G B.5.3 Yi, Zi are calculated according to the method set out in B.9. For a full width flange, Yi = 10.5 mm.

G B.5.4 The stretch zone is defined between Y = 33.29 and Y = 37.639.

Profile segment	Start, Y_s (mm)	End, Y_e (mm)	Line Z= mY +c		Arc centre (mm)		Radius (mm)
			Slope, m	Intercept, c	Y_c	Z_c	
1	0.0	1.111	7.115	13.500			
2	1.111	Y_i			11.014	20.013	10.000
3T	Yi	26.188 - ΔY			9.506 - ΔY	12.028	18.000
4T	26.188 - ΔY	28.947 - ΔY	- 2.475	83.606 -2.475 xΔY			
5T	28.947 - ΔY	33.290 - ΔY			41.0	16.830	-13.000
6S	33.290 - ΔY	37.639	Stretch zone		41.0	16.803	-13.000
7	37.639	52.413			63.5	100.871	-100.000
8	52.413	70.000			89.000	329.453	-330.000
9	70.000	89.000			89.000	329.453	-330.000
10	89.000	99.000	0.000	-0.547	Taper 1 in 10		
11	99.000	135.000	0.100	9.353			

Table 43: P8 ETT Tread profile equations

G B.5.5 Table *43* to be read in conjunction with *A.8*, Table *21*.

B.6 P10 ETT profiles

Guidance

G B.6.1 For a detailed description of the profile and wear limits, see *A.10*.

G B.6.2 In the following equations ΔY denotes the difference between the standard flange width, 31 mm, and the ETT flange width required. ΔY cannot theoretically be greater than 4 mm, which would take the profile to the wear limit.

G B.6.3 Yi, Zi are calculated according to the method set out in *B.9*. For a full width flange, Yi = 15 mm.

G B.6.4 The stretch zone is defined between Y = 56.0 and Y = 61.0.

Profile segment	Start, Y_s (mm)	End, Y_e (mm)	Line Z= mY +c		Arc centre (mm)		Radius (mm)
			Slope, m	Intercept, c	Y_c	Z_c	
1	0.07.235	7.235			20.500	9.519	20.500
2	7.235	Y_i			15.000	16.000	12.000
3T	Yi	20.337 - ΔY			15.000 - ΔY	16.000	12.000
4T	20.337 - ΔY	30.236 - ΔY			11.442 - ΔY	8.835	20.000
5T	30.236 - ΔY	33.290 - ΔY	- 2.475	31.573+ΔZ-2.7487 x 31.573			
6T	31.573 - ΔY	35.000 - ΔY			43.789 - ΔY	16.446	-13.000
7T	35.000 - ΔY	44.000 - ΔY	Tabulated UIC coordinates		70.000 - ΔY	0.000	
8T	44.000 - ΔY	56.000 - ΔY			70.000 - ΔY	0.000	
9S	56.000 - ΔY	89.000			70.000 - ΔY	0.000	
10	61.000	70.000			70.000	0.000	
11	70.000	102.158			70.000	0.000	
12	102.158	135.000	-0.067	6.031			

Table 44: P10 ETT Tread profile equations

G B.6.5 Table *44* to be read in conjunction with *A.10*, Table *27*.

B.7 P11 ETT profiles

Guidance

G B.7.1 For a detailed description of the profile and wear limits, see *A.11*.

G B.7.2 In the following equations ΔY denotes the difference between the standard flange width, 28 mm, and the ETT flange width required. ΔY cannot theoretically be greater than 4 mm, which would take the profile to the wear limit.

G B.7.3 Yi, Zi are calculated according to the method set out in *B.9*. For a full width flange, Yi = 11.113 mm.

G B.7.4 The stretch zone is defined between Y = 41.35 and Y = 44.65.

Profile segment	Start, Y_s (mm)	End, Y_e (mm)	Line Z= mY +c		Arc centre (mm)		Radius (mm)
			Slope, m	Intercept, c	Y_c	Z_c	
1	0.0	Yi			12.700	17.320	12.700
2T	Yi	21.322 - ΔY			8.370 - ΔY	14.225	15.875
3T	21.322 - ΔY	28.318 - ΔY			-16.455 - ΔY	-5.108	47.625
4T	28.318 - ΔY	32.801 - ΔY			49.000 - ΔY	18.626	-22.000
5T	32.801 - ΔY	41.350 - ΔY			43.000 - ΔY	13.331	-14.000
6S	41.350 - ΔY	44.653			43.000 - ΔY	13.331	-14.000
7	44.653	66.492			63.000	-129.662	130.000
8	66.492	70.000	-0.050	3.500			
9	70.000	99.000	-0.050	3.500			
10	99.000	135.000	-0.100	8.450			

Table 45: P11 ETT Tread profile equations

G B.7.5 Table *45* to be read in conjunction with *A.11*, Table *31*.

B.8 P12 ETT profiles

Guidance

G B.8.1 For a detailed description of the profile and wear limits, see *A.12*.

G B.8.2 In the following equations ΔY denotes the difference between the standard flange width, 28.5 mm, and the ETT flange width required. ΔY cannot theoretically be greater than 4.5 mm, which would take the profile to the wear limit.

G B.8.3 Yi, Zi are calculated according to the method set out in *B.9*. For a full width flange, Yi = 10.32 mm.

G B.8.4 The stretch zone is defined between Y = 47 and Y = 51.5.

Profile segment	Start, Y_s (mm)	End, Y_e (mm)	Line Z= mY +c		Arc centre (mm)		Radius (mm)
			Slope, m	Intercept, c	Y_c	Z_c	
1	0.0	0.893	7.116	15.563			
2	0.893	Y_i			10.320	20.590	9.520
3T	Yi	26.720 - ΔY			10.320 - ΔY	12.650	17.460
4T	26.720 - ΔY	29.000 - ΔY	- 2.737	12.4 -2.737 x29 -ΔY			
5T	29.000 - ΔY	47.000 - ΔY	Tabulated P12 data				
6S	47.000 - ΔY	51.500					
7	51.500	70.000					
8	70.000	108.500					
9	108.500	135.000	-0.100	9.281			

Table 46: P12 ETT Tread profile equations

G B.8.5 Table 46 to be read in conjunction with A.12, Table 34.

B.9 Calculation of flange tip intersections

Guidance

G B.9.1 To generate an ETT profile the intersection of the inner and outer flange curves at the flange tip is calculated.

G B.9.2 For two arcs at centres Y_{C1}, Z_{C1}, Y_{C2}, Z_{C21} and respective radii R_1 and R_2, the intersection Y_i, Z_i, can be calculated using the following formulae:

$$L = \sqrt{(Y_{C1} - Y_{C2})^2 + (Z_{C1} - Z_{C2})^2}$$

$$A = \frac{1}{4}\sqrt{(L + R_1 + R_2).(L + R_1 - R_2).(L - R_1 + R_2).(-L + R_1 + R_2)}$$

$$Y_i = \frac{(Y_{C1}+Y_{C2})}{2} + \frac{(R_1^2 - R_2^2)}{2L^2}\,.(Y_{C2} - Y_{C1}) \pm 2A\frac{(Z_{C2} - Z_{C1})}{L^2}$$

$$Z_i = \frac{(Z_{C1}+Z_{C2})}{2} + \frac{(R_1^2 - R_2^2)}{2L^2}\,.(Z_{C2} - Z_{C1}) \mp 2A\frac{(Y_{C2} - Y_{C1})}{L^2}$$

G B.9.3 The correct pair of coordinates (Y_i, Z_i) is determined by inspection.

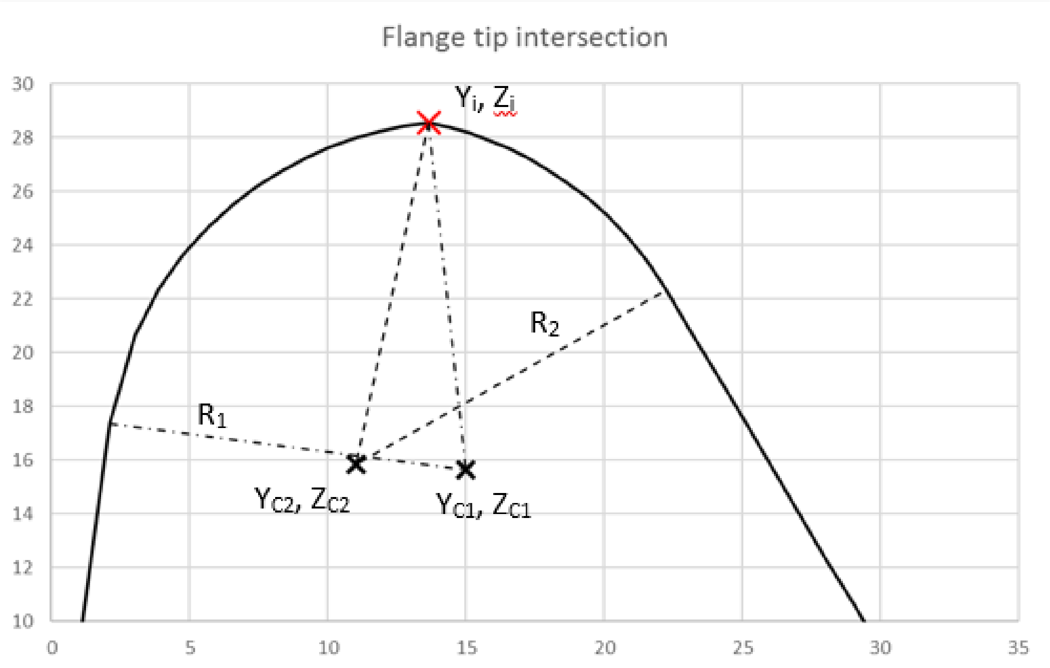


Figure 21: Flange tip intersection

B.10 Calculation of stretch zones

Guidance

G B.10.1 For the EPS profile defined in EN 13715 Annex D, part of the flange root radius is stretched. A similar approach has been adopted for use with GB profiles.

G B.10.2 For each profile a stretch zone has been defined. The coordinates are given in the individual ETT profile descriptions.

G B.10.3 For the stretch zone the Y, Z coordinates are evaluated for the standard profile and then the Y values are modified to stretch the segment to fit to the thinner ETT flange.

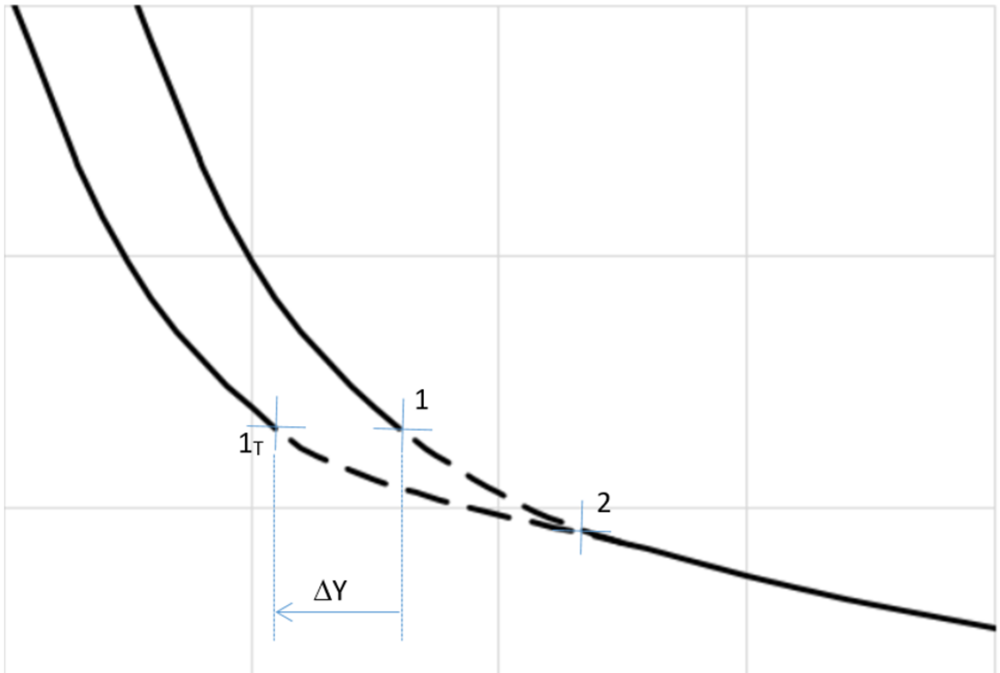


Figure 22: ETT stretch transfer function

G B.10.4 A transfer function is defined between Y_1 and Y_2 as:

$$T = \frac{1 + sin\left(\pi \frac{Y_O - Y_m}{Y_1 - Y_2}\right)}{2}$$

Where $$Y_m = \frac{Y_1 + Y_2}{2}$$

G B.10.5 Y_O is the Y coordinate of a point in the stretch zone (for the standard, design flange thickness profile).

G B.10.6 So the translated Y coordinates for the stretch zone are:

$$Y_T = Y_O - T.\Delta Y$$

G B.10.7 Where ΔY is the reduction in flange thickness.

G B.10.8 The transformed Y value is paired with the original Z value; that is, coordinate (Y_O, Z_O) becomes (Y_T, Z_O).

B.11 Radial adjustment for coned profiles

Guidance

G B.11.1 Where coned profiles are translated laterally (Y), the translated profile is also translated radially (Z) to maintain the datum point of (70, 0). Typically, this radial increment is small since it is a function of the tread cone angle.

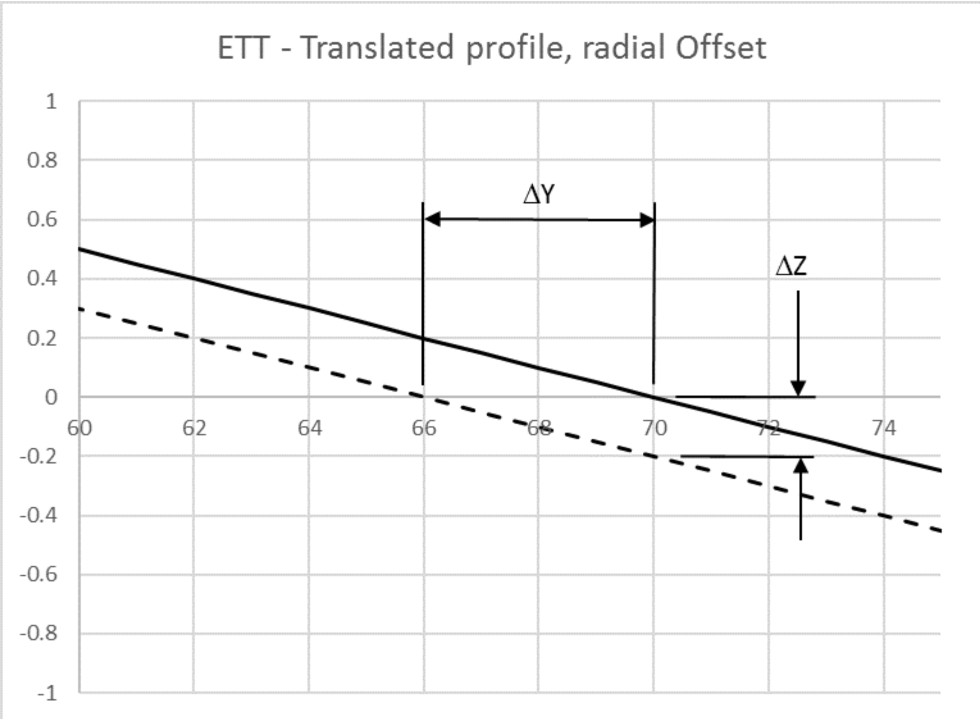


Figure 23: ETT radial offset adjustment

Appendix C Safety at Obtuse Crossings

C.1 Safety at Obtuse Crossings

C.1.1 The calculated sideslip passing through the obtuse crossing configurations set out in table 47 shall not exceed the maximum allowable sideslip for the chosen wheel tread profile.

Crossing angle	Gap (mm)	Stagger (mm)	Unchecked length L_{uc} (m)	Minimum curve radius R_{min} (m)
1 in 8.0	536	87	0.449	500
1 in 7.5	502	93	0.409	400
1 in 6.5	433	107	0.326	240
1 in 5.5	371	126	0.245	160

Table 47: Obtuse crossing data

Rationale

G C.1.2 This requirement is known as the 'low speed rule' and ensures the safe operation of wheelsets through obtuse crossings which have short gaps that allow the passage of flanges along the opposite path and therefore provide no flange guidance. Derailment risk is assessed by determining the wheelset lateral displacement when passing through a crossing gap where excessive displacement would result in contact with the tip of the point rail on a part of the flange where a contact angle of less than 45° could induce climb rather than ensure guidance into the correct path.

Guidance

G C.1.3 Sideslip, or lateral displacement, through the unguided section of an obtuse crossing is assessed using the following formula:

$$L_{uc} \quad \psi_o + \Delta_{slip} \quad + 5 \quad L_{ug} < \Delta_{crit}$$ formula (1)

Where:

L_{uc} is the unchecked length — m

Ψ_o is the steady-state angle of attack — mrad

Δ_{slip} is the lateral slip distance — mm

L_{ug} is the unguided length — m

Δ_{crit} is the allowable sideslip — mm

G C.1.4 The lateral slip distance Δ_{slip} is a function of the lateral force applied due to cant and wind loading. The resultant external lateral force on the vehicles F_{ext} is then given by the greater of:

$F_{ext} = 0.46 \; A_w$

or formula (2)

$F_{ext} = 0.23 \; A_w + 0.05 \; W$

Where:

A_w is the area exposed to the wind m^2

W is the total vehicle weight kN

F_{ext} is the resultant lateral body force kN

G C.1.5 This formula considers:

- A wind speed of 25 m/s and zero track cant.
- A wind speed of 17.5 m/s combined with an adverse track cant of 3˚.

G C.1.6 The vehicle types most at risk are two-axled high-sided vehicles with low axle loads.

G C.1.7 The maximum allowable sideslip, Δ_{crit} is the horizontal distance between the flange and wing rail at a height where a 45˚ tangent meets the flange profile when the opposing wheel back face is against the check rail as shown in figure *24*.

G C.1.8 The value of Δ_{crit} for a P6 profile for example is 9 mm.

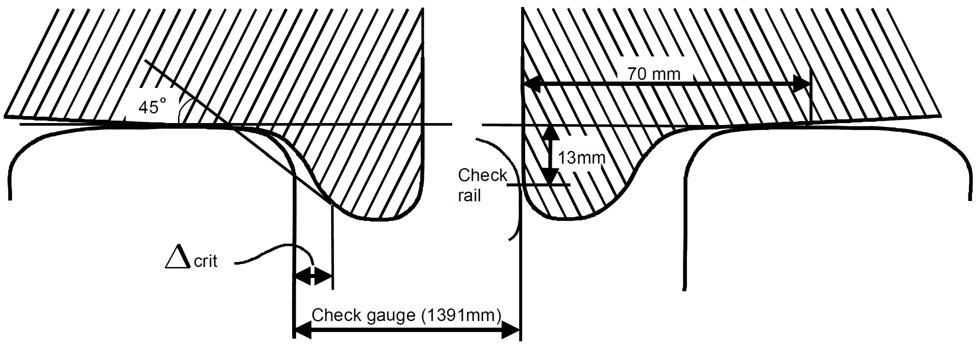


Figure 24: Definition of Δ_{crit}

G C.1.9 The unguided length, L_{ug} is then the unchecked length, L_{uc} taken from Table *47* for the chosen crossing angle minus twice the engagement, C for the chosen wheel diameter and check rail height as shown in figure *25* and is effectively the distance over which the wheel travels where flange back of front guidance is unavailable.

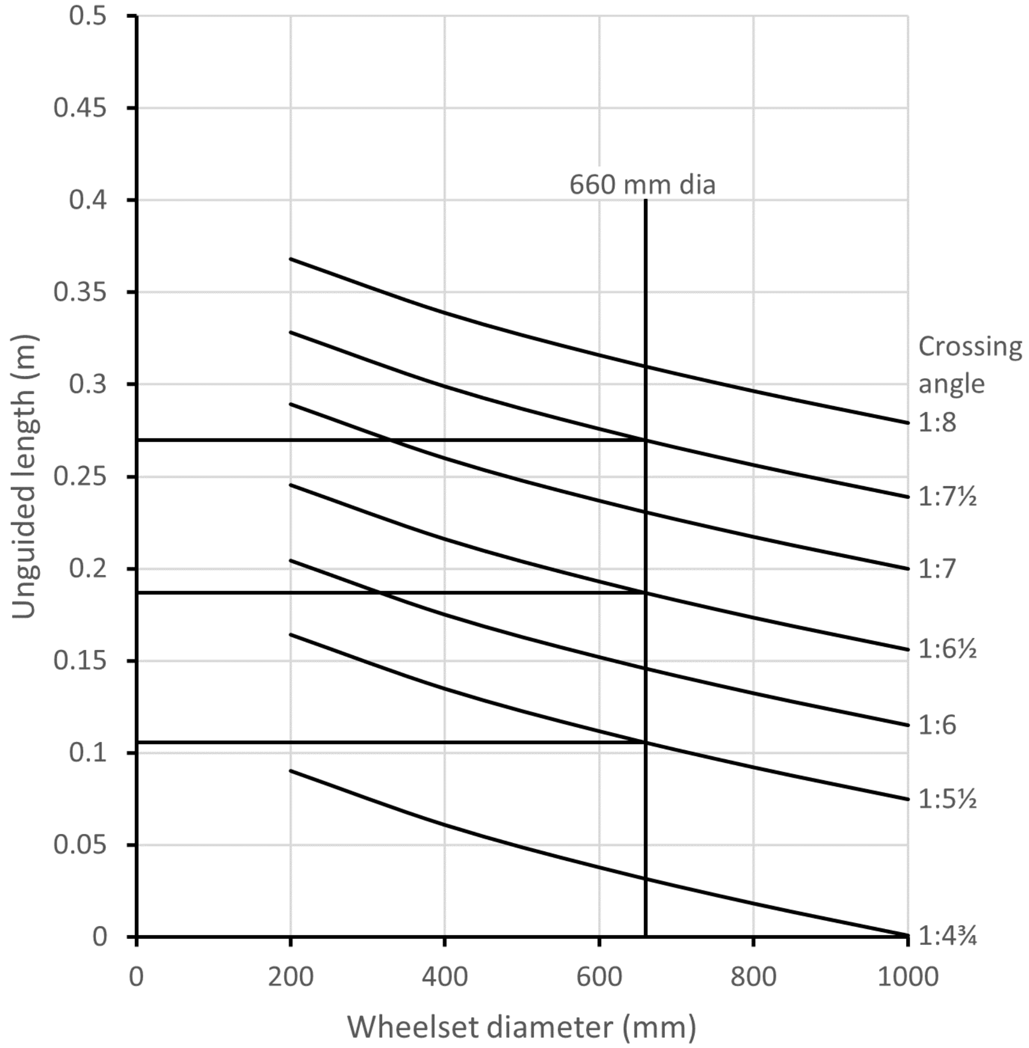


Figure 25: Unguided length (as a function of wheel diameter and crossing angle)

G C.1.10 The engagement length, C is the maximum distance ahead of and behind the point directly below the axle centreline where flange back contact with the check rail can occur. It is assumed that the extreme point of contact on the flange back is at points on a 'checking circle' 20 mm greater in radius than the wheel tread radius. Figure *26* shows the engagement length for three different check rails as a function of wheel diameter.

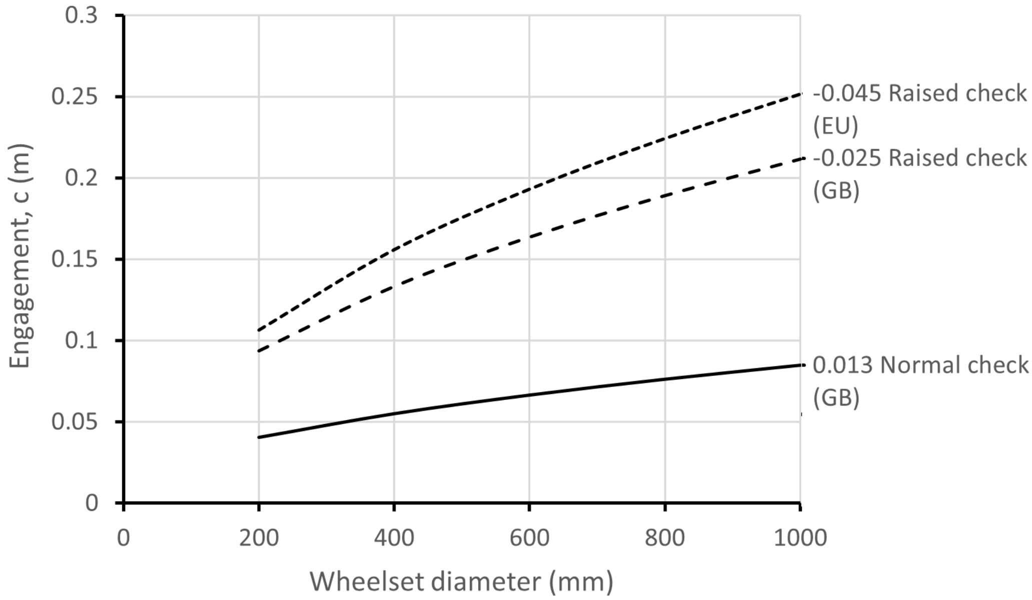


Figure 26: Engagement vs wheel diameter

$C = \sqrt{(\phi + hw + hc)(hw - hc)}$

Where:

C is the engagement length	m
ø is the wheel diameter	m
hw is the radial distance from the wheel tread to the checking circle	0.020 m
hc is the effective point on check rail below railhead	0.013 m for normal check
	-0.025 m for raised check (GB)
	-0.045 m for raised check (EU)

G C.1.11 Raised check rails are shown to indicate their potential benefit in increasing engagement.

G C.1.12 The procedure for applying formula (1) is as follows:

a) Determine the value of Δ_{crit} the maximum permissible sideways displacement in the gap for the wheel profile chosen, refer to Figure 24
b) Choose the crossing angle to be considered.
c) Determine the unchecked length L_{uc} for the crossing angle being considered, refer to Table 47
d) Determine the unguided length L_{ug} for the crossing angle and wheel diameter being considered, refer to Figure 25.
e) Determine the minimum curve radius R_{min} for the crossing angle being considered, refer to Table 47.

f) Determine the steady state angle of attack of the leading wheelset, assuming the vehicles to be running on a constant curve of radius equal to the minimum permissible radius for the crossing angle being considered. Assume a wheel / rail friction coefficient of 0.1, a track gauge of 1438 mm (nominal gauge plus 6 mm maintenance allowance) and full allowable wheel flange wear. Add to this calculated angle of attack value an allowance for the permissible wheelset yaw misalignment tolerance in the vehicle to give the Ψo value to substitute in formula (1). In determining the steady state angles of attack of the wheelsets, the external lateral forces on the vehicles are neglected.

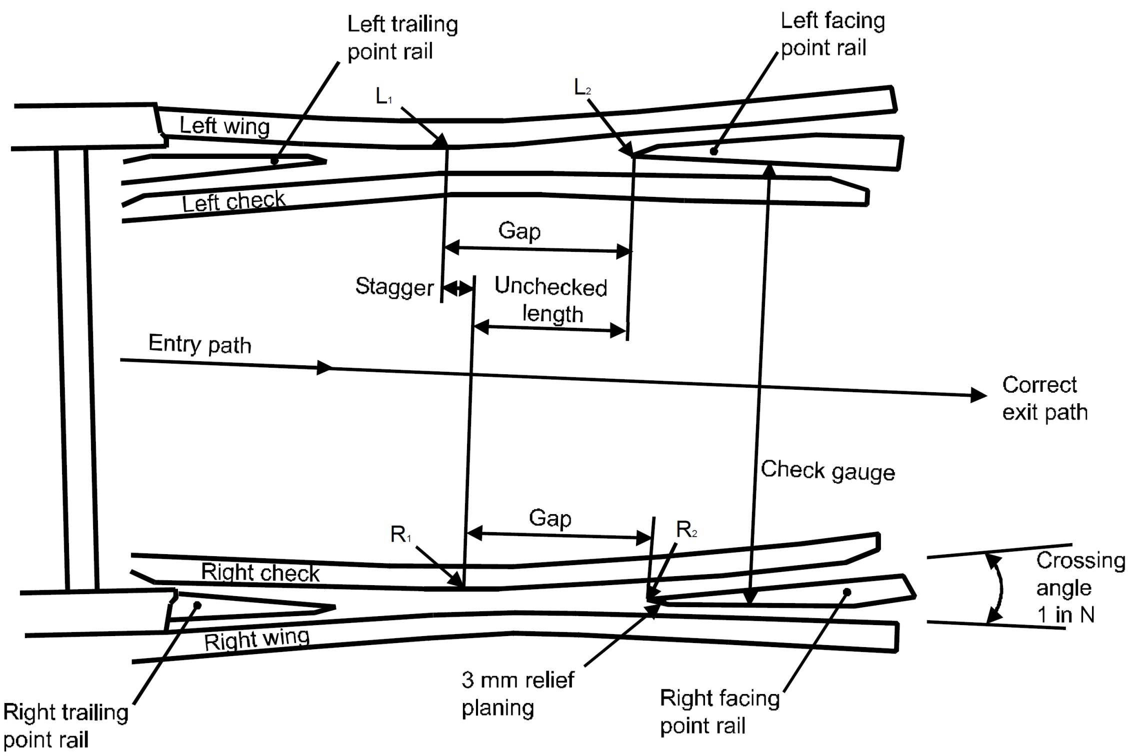
g) Superimpose on the steady state curving situation *f)* above, an external force applied to the vehicle body of F_{ext} as determined by formula (2). Calculate the value of Δ_{slip} for the leading wheelset, which would occur if its flange force were suddenly removed, assuming a wheel / rail friction coefficient of 0.1.

h) Check that the resulting total sideslip does not exceed Δ_{crit}.

i) Repeat *b)* to *h)* for the remaining crossing angles.

G C.1.13 Lateral displacement through obtuse crossings can be reduced by minimising:

- the generation of lateral loads by buffers and drawgear and by other inter-vehicle constraints;
- the possibility of braking systems causing wheel locking to avoid the occurrence of exceptionally low lateral adhesion levels; and
- the generation of lateral loads caused by vehicle and suspension parameters.



Nominal gauge	1435 mm
Nominal check gauge	1391 mm
Nominal flange way	41 mm

Figure 27: Obtuse crossing layout

Definitions

defect	Any fault(s) in a component, or assembly, which may prevent the component, or assembly, from fulfilling its design purpose.
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
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.
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.

References

The Standards Catalogue gives the current issue number and status of documents published by RSSB. This information is available from https://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

GMRT2400	Engineering Design of On-Track Machines in Running Mode

RSSB Documents

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-2766-RST	Rail Industry Standard for Wheelsets
RIS-8270-RST	Route Level Assessment of Technical Compatibility between Vehicles and Infrastructure
T641 RSSB (2008)	Cost effective turning of flange worn wheel profiles
T963 RSSB (2013)	Improving wheelset life by better understanding the causes of wheel damage

Other References

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
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BS EN 13260:2009 +A1:2010	Railway applications. Wheelsets and bogies. Wheelsets. Product requirements
BS EN 13261:2009 +A1:2010	Railway applications. Wheelsets and bogies. Axles. Product requirements
BS EN 13715:2006 +A1:2010	Railway applications. Wheelsets and bogies. Wheels. Tread profile
BS EN 13979-1:2003 +A2:2011	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
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.
Institute of Railway Research IRR Ref: 110/118	Economic Tyre Turning on GB Railways - Wheel Wear and Rail Damage Predictions (COF-UOH-09 & COF-UOH-15)
Institute of Railway Research IRR Ref: 110/239	Investigating the Need for a Maximum Flange Width in GMRT2466.
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.

SI 2011/3066	Railways (Interoperability) Regulations 2011 (as amended).
VDYN 155 (1990)	UIC small wheel profile S1002-SW and obtuse crossing negotiation
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.