Railway Group Standard
GCRT5021 | Issue Six | December 2023

Track System Requirements

This document sets out Great Britain (GB) requirements in scope of the national technical rules for track geometry, track systems and track components to provide for the safe guidance and support of rail vehicles.

Published by **Rail Safety and Standards Board**

Railway Group Standard
GCRT5021
Issue: Six
Date: December 2023

Track System Requirements

Synopsis

This document sets out Great Britain (GB) requirements in scope of the national technical rules for track geometry, track systems and track components to provide for the safe guidance and support of rail vehicles.

Published by RSSB

Issue record

Issue	Date	Comments
One	April 2000	Original document Superseded Railway Group Standard GCRT5010 and GCRT5017 with some further additions.
Two	October 2003	Replaces issue one Incorporated changes advised in GCGN5523 and requirements held in GCRT5011 issue two, GCRT5014 issue one and GCRT5024 issue one.
Three	April 2007	Replaces issue two Incorporates requirements held in GCRT5014 issue two, GCRT5022 issue two, and GIRT7004 issue one. Requirements that do not meet the risk scope test set out in the Railway Group Standards Code (issue two, 2006) have been withdrawn.
Four	December 2009	Small scale change, replaces issue three Sections 1.2.1, 2.11.6, 2.11.7, 2.11.8 and 4.8.1.2 are revised. Section 4.2 is deleted (requirement withdrawn).
Five	03 December 2011	Replaces issue four Revised requirements and new Appendices: Sections 2.5.8, 2.5.9 and 2.7.2 are revised. Sections 3.2.2 and 3.2.5 are open points. These are requirements that are yet to be specified. Appendices A, B, C, D, G and H are new. Withdrawn Appendix: Appendix A on rail profile 60 E 2 is withdrawn.

Issue	Date	Comments
Six	December 2023	Replaces issue five. Rationale and guidance added to support requirements. Part 2, Part 3 and Part 4 have all been revised to include rational and guidance. Section 2.8 regarding sidings has been removed and the requirements have been incorporated in the relevant sections of Part 2. Sections 4.1, 4.2, 4.3, and 4.5 of Part 4 have been withdrawn and moved to RIS-7707-INS, which provides infrastructure requirements and guidance for S&C. Appendices A-H have been withdrawn as guidance is now included with requirements.

Revisions have not been marked by a vertical black line in this issue because the document has been revised throughout.

Superseded documents

The following Railway Group documents are superseded:

Superseded documents	Sections superseded	Date when sections are superseded
GCRT5021, issue five, December 2011 Track System Requirements	All	December 2023

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/

Contents

List of Tables

Part 1 Purpose and Introduction

1.1 Purpose

1.1.1 This document sets out requirements for track geometry, track systems and track components to provide for the safe guidance and support of rail vehicles.

1.2 Introduction

1.2.1 Background

1.2.1.1 Safe and efficient operation of vehicles on the railway requires the existence of adequate infrastructure. A main part of this infrastructure is the track and its wide variety of associated systems and components.

1.2.1.2 To manage the interface with the rolling stock, a set of requirements needs to be specified to ensure that vehicles are safely supported and guided on the track.

1.2.2 Principles

1.2.2.1 The requirements of this document are based on the following principles.

1.2.2.2 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).

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

a) To fill identified open points in National Technical Specification Notices (NTSNs).
b) To support GB specific cases in NTSNs.
c) To enable technical compatibility between infrastructure that conforms to the requirements of the NTSN, and the existing vehicles.

1.2.3 Structure of this document

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

1.2.3.2 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’.

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

1.2.4 Related requirements in other documents

1.2.4.1 The following Railway Group Standards contain requirements that are related to the scope of this document:

a) GMRT2141 sets out requirements for rolling stock to to achieve acceptable resistance against flange climbing derailment and against roll-over induced by overspeeding.
b) GMRT2142 sets out requirements to be applied to railway vehicles so that they can operate under gale conditions in Great Britain.

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

1.2.5 Supporting documents

1.2.5.1 The following Rail Industry Standards support this Railway Group Standard:

a) RIS-7016-INS brings together requirements to provide an integrated and consistent set covering station platforms, the interface between platforms, tracks and trains and buffer stops.
b) RIS-7707-INS sets out requirements and guidance for new, renewed and upgraded switches and crossings (S&C) to provide for identification and safe operation.
c) RIS-7706-INS sets out requirements and guidance to support the process of adding, removing or modifying a Lettered Differential Permissible Speed (LDPS) on the GB mainline railway network.
d) RIS-8012-CCS sets out the means by which tilting trains may be operated at higher speeds than non-tilting trains around curves.

1.2.5.2 Permission to reproduce extracts from British Standards is granted by BSI Standards Limited (BSI). No other use of this material is permitted. British Standards can be obtained from BSI Knowledge knowledge.bsigroup.com.

1.3 Approval and authorisation of this document

1.3.1 The content of this document will be approved by Infrastructure Standards Committee on 19 September 2023.

1.3.2 This document will be authorised by RSSB on 27 October 2023.

Part 2 Requirements for Track Geometry

2.1 Normal limiting design values and exceptional limiting design values

Guidance

G 2.1.1 The requirements in this section set out normal limiting design values and exceptional limiting design values for track geometry parameters.

G 2.1.2 Normal limiting design values are used for all parameters where site conditions allow.

G 2.1.3 It is good practice to avoid design values near normal limiting values to increase track asset life, improve energy efficiency and ride quality.

G 2.1.4 Exceptional limiting design values are used where either geographical constraints or the speed requirements mean that normal limiting design values need exceeding. When exceptional limits are used, justification and rationale is provided. At certain sites, it may be appropriate to exceed exceptional values. If this is the case, a deviation against the relevant clause will be necessary.

2.2 Horizontal alignment

Guidance

G 2.2.1 On running lines, horizontal alignments consist of circular curves and straight track connected tangentially, and where necessary by transition curves. The minimum length of each geometrical element is appropriate to the length and characteristics of vehicles likely to use the track.

G 2.2.2 For buffer stops which are not located in station platforms, it is good practice to assess the risk of the potential fouling of an adjacent running line, especially considering the horizontal alignment design.

G 2.2.3 Requirements and guidance on horizontal alignment of track in relation to station platforms buffer stops and arresting devices are set out in RIS-7016-INS.

2.3 Permissible Speed

Guidance

G 2.3.1 Permissible speed limits enable the safe passage of a train over the track.

G 2.3.2 The permissible speed on a curve is calculated taking account of the following factors:

a) The radius of the curve.
b) The applied cant.
c) The permitted values of cant deficiency.
d) The permitted values of rates of change of cant and cant deficiency on the transition curves either side of the circular curve.
e) The permitted values of rates of change of cant and cant deficiency over instantaneous changes of radius between successive design elements.
f) The maximum cant deficiency at which the train is designed to travel.

G 2.3.3 There could be reasons other than track geometry design that restrict the permissible speed, for example the ability to maintain the track to sufficiently high track quality standards, the nature of the signalling system, or the strength of structures.

G 2.3.4 Higher speeds may be permitted for certain types of train utilising the lettered differential permissible speed process detailed in RIS-7706-INS.

2.4 Enhanced permissible speed

Guidance

G 2.4.1 The application of enhanced permissible speed allows higher train speed whilst keeping the likelihood of overturning within tolerable limits.

G 2.4.2 The enhanced permissible speed is calculated for each type of vehicle proposed for an enhanced speed on each curve. On bi-directional tracks, the enhanced permissible speed in each direction is considered separately. In the case where there are double or multiple lines, the enhanced permissible speed on each track is considered separately.

G 2.4.3 The conditions under which trains are permitted to travel at an enhanced permissible speed are set out in RIS-8012-CCS.

G 2.4.4 The calculation of enhanced permissible speed takes into account the factors listed in *G 2.3.2* together with the following additional factors:

a) The dynamic roll-over resistance of the train is given in GMRT2141.
b) The maintenance tolerances on cant (the amount by which, in practice, the applied cant could be less than its design value).
c) The expected local wind conditions.
d) The effect of wind on the train, taking into account the characteristics of the train given in GMRT2142.
e) The system adopted for controlling the speed of the train and the extent to which overspeed can occur is set out in RIS-8012-CCS.

G 2.4.5 Enhanced permissible speeds is applicable on the through route of S&C but not on the turnout route.

G 2.4.6 RIS-7704-INS provides information and guidance to train manufacturers and operators for the calculation of enhanced permissible speeds for tilting trains.

2.5 Circular curves

2.5.1 Minimum radii

2.5.1.1 The limiting design values for curve radii shall exceed the values given in Table 1.

	Normal limit (m)	Exceptional limit (m)
Passenger lines	200	150
Non-passenger lines	150	125

Table 1: Lower limit for horizontal curves

Rationale

G 2.5.1.2 The requirement is needed for GB technical compatibility.

G 2.5.1.3 The values for minimum curve radii represent the safe curving radii for GB rolling stock, including heritage vehicles.

G 2.5.1.4 The minimum curve radius on non-passenger running lines is smaller than that on passenger running lines, because many passenger vehicles are not designed to operate on small radius curves due to their bogie bases, wheelbases and suspensions.

Guidance

G 2.5.1.5 Horizontal curve radii are selected to take account of the curving characteristics of vehicles likely to use the track.

G 2.5.1.6 It is good practice to avoid designing small radii curves to improve overall railway performance.

G 2.5.1.7 Small radius curves result in high lateral loads on the track and cause high rail wear rates.

2.5.2 Reverse curves

2.5.2.1 A length of straight track at least 3 m long shall be provided between the reverse curves if one of the curves has a radius of less than 160 m.

Rationale

G 2.5.2.2 The requirement is needed for GB technical compatibility.

G 2.5.2.3 The reverse curves requirement prevents buffer locking and undesirable vehicle dynamics.

G 2.5.2.4 This limit represents widespread industry practice with historic evidence of safe operation at these limits.

Guidance

G 2.5.2.5 When designing reverse curves, it is good practice to consider the need for a length of straight track or transition between the curves, taking account of the following factors:

a) The ability of vehicles using the route to traverse the curves.
b) The likelihood of buffer locking.
c) Vehicle coupling designs.

2.5.3 Limiting design values for cant

2.5.3.1 The limiting design values for cant shall not exceed the values given in Table 2.

	Normal limit (mm)	Exceptional limit (mm)
Station platforms	110	130
Fixed obtuse crossings	110	110
Elsewhere	150	180

Table 2: Upper limits for cant

2.5.3.2 The allowed cant (C_{max}) on curves with a radius less than 320 m shall not exceed the lesser of:

a) C_{max} = (R - 50) / 1.5, where C_{max} is in millimetres and R is the curve radius in metres.
b) The normal limit set out in Table 2

Rationale

G 2.5.3.3 The requirement is needed for GB technical compatibility.

G 2.5.3.4 The INF NTSN requirement for cant on small radius curves is applicable to curves up to 305m radius where GB cant limits require this to be applicable to curves up to 320 m.

G 2.5.3.5 Cant limits facilitate the safe curving of rolling stock, managing lateral forces and wheel unloading.

Guidance

G 2.5.3.6 High cant on small radius curves increases the risk of derailment, especially when vehicles are running at low speed. At low speed when the train is curving in cant excess, the outside wheel is subject to lower vertical force which increases the likelihood of flange climb derailment.

G 2.5.3.7 At low speed, high cant poses the following risks:

a) freight load displacement;
b) passenger discomfort;
c) instability of on-track machines.

G 2.5.3.8 Requirements and guidance for negative cant are set out in 4.1.2.

2.5.4 Limiting design values for cant deficiency on plain line track

2.5.4.1 The limiting design values for cant deficiency on plain line track shall not exceed those set out in Table 3.

	Normal (mm)	Exceptional (mm)
Permissible speed	110[a)]	150[b) c)]
Enhanced permissible speed (curve radius less than 400 m)	110	150
Enhanced permissible speed (curve radius less than 700 m but greater than or equal to 400 m)	185	225
Enhanced permissible speed (curve radius greater than or equal to 700 m)	265	300

a) For modern and legacy CWR track only, 90 mm elsewhere.
b) For legacy CWR the exceptional cant deficiency limit is 110 mm.
c) For jointed track, see 2.5.4.3.

Table 3: Upper limits for cant deficiency on plain line track

2.5.4.2 Cant excess shall not be designed for any traffic operating at line speed.

2.5.4.3 An exceptional limiting design value for cant deficiency of 110 mm is permissible on jointed track for rolling stock classified as SP, provided:

a) The track quality have been assessed as being suitable for taking additional lateral forces.
b) The condition of track components has been assessed as being suitable for taking additional lateral forces.
c) If applicable, the condition of rail joints has been assessed as being suitable for taking additional lateral forces.

Rationale

G 2.5.4.4 The requirement is required for GB technical compatibility.

G 2.5.4.5 Cant deficiency is responsible for the lateral forces that are experienced by trains, drivers, and passengers. Limiting the cant deficiency design values controls the magnitude of lateral forces and associated ride discomfort that may lead to rough ride complaints.

G 2.5.4.6 High cant deficiency increases the lateral force exerted on the outer rail so limits for jointed track are lower than for CWR.

G 2.5.4.7 These limits represent widespread industry practice with historic evidence of safe operation at these limits.

Guidance

G 2.5.4.8 It is good practice to ensure all vehicles and speeds around a curve are considered when determining appropriate levels of cant deficiency and avoiding cant excess.

G 2.5.4.9 Over-canted track is to be avoided as it can increase rail wear and cause rail corrugation.

G 2.5.4.10 An increase in cant deficiency generally decreases rolling contact fatigue (RCF) without a detrimental increase in side-wear.

G 2.5.4.11 It is good practice to consider the capability of rolling stock when determining cant deficiency levels. Some rolling stock may not be designed to withstand curving at or approaching exceptional cant deficiency limits.

G 2.5.4.12 The requirements for rolling stock to be classified as SP are set out in RIS-2711-RST.

2.6 Transition curves

2.6.1 General guidance for transition curves

Guidance

G 2.6.1.1 It is good practice to design a transition curve between two circular curves or between a circular curve and straight track. Curvature increases (or decreases) regularly over the whole length of the transition curve.

G 2.6.1.2 Where it is not possible to provide a transition curve, the permissible speed is calculated assuming a virtual transition.

G 2.6.1.3 A virtual transition occurs where there is an abrupt change in curvature and cant deficiency. To control lateral forces and jerk, the changes in cant deficiency are calculated over an assumed distance of 12.2 m. The maximum limits are set out in *2.6.4.1*.

G 2.6.1.4 The distance of 12.2 m is the assumed distance between bogie centres, which was historically the shortest distance between bogie centres. Analysis of bogie centre distances on a planned route may suggest that calculating the virtual transition over a different distance is appropriate.

G 2.6.1.5 If a different virtual transition length is chosen, it is good practice to use the shortest distance between bogie centres of the vehicles planned to operate on the route. BS EN 13803:2017 provides guidance on virtual transitions and references virtual transition distances of 10.07 m, 12.2 m and 20 m.

G 2.6.1.6 Designs of transition curves take the permissible speed and any enhanced permissible speeds into account, together with the cant and radius on adjoining curves.

G 2.6.1.7 On all transition curves, cant is proportional to the instantaneous curvature. The maximum limit for instantaneous cant gradient is set out in *2.6.2.1*.

G 2.6.1.8 There are various transition curve forms, such as clothoid and bloss. Clothoid spiral transitions are the most commonly used for railway design. To avoid an abrupt end to a transition curve when designing high speed lines, a transition with a non-linear curvature variation, such as a bloss transition, can be utilised.

G 2.6.1.9 On transitions between reverse curves with no intervening straight, the point of zero cant coincides with the reverse point (point of zero curvature). Where possible, the rates of change of cant, cant deficiency and curvature are approximately the same on either side of the reverse curve. The same type of transition is used on either side of the reverse curve.

G 2.6.1.10 The limiting values for rates of change of cant and rates of change of cant deficiency set out in *2.6.3* and *2.6.4* assume a clothoid spiral transition curve.

2.6.2 Cant gradient

2.6.2.1 The cant gradient shall not exceed 1 in 400.

Rationale

G 2.6.2.2 The requirement is needed for GB technical compatibility.

G 2.6.2.3 The limit on cant gradient prevents excessively abrupt changes in cant.

G 2.6.2.4 Abrupt changes in cant can cause wheel unloading and therefore pose a derailment risk.

Guidance

G 2.6.2.5 When proposing to install cant gradients approaching 1 in 400, consider the deflection of the track at skew stiffness transitions, such as underbridges.

G 2.6.2.6 Cant gradient is independent of vehicle speed, unlike rate of change of cant.

2.6.3 Limiting design values for rate of change of cant

2.6.3.1 The rate of change of cant shall not exceed the values set out in Table 4.

	Normal Limit (mm/s)	Exceptional limit (mm/s)
Permissible speed	55	85
Enhanced permissible speed	75	95

Table 4: Upper limits of rate of change of cant

Rationale

G 2.6.3.2 The requirements are needed for GB technical compatibility.

G 2.6.3.3 Limits on rate of change of cant manage the risk of derailment due to wheel unloading.

G 2.6.3.4 These limits represent widespread industry practice with historic evidence of safe operation at these limits.

Guidance

G 2.6.3.5 It is good practice to design transitions which minimise the rate of change of cant to improve vehicle dynamics and ride comfort.

2.6.4 Limiting design values for rate of change of cant deficiency

2.6.4.1 The rate of change of cant deficiency shall not exceed the values set out in Table 5.

	Normal limit (mm/s)	Exceptional limit (mm/s)
Permissible speed	55	70
Enhanced permissible speed	110	150
Modern CWR S&C[a)]	80	95
Other S&C	55	55

a) CWR S&C track systems comprising strings of long welded rail with a designated section mass of not less than 56 kg/m with vertical inclination or 60 kg/m with inclination.

Table 5: Upper limits for rate of change of cant deficiency

Rationale

G 2.6.4.2 The requirements are needed for GB technical compatibility.

G 2.6.4.3 The limits on rate of change of cant deficient manage the risk of excessive lateral acceleration experienced by passengers and staff.

G 2.6.4.4 These limits represent widespread industry practice with historic evidence of safe operation at these limits.

Guidance

G 2.6.4.5 Reducing the designed rate of change of cant deficiency improves ride comfort for passengers and staff.

G 2.6.4.6 Long transitions assist in reducing the rate of change of cant deficiency.

2.7 Vertical alignment

2.7.1 General guidance for vertical alignment

Guidance

G 2.7.1.1 On running lines, vertical alignments consist of lengths of track at constant gradient connected by either parabolic or circular vertical curves.

2.7.2 Limiting design value for track gradient

2.7.2.1 Track gradient shall not exceed the upper limits set out in Table 6.

Normal limit (mm/m)	Exceptional limit (mm/m)
12.5	20
	35 (notes [a] and [b])

a) For sections up to 500 m in length, where trains are not intended to stop in normal operation.
b) For passenger only lines where the slope of the moving average profile over 10 km is less than or equal to 25 mm/m and the maximum length of continuous 35 mm/m gradient does not exceed 6 km.

Table 6: Limits for track gradients

Rationale

G 2.7.2.2 The requirement is needed for GB technical compatibility.

G 2.7.2.3 Gradient limits ensure that train performance is not compromised by excessive gradients.

G 2.7.2.4 Gradient limits reduce the risk of signals passed at danger (SPADs) and potential wheel spin incidents.

Guidance

G 2.7.2.5 For new lines, the limits for track gradients in platforms and sidings are set out in the INF NTSN.

G 2.7.2.6 When designing track gradients, the following factors are relevant:

a) Braking and traction performance of operational and maintenance vehicles likely to use or work on the line.
b) Position of signals and operational regime. For example, the likelihood of a train being required to start on the gradient or stop at a station or signal.
c) Projected rail adhesion conditions, including the effect of the weather.
d) The combined effect of gradient and horizontal curvature where the gradient coincides with a small radius horizontal curve.

G 2.7.2.7 To avoid problems with available tractive effort, it is good practice that the design value for track gradient for freight traffic does not exceed 10 mm/m.

G 2.7.2.8 It is good practice to minimise the track gradient in sidings.

2.7.3 Vertical curves

Guidance

G 2.7.3.1 The INF NTSN sets out the limits for vertical curves.

G 2.7.3.2 It is good practice to design vertical curves with radii greater than 1000 m, for both hollows and crests.

G 2.7.3.3 The following factors are relevant to the design of vertical curves:

a) The ability of vehicles likely to use the line to traverse the curves (considering, for example, vertical buffer locking and vehicle coupling and interconnection designs).
b) Clearances between features on the track and the underside of the vehicle.
c) Clearances to structures over the track, including overhead wires.

G 2.7.3.4 It is good practice to avoid placing S&C on vertical curves, both hollow and crest, especially where the radius is less than 10,000 m, as it can reduce performance or demand non-standard components.

2.8 Track gauge

Guidance

G 2.8.1 The nominal track gauge for GB railways is set out in the INF NTSN.

G 2.8.2 Due to characteristics of certain rolling stock, such as types with three axle bogies, it may be desirable to widen the gauge around tight curves. It is good practice to consider the following when widening gauge:

a) Characteristics of the vehicles likely to use the track.
b) The length and location of the curve.
c) The applied cant.

G 2.8.3 Gauge widening is carried out to reduce derailment risk and does not improve curving characteristics of rail vehicles.

G 2.8.4 Track gauge is widened by moving the inner rail away from the designed track centre line to achieve alignment continuity along the outer (steering) rail. If a check rail is installed then the nominal check rail gauge (the distance between the rubbing face of the check rail and the opposite rail) remains the same when gauge widening. Guidance on check rails is given in *3.2.5*.

G 2.8.5 Values for gauge widening for the purpose of computer simulations designed to examine whether a vehicle has an acceptable resistance to flange climbing derailments at low speed is set out in Appendix C of GMRT2141.

2.9 Track geometry faults

2.9.1 Guidance on corrective action

Guidance

G 2.9.1.1 The corrective actions set out in *2.9.2.1* to *2.9.5* apply to isolated track faults (that is, they are not combined with other track faults).

G 2.9.1.2 Track geometry faults are categorised as alert limit (AL), intervention limit (IL) or immediate action limit (IAL) to reflect the increasing severity of the fault. AL and IL limits are provided for guidance as the requirements will refer to the IAL, with the exception of Tables *9*, *10*, *13*, *14*, *15*, and *16*.

G 2.9.1.3 Intervention timescales and fault mitigations are chosen which are commensurate to the derailment risk posed by the fault. Example timescales for geometric fault categories on a mixed traffic track line are:

a) IAL - 36 hours.
b) IL - 14 to 28 days.
c) AL - no timescale limit.

G 2.9.1.4 It is good practice to ensure that track geometry is proactively maintained below the IL limit.

G 2.9.1.5 The speed range to be used when determining the lateral alignment fault limits for a section of track is the highest permissible or enhanced permissible speed over the section of track concerned.

G 2.9.1.6 As the speed ranges used in the section do not exceed 125mph, on lines where the highest permissible or enhanced permissible speed is in excess of 125 mph, it is good practice to consider the use of more onerous fault limits, short intervention timescales, and speed restrictions.

G 2.9.1.7 When track faults are discovered in combination, the circumstances are reviewed and, if necessary, more stringent action is taken.

G 2.9.1.8 It is good practice to have procedure in place to determine the severity of cyclic top faults

G 2.9.1.9 Cyclic top can cause resonance within the suspension components which leads to irregular vehicle dynamics and potentially extreme wheel unloading. This can cause derailment, with the risk higher for freight vehicles.

G 2.9.1.10 The track limits set out in clauses *2.9.2*, *2.9.3*, *2.9.4*, and *2.9.5* are based on dynamically recorded measurements with the track under load. Loaded track conditions are defined in BS EN 13848-1:2019.

G 2.9.1.11 The use of condition monitoring technology, such as analysis of axlebox acceleration, can enable the proactive management of track faults.

G 2.9.1.12 This section details GB geometric fault limits which differ from the limits detailed in the INF NTSN. These differences are due to technical compatibility, speed band categorisation and differences in data filtering. In almost all cases, the GB limit is more onerous than the INF NTSN limit and where this is not the case, the rationale is detailed.

2.9.2 Track twist faults

2.9.2.1 Track twist measured over 3 m shall not exceed the IAL values set out in Table 7.

Speed range (mph)	AL (mm)	IL (mm)	IAL (mm)
0-25	12	15 *	24
26-50	12	15 *	24
51-75	12	15 *	24
76-100	12	15	21
101-125	12	15	21
*Consider more onerous response timescales for twist faults on curves <400 m radius.			

Table 7: Upper limits for track twist

2.9.2.2 The line shall be blocked if a track twist fault reaches or exceeds 33 mm over 3 m.

Rationale

G 2.9.2.3 The requirements are needed for GB technical compatibility and varies from the values stated in BS EN 13848-5:2017.

G 2.9.2.4 These limits reduce the likelihood of derailment due to wheel unloading and represent widespread industry practice with historic evidence of safe operation at these limits.

G 2.9.2.5 At lower speeds (< 75 mph) the GB IAL is less onerous than the limit set in the INF NTSN. This is justified by historic safe use.

Guidance

G 2.9.2.6 Twist faults cause wheel unloading and can pose a significant risk of derailment if not managed appropriately.

G 2.9.2.7 Long wheelbase vehicles, such as freight wagon, are more prone to wheel unloading over twist faults.

2.9.3 Track gauge faults

2.9.3.1 Wide track gauge shall not exceed the the IAL limits set out in Table 8.

Speed range (mph)	AL (mm)	IL (mm)	IAL (mm)
0-25	1455	1460	1470
26-50	1450	1460	1470
51-75	1450	1460	1470
76-100	1450	1460	1470
101-125	1450	1458	1463

Table 8: Upper limits for track gauge

2.9.3.2 The line shall be blocked if a track gauge fault exceeds 1478 mm on lines with speeds up to 100 mph.

2.9.3.3 The line shall be blocked if a track gauge fault exceeds 1472 mm on lines with speeds between 101 mph and 125 mph.

2.9.3.4 Tight track gauge shall exceed the IL limits set out in Table 9.

Speed range (mph)	AL (mm)	IL (mm)	IAL (mm)
0-25	1426	1424	-
26-50	1426	1424	-
51-75	1427	1424	-
76-100	1430	1424	-
101-125	1430	1428	-

Table 9: Lower limits for track gauge

2.9.3.5 Track gauge in S&C shall be maintained within the ranges set out in Table 10 throughout the moveable length of switches, switch diamonds and swing-nose crossings, including the 100 mm in front of the switch toes.

Type of S&C	Lower limit (mm)	Upper limit (mm)
Vertical CEN56	1430	1438
Bullhead or 109/110/113A inclined	1433	1441
RT60 and NR60	1433	1441

Table 10: Limits for track gauge in S&C

Rationale

G 2.9.3.6 The requirements are needed for GB technical compatibility.

G 2.9.3.7 Wide gauge limits mitigate derailment due to gauge spread.

G 2.9.3.8 Tight gauge limits prevent ride comfort issues, specifically wheelset hunting.

G 2.9.3.9 These limits represent widespread industry practice with historic evidence of safe operation.

G 2.9.3.10 The gauge limits for S&C are specified to prevent damage to the points and to mitigate the risk of derailment.

Guidance

G 2.9.3.11 Tight gauge is not associated with component failure, deterioration or wear, so IALs are not stated.

G 2.9.3.12 Vehicles with higher gauge spreading forces will cause track gauge faults to deteriorate at a faster rate.

G 2.9.3.13 Gauge is measured 14 mm below the running surface of the rail.

G 2.9.3.14 It is good practice to maintain the track gauge through S&C within the limits required for the maintenance of point operating tolerances.

2.9.4 Vertical profile (top) faults

2.9.4.1 The limits for vertical profile (top) faults shall not exceed the IAL values in Table *11*.

Speed range (mph)	AL (mm)	IL (mm)	IAL (mm)
0-25	23	26	38
26-50	20	23	36
51-75	18	21	33
76-100	16	19	30
101-125	14	18	26

Table 11: Upper limits for vertical profile faults

Rationale

G 2.9.4.2 The requirement is needed for GB technical compatibility.

G 2.9.4.3 These limits prevent poor ride comfort and, in extreme cases, derailment.

G 2.9.4.4 These limits represent widespread industry practice with historic evidence of safe operation at these limits.

Guidance

G 2.9.4.5 Vertical profile faults can cause and exacerbate other track faults, such as corrugation and cyclic top.

2.9.5 Lateral alignment faults

2.9.5.1 The upper limits for lateral alignment faults shall not exceed the IAL values given in Table *12*.

Speed range (mph)	AL (mm)	IL (mm)	IAL (mm)
0-25	21	27	50
26-50	17	21	43
51-75	13	16	35
76-100	11	12	28
101-125	9	11	21

Table 12: Upper limits for lateral alignment faults

Rationale

G 2.9.5.2 The requirement is needed for GB technical compatibility.

G 2.9.5.3 These limits prevent poor ride comfort and in extreme cases, derailment.

G 2.9.5.4 These limits represent widespread industry practice with historic evidence of safe operation at these limits.

Guidance

G 2.9.5.5 Increased lateral irregularities can significantly increase the localised rail wear.

G 2.9.5.6 The derailment risks from flange climbing and gauge spread are increased with larger lateral irregularities.

2.9.6 Track geometric quality - standard deviations

2.9.6.1 The standard deviations of eighth mile sections for speeds less than or equal to 80 mph shall be calculated from measured data for each parameter listed below:

a) The vertical profile (top) of the rails, filtering out wavelengths greater than 35 m.
b) The lateral alignment of the rails, filtering out wavelengths greater than 35 m.

2.9.6.2 Where the permissible or enhanced permissible speed exceeds 80 mph the standard deviations of eighth mile sections shall be calculated from measured data for each parameter listed below:

a) The vertical profile (top) of the rails, filtering out wavelengths greater than 70 m.
b) The lateral alignment of the rails, filtering out wavelengths greater than 70 m.

2.9.6.3 The standard deviations for any section of track shall not exceed the very poor standard deviations set out in tables *13* and *14* or the poor standard deviations set out in tables *15* and *16*.

Speed band (mph)	Good	Satisfactory	Poor	Very poor
10-20	≤5.2	7.4	8.3	9.9
21-30	≤4.3	6.1	7.0	7.7
31-40	≤4.1	5.8	6.7	7.2
41-50	≤3.8	5.4	6.3	6.7
51-60	≤3.5	5.0	5.9	6.3
61-70	≤3.0	4.3	5.4	6.0
71-80	≤2.7	3.8	4.8	5.7
81-100	≤2.2	3.2	4.0	5.3
101-115	≤1.9	2.7	3.4	5.0
116-125	≤1.7	2.4	3.0	4.7

Table 13: Levels of track quality for vertical alignment (top) with the 35 m wavelength filter

Speed band (mph)	Good	Satisfactory	Poor	Very poor
10-20	≤3.0	5.0	5.6	9.9
21-30	≤2.7	4.5	5.2	8.6
31-40	≤2.5	4.1	4.7	7.9
41-50	≤2.2	3.7	4.5	7.3
51-60	≤2.0	3.3	4.2	7.0
61-70	≤1.7	2.9	3.6	6.7
71-80	≤1.5	2.5	3.1	6.3
81-100	≤1.3	2.1	2.7	6.0
101-115	≤1.1	1.8	2.3	5.7
116-125	≤1.0	1.6	2.0	5.0

Table 14: Levels of track quality for horizontal alignment (line) with the 35 m wavelength filter

Speed band (mph)	Good	Satisfactory	Poor
71-80	≤3.7*	5.7*	6.3*
81-100	≤3.3	5.1	5.6
101-115	≤2.9	4.5	5.0
116-125	≤2.4	4.0	4.4
*These values apply to 80 mph track only			

Table 15: Levels of track quality for vertical alignment (top) with the 70 m wavelength filter

Speed band (mph)	Good	Satisfactory	Poor
71-80	≤3.0*	5.2*	5.7*
81-100	≤3.3	4.5	5.0
101-115	≤2.2	3.8	4.3
116-125	≤1.8	3.2	3.7
*These values apply to 80 mph track only			

Table 16: Levels of track quality for horizontal alignment (line) with the 70 m wavelength filter

Rationale

G 2.9.6.4 The requirements are needed for GB technical compatibility.

G 2.9.6.5 Track quality derived by standard deviations helps achieve good ride quality and prevent excessively poor track.

G 2.9.6.6 35 m and 70 m wavelengths align with current track geometry monitoring technology on GB railways.

Guidance

G 2.9.6.7 It is good practice to maintain track geometry as to avoid poor standard deviations.

G 2.9.6.8 Poor track quality is often caused by underlying issues with the ballast or sub-ballast. Addressing the root cause of the poor track quality will enable an effective, long-term solution.

G 2.9.6.9 In certain circumstances, inherent track geometry and design constraints can result in poor track quality measurement from certain track measurement systems. In these circumstances, it may be appropriate to monitor the track quality rather than apply a speed restriction or carry out corrective work.

G 2.9.6.10 The values for track quality in *2.9.6.3* are based on a measurement system utilising a Butterworth Filter to process track measurement data. Should another mathematical filter be used to derive track quality, consider revising the track geometric quality limits.

Part 3 Requirements for the Track System and Components

3.1 Performance specification for the track system

3.1.1 Vertical track loading, longitudinal track loading and lateral track loading shall be calculated for all planned operating conditions which the track will experience.

3.1.2 Track systems shall be designed to have performance characteristic capable of sustaining the loads defined in *3.1.1*.

Rationale

G 3.1.3 This requirement is for compatibility with the existing GB mainline railway.

G 3.1.4 The track system is designed so that it can support the traffic it is planned to carry.

G 3.1.5 Minimum track loading limits are not specified as loading conditions vary depending on several factors, such as the type of rolling stock and tightness of curvature.

Guidance

G 3.1.6 The INF NTSN states factors to take into account when determining the track resistance to applied loads and references BS EN 14363:2016+A1:2018.

G 3.1.7 In order to fully define the track system loading regime the designer considers vertical track loading, longitudinal track loading and lateral track loading when designing the track system. Track loading research (*G 3.1.8* and *G 3.1.9*) gives useful information for determining specific loading conditions. It is good practice to optimise track system design to the loads it will experience. For example, a light rail track system does not need to resist same loads as a freight rail track system.

G 3.1.8 RSSB research report T1073 (2020) details good practice in determining the vertical loads on track by calculating the vertical dynamic force of a rail vehicle by applying a dynamic amplification factor to a modified version of the load pattern of LM71 set out in EN1991-2:2003.

G 3.1.9 Additionally, research project COF-UOH-59 (2023) sets out the framework for defining the lateral limit loads to be applied for design purposes. The framework considers the following aspects:

a) Type of railway (such as light rail, urban or high speed).
b) Curve radii (such as tight radii curves or medium radii curves).

G 3.1.10 For a track system which will carry three-axle-bogie units, additional lateral load capability may be needed as these vehicles exert significant lateral forces onto the rails when curving.

G 3.1.11 GMRT2141 sets out the requirements for railway vehicles regarding permissible track forces.

3.2 Requirements for rails, rail gaps and rail fastenings

3.2.1 Profile of rails

3.2.1.1 The rail head profile of new rails for plain line shall be either 60 E 1, 60 E 2 or 56 E 1 as set out in BS EN 13674-1:2011+A1:2017.

3.2.1.2 The rail head profile of new rails for S&C shall be compatible with the profile of new rails for plain line.

Rationale

G 3.2.1.3 The requirement is needed for technical compatibility with GB infrastructure.

G 3.2.1.4 This requirement ensures compatibility with new rail head profiles and the wheel profiles used on GB rolling stock.

G 3.2.1.5 Compatible wheel and rail profiles facilitates the reduction in wheel and rail wear, wheel and rail defects, and improved energy efficiency.

Guidance

G 3.2.1.6 The rail head profile for both in-service and reprofiling of rails (for example by grinding) is not specified. However, it is good practice to reprofile the rail to a profile which is compatible with the common wheel profile that operates on the track.

3.2.2 Rail inclination

3.2.2.1 In plain line track, rails shall have a nominal inclination of 1 in 20 towards the track centre line.

3.2.2.2 At S&C, rails shall have a nominal inclination of 1 in 20 towards the track centre line or be vertical, depending on the design of S&C considered.

Rationale

G 3.2.2.3 The requirement is needed for GB technical compatibility.

G 3.2.2.4 1 in 20 rail inclination ensures a suitable equivalent conicity with the wheel profiles used on the GB mainline railway.

G 3.2.2.5 The equivalent conicity for GB mainline railways helps achieve effective vehicle curving as well as stability at high speed.

Guidance

G 3.2.2.6 The definition of equivalent conicity is set out in BS EN 15302:2021 Railway applications — Wheel-rail contact geometry parameters — Definitions and methods for evaluation.

3.2.3 Hardness of new rails

Guidance

G 3.2.3.1 The range of hardness of new rail steels is set out in BS EN 13674-1:2011+A1:2017.

G 3.2.3.2 In certain circumstances, the use of premium rail steels can promote rail cracking as initial crack growth can exceed the wear rate. It is good practice to undertake detailed analysis of potential failure modes prior to using premium rail steels.

3.2.4 Gaps between rail ends

3.2.4.1 Trains shall not be permitted to pass over gaps between rail ends at speeds greater than those set out in Table *17*.

Speed (mph)	Gap (mm)	Comments
91 and above	0	CWR is required to satisfy this requirement. Nominal gaps are associated with tight joints and insulated rail joints.
21-90	1-15	In jointed track 15 mm represents maximum nominal expansion gap.
6-20	16-50	Used for engineering and emergency repair work.
0-5	51-75	Used for engineering and emergency repair work.
Trains not permitted	76 and above	Line is blocked.

Table 17: Maximum train speed over rail gaps

Rationale

G 3.2.4.2 The requirements are needed for GB technical compatibility.

G 3.2.4.3 Excessive rail end gaps increases the risk of rail breaks and joint failures which could lead to derailment.

Guidance

G 3.2.4.4 The values set out in Table *17* are dependent on arrangements being in place to ensure the integrity and support of the rail. Where the joints are not well supported, or the integrity is compromised, it is good practice to improve the joint support/integrity as soon as practicable.

3.2.5 Check rails on curves

3.2.5.1 All passenger lines, and freight only lines adjacent to passenger lines, with a horizontal radius of 200 m or less shall be fitted with a continuous check rail to the inside rail of the curve.

3.2.5.2 Check rails shall extend at least 9 m into the straight or circular curve adjacent to the section of track with a radius of 200 m or less and its associated transitions.

3.2.5.3 Check rails shall have a machined or forged flare at each end of sufficient length to give guidance to vehicle wheel flanges entering the flangeway.

Rationale

G 3.2.5.4 The requirements are required for GB technical compatibility.

G 3.2.5.5 Check rails control the high lateral forces on the outer rail of tight curves.

G 3.2.5.6 High lateral forces increase the risk of flange climb derailment.

Guidance

G 3.2.5.7 When designing track, it is good practice to avoid radii which require check rails to be installed.

G 3.2.5.8 Check rails require additional inspection and maintenance.

3.2.6 Rail fastenings - electrical insulation for track circuits

3.2.6.1 Where track circuits are installed, rail fastenings and supports shall be designed and selected to provide electrical insulation between individual rails and between rails and the adjacent infrastructure and the general mass of the earth.

3.2.6.2 The electrical insulation provided shall be consistent with the requirements of the type of track circuit installed.

Rationale

G 3.2.6.3 The requirements are required for GB technical compatibility and are not covered in the INF NTSN.

G 3.2.6.4 Insufficient rail fastening insulation can lead to track damage, signal failures and damage to under track pipes.

Guidance

G 3.2.6.5 General requirements for train detection systems, including track circuits, are set out in GKRT0028.

3.2.7 Rail head width and sidewear

3.2.7.1 Rails shall be changed or transposed before:

a) Sidewear reaches the bottom of the gauge face of the rail.
b) Sidewear results in a head width (measured in accordance with the definition of 'sidewear') less than that set out in Table *18*.

Speed (mph)	Rail section	Minimum head width (mm)
0 - 80	56E1	52
	60E1	54
	Any	Sidewear scar reaches the bottom of the gauge face
81 - 125	56E1	61
	60E1	63
	Any	Sidewear scar reaches the bottom of the gauge face

Table 18: Rail head width limits

Rationale

G 3.2.7.2 The requirements are required for GB technical compatibility.

G 3.2.7.3 Sidewear limits prevent excessive widening of track gauge and ensures a sufficient area of the rail head.

Guidance

G 3.2.7.4 Table *18* assumes an unworn rail head width of not less than 70 mm.

G 3.2.7.5 It is best practice to rerail with new rail rather than with transposed or cascaded rails unless on low tonnage and low speed lines. This is because transposed or cascaded rails can contain defects which can subsequently lead to rail failures.

G 3.2.7.6 Wear limits to prevent wheel / fishplate strikes are set out in *3.2.8*. These limits may require rails to be changed ahead of the limits set out in *3.2.7* where rail depths are significantly less than those for new rail.

3.2.8 Rail depth and loss of section - prevention of wheel / fishplate strikes

3.2.8.1 Rails shall shall not be permitted to wear below the limits set out in the 'no sidewear' column in Table 19.

3.2.8.2 Rails within 9 m of fishplates shall not be permitted to wear below the limits set out in the 'sideworn' column in Table 19.

Rail Section	Minimum depth - no sidewear (mm)	Minimum depth - sideworn (mm)
60E1 / 60E2	158	158 + L
109 / 110A / 56E1 (113A)	145	145 + L
98 lbs / yd flatbottom and 95 and 97.5 lbs / yd bullhead	131	131 + L
85 lb / yd bullhead	127	127 + L
Where L is the loss of head width in mm due to sidewear on the current running face (measured in accordance with the definition of 'sidewear').		

Table 19: Wear limits to prevent wheel fishplate strikes

Rationale

G 3.2.8.3 The requirements are used for GB technical compatibility.

G 3.2.8.4 Minimum rail depths are required to prevent wheel flanges striking fishplates and other rail-mounted infrastructure.

Guidance

G 3.2.8.5 Minimum permitted rail depths are depths measured outside the area of underfoot gall.

3.2.9 Interface between rails to be permanently joined

3.2.9.1 Where differently worn rail are to be permanently joined, the interface shall meet the following requirements:

a) The less sideworn rail shall be blended in over a distance of at least 1.5 m from the joint.
b) The sidewear angle of the more sideworn rail shall be maintained throughout the blended length.
c) The gauge corner shall be rounded throughout the blended length to eliminate sharp or square edges.

Rationale

G 3.2.9.2 The requirements are required for GB technical compatibility.

G 3.2.9.3 Sudden discontinuity of the rail head and running edge can cause damage to wheels or initiate a derailment.

Guidance

G 3.2.9.4 Requirements and guidance regarding the profile of rails are set out in *3.2.1*.

3.3 Performance requirements for trackbed

3.3.1 Trackbed performance

Guidance

G 3.3.1.1 It is good practice to implement a repeatable method of assessing the stiffness of trackbeds. This can be utilised to assess the trackbed stiffness during track construction.

G 3.3.1.2 Trackbed transitions zones between ballasted track and non-ballast track prevent track deterioration and rail failures. This is also applicable to areas where a change in support stiffness beneath ballasted track prevents the required track geometry from being readily achieved.

Part 4 Particular Requirements for S&C

4.1 Track Geometry for S&C

4.1.1 Limiting design values for cant deficiency in S&C

4.1.1.1 The limiting design values for cant deficiency in S&C shall not exceed those set out in Table *20*.

Parameter	Normal limit (mm)	Exceptional (mm)
Through route		
S&C not designed to withstand stressing	90	-
S&C designed for use in CWR without adjustment switches	110	150[a)]
		200[b)]
Turnout route		
Modern CWR S&C	110	-
Fixed obtuse crossings	75	-
Switch toes	125[c)]	-
Elsewhere	90	-

a) S&C designed for use in CWR where the main line radius is greater than or equal to 400 m.
b) S&C incorporating additional special features that eliminate discontinuities at the crossing nose.
c) Existing designs of switches with turnout speeds up to 105 mph.

Table 20: Upper limits for cant deficiency

Rationale

G 4.1.1.2 The requirement is needed for GB technical compatibility.

G 4.1.1.3 Cant deficiency is responsible for the lateral forces that are experienced by trains, drivers, and passengers. Limiting the cant deficiency design values controls the magnitude of lateral forces and associated ride discomfort that may lead to rough ride complaints.

G 4.1.1.4 High cant deficiency increases the lateral force exerted on the outer rail so limits for jointed track are lower than for CWR.

G 4.1.1.5 These limits represent widespread industry practice with historic evidence of safe operation at these limits.

Guidance

G 4.1.1.6 Historically, it has been permissible to disregard the rate of change of cant deficiency at switch toes. This is no longer considered good practice due to the disturbed vehicle dynamics not being limited and has led to unacceptable ride comfort in some designs of S&C. The limiting design values for cant deficiency at switch toes is determined by the maximum values of abrupt change of cant deficiency set out in the INF NTSN.

G 4.1.1.7 S&C which is designed to withstand stressing is inherently more robust and able to withstand the additional lateral forces resulting from higher cant deficiency values.

G 4.1.1.8 These limits are intended to be applied when implementing a standard switch design into a scheme.

G 4.1.1.9 Values for cant deficiency for the turnout route at enhanced permissible speed are not applicable to the turnout route, as set out in *2.4*.

G 4.1.1.10 It is considered good practice for S&C configured to have cant deficiency in excess of 110 mm to have additional features, including:

a) Rail profile CEN 60;
b) Provision of high speed flares on the check rails and facing wing rails on crossings installed on the low rail; and
c) Not having features in track support structure, within 20 m of the approach to or exit from the S&C, that have the potential to disturb the vehicle dynamics, such as longitudinal bearers, level crossings or direct fastening structures.

G 4.1.1.11 In addition to the features set out in *G 4.1.1.10*, details of the assessment of the following are recorded with the design information;

a) degree of track fixity;
b) changes in cant deficiency on the approach to or exit from the S&C; and
c) maintenance regime.

4.1.2 Negative cant

4.1.2.1 The limiting design values for negative cant shall not exceed those set out in Table *21*.

Parameter	Normal limit (mm)	Exceptional limit (mm)
Through route	0	0
Turnout route and adjoining plain line		
Fixed obtuse crossing	0	65
Elsewhere	0	80

Table 21: Upper limits for negative cant

Rationale

G 4.1.2.2 The requirements are required for GB technical compatibility.

G 4.1.2.3 Negative cant is limited to manage the risk of overturning on the turnout route of S&C when negative cant is applied.

G 4.1.2.4 High values of negative cant on fixed obtuse crossings increases the risk of a train taking the unintended route in the unguided length of the crossing.

Guidance

G 4.1.2.5 The requirement to use switch diamonds where negative cant at fixed obtuse crossings is in excess of 65mm is given by *4.2*.

G 4.1.2.6 It is good practice to avoid placing S&C in locations where negative cant would be required. Turnout routes that are contraflexure to the through route may require negative cant within the limits set out in Table *21*.

G 4.1.2.7 The length of plain line immediately adjoining S&C, where negative cant needs to be applied, is dependent on the cant gradient limit set out in *2.6.2* and avoiding designed twist faults.

4.2 Selection of crossing

4.2.1 Swing nose crossings shall be used:

a) where an acute crossing angle flatter than 1 in 35 is required; and
b) where the line speed exceeds 125 mph.

4.2.2 Switch diamonds shall be used where any of the following apply:

a) The angle of the obtuse crossing is flatter than 1 in 8;
b) The permissible or enhanced permissible speed exceeds 105 mph;
c) The cant on either route through the crossing exceeds 110 mm;
d) Negative cant in excess of 65 mm occurs on either route through the crossing; and
e) The radius of either track is sufficiently small to give rise to an appreciable risk that a wheel flange may pass on the wrong side of a point rail nose.

Rationale

G 4.2.3 The requirements are used for GB technical compatibility.

G 4.2.4 Fixed crossings flatter than 1 in 35 become impractical to maintain due to the narrowness of the crossing nose and therefore a swing nose crossing is mandated for crossings flatter than 1 in 35.

G 4.2.5 The hazard being mitigated by limiting the use of fixed obtuse crossings is a lack of lateral guidance of the wheelset through the obtuse crossings, which could allow a wheelset to take the unintended route, causing damage to the crossing nose and wheel tread or, in the worst case, derailment.

Guidance

G 4.2.6 Swing nose crossings are designed to eliminate the gap between the crossing nose and associated wing rail providing constant support to the passing wheel. This improves wheel trajectory and reduces vertical dynamic forces on the crossing.

G 4.2.7 As the angle of the common crossing becomes more acute the crossing angle is said to be flatter. The flatter the crossing angle the larger the gap between the crossing nose and wing rail. Flatter crossings are required for higher speed leading to higher vertical dynamic forces and subsequently more maintenance. A swing nose crossing achieves a continuous wheel path by moving the crossing vee between adjacent wing rails in unison with the switches. Swing nose crossings are more complex than common crossings, requiring point operating equipment and detection.

G 4.2.8 A crossing angle of 1 in 35 or flatter is used for a line speed of 125 mph (200 km/h).

4.3 Use of check rails

4.3.1 The wheel transfer area between crossing nose and wing rail of fixed crossings shall be protected on the opposite running rail by a check rail on each route.

4.3.2 Raised check rails in S&C shall only be used in third or fourth rail electrified areas where the raised check rail presents no conflict with the collector shoe.

Rationale

G 4.3.3 These requirements are needed for GB technical compatibility, especially regarding raised check rails.

G 4.3.4 Minimum lengths of check rail parallel to the wheel transfer area are provided to protect crossing nose from the passing wheel.

G 4.3.5 Restrictions on the use of raised check rails in third and fourth rail electrified areas prevent the loss of collector shoes from rolling stock negotiating S&C.

Guidance

G 4.3.6 The limits placed on the height and position of check rails for fixed crossings are set out in GIRT7073 via the lower sector infrastructure gauge.

4.4 Flangeway, track gauge, and free wheel passage

4.4.1 General guidance for flangeway and track gauge

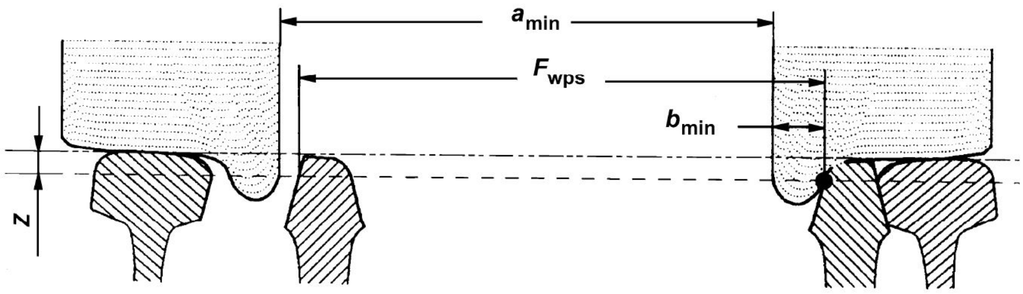
Guidance

G 4.4.1.1 Where stretcher bars are used, fitting multiple stretcher bars can mitigate the risk of a mechanical failure. A lock stretcher bar, where provided, is not a stretcher bar for the purpose of achieving the minimum flangeway. The application of stretcher bars as an effective control measure is dependent on:

a) The rail specification
b) The length of the switch.

G 4.4.1.2 Where points are located within a curved track with installed cant, the design of the point system includes measures to control the effect of gravity on the open switch. The limiting values for flangeway and free wheel passage for any position through the switch are set out in 4.4.2. Track gauge, flangeway, and free wheel passage are linked, as shown in Figure 1. The minimum flangeway can be derived by subtracting the free wheel passage from the track gauge. Free wheel passage is determined by the wheelset geometry as set out in GMRT2466. The width of free wheel passage is the sum of the minimum back-to-back and minimum flange width.

$$F_{WPS} < a_{min} + b_{min} \quad (3)$$



Key

a_{min} minimum value of wheel back-to-back
b_{min} minimum flange width
F_{WPS} free wheel passage in switches
Z stock rail machining reference plane

Figure 1: Extract from BS EN 13232-9

4.4.2 Flangeway and free wheel passage in switches

4.4.2.1 New designs of switches in points shall be configured so that the flangeway and free wheel passage conforms to the limits set out in Table 22 in both the normal and reverse positions.

Parameter	Limit (mm)
Minimum flangeway at the switch toes	100
Minimum flangeway elsewhere through switches	60
Maximum free wheel passage	1375

Table 22: Limiting values for flangeway and free wheel passage in switches

4.4.2.2 It is permissible to use historic designs of switches with a design minimum flangeway of less than 60 mm, provided that:

a) the flangeway is maintained in accordance with the relevant predecessor to this document; and,
b) the track gauge is maintained in accordance with requirements set out in 2.9.3.

Rationale

G 4.4.2.3 The requirements are required for GB technical compatibility.

G 4.4.2.4 Maintaining flangeway and free wheel passage throughout the length of the switch ensures that there is adequate clearance for wheel flanges between the open switch rail and its associated stock rail.

G 4.4.2.5 Minimum flangeways and maximum free wheel passage different than those stated in the requirement could result in contact of the wheel back of flange and resultant lateral force on the points operating equipment and locking system. Such contact can lead to gradual deterioration of the stretcher bars with the potential to develop fatigue cracks and possible failure of the stretcher bar.

G 4.4.2.6 The minimum flangeway in switches was increased from 50 mm as a result of the Potters Bar formal inquiry (2002).

Guidance

G 4.4.2.7 Provision of a maximum free wheel passage of 1375 mm corresponds to a flangeway of not less than 60 mm through the switch when the nominal track gauge of S&C is 1435 mm.

G 4.4.2.8 The requirements in 4.4.2.1 apply to new designs of switches and current designs of switches with a design minimum flangeway of 60 mm, for example NR60.

G 4.4.2.9 The maximum value for free wheel passage in open switches set out in this document provides greater clearance between the open switch rail and the adjacent wheel than the equivalent value set out in INF NTSN.

G 4.4.2.10 GIRT7004 issue one is the predecessor to this document containing requirements for the maintenance of flangeways less than 60 mm in historic switch designs.

G 4.4.2.11 Track gauge limits for switches are set out in *2.9.3*.

4.4.3 Flangeway and free wheel passage in switch diamonds

4.4.3.1 Switch diamonds shall be configured so that the flangeway and free wheel passage conforms to the limits set out in Table *23* in both the normal and reverse position.

Parameter	Limit (mm)
Minimum flangeway at the switch toes	100
Minimum flangeway at the switch toes when operated by clamp point lock mechanism	85
Minimum flangeway elsewhere	60
Maximum free wheel passage	1375

Table 23: Limiting values for flangeway and free wheel passage in switch diamonds

Rationale

G 4.4.3.2 The requirements are required for GB technical compatibility.

G 4.4.3.3 Maintaining flangeway and free wheel passage throughout the length of the switch diamond ensures that there is adequate clearance for wheel flanges between the open switch and its associated wing rail.

G 4.4.3.4 The gauge and flangeway dimensions are specified to prevent damage to the points and to mitigate the risk of derailment.

G 4.4.3.5 Provision of maximum free wheel passage ensures compatibility with wheelsets compliant with GMRT2466.

Guidance

G 4.4.3.6 Track gauge limits for switch diamonds are set out in *2.9.3*.

4.4.4 Flangeway and free wheel passage in swing nose crossings

4.4.4.1 Swing nose crossings shall be configured so that the flangeway and free wheel passage conform to the limits set out in Table 24 in both the normal and reverse positions.

Parameter	Limit (mm)
Minimum flangeway at nose of swing nose crossing	85
Minimum flangeway elsewhere, through the length of crossing	60
Maximum free wheel passage	1375

Table 24: Limiting values for flangeway and free wheel passage in swing nose crossings

4.4.4.2 It is permissible to use historic designs of swing nose crossings with a design minimum flangeway of less than 60 mm, provided that:

a) the flangeway is maintained in accordance with the relevant predecessor to this document; and,
b) the track gauge is maintained in accordance with requirements set out in 2.9.3.

Rationale

G 4.4.4.3 The requirements are required for GB technical compatibility.

G 4.4.4.4 Limiting values for flangeway and free wheel passage provide an unobstructed wheel path during the passage of trains.

G 4.4.4.5 Provision of the maximum free wheel passage achieves compatibility with wheelsets compliant with GMRT2466.

Guidance

G 4.4.4.6 The requirements for minimum flangeway and free wheel passage in 4.4.4.1 apply to new designs of swing nose crossings and current designs of swing nose crossings with a design minimum flangeway of 60 mm.

4.4.5 Flangeway and check gauge for fixed crossings

4.4.5.1 Fixed crossings shall be configured so that the flangeway and check gauge conform to the dimensional limits for wheels and wheelsets as set out in GMRT2466.

Rationale

G 4.4.5.2 The calculation of the maximum unguided length of obtuse crossings set out in GMRT2466 is a GB specific case in the INF NTSN.

G 4.4.5.3 This requirement ensures that the flangeway and check gauge for fixed crossings is compatible with the dimensional limits for wheels and wheelsets.

Guidance

G 4.4.5.4 GMRT2466 sets out dimensional limits for wheels and wheelsets, including the distance between wheel flange backs. The datum point for measuring track gauge, flangeway and check gauge is different from the datum points for measuring wheel flange thickness and height.

G 4.4.5.5 GMRT2466 references a nominal check gauge of 1391 mm.

G 4.4.5.6 BS EN 13232-3:2003+A1:2011 provides guidance on the calculation on the maximum unguided length of obtuse crossings.

Part 5 Application of this document

5.1 Scope

5.1.1 If a change to an infrastructure subsystem is considered new, renewal or upgrade as defined in the Railways (Interoperability) Regulations 2011 (as amended), then all or part of the infrastructure subsystem is required to comply with the infrastructure NTSNs and other relevant NTSNs and NTRs, unless given exemptions allowed for in the regulations.

5.1.2 The requirements of this document apply to all new, renewed and upgraded (excluding like-for-like replacement of components) track systems.

5.1.3 The requirements of this document apply to all track in running lines and sidings. It is limited to:

a) Track with permissible or enhanced permissible speeds up to and including 140 mph.
b) Track which carries vehicles with axle loads no greater than 25.5 t.

5.1.4 Where it is known, or becomes known, that existing track system does not comply with the requirements of the following sections, then action to bring them into compliance is required:

a) 2.9 (Track geometry faults)
b) 3.2 (Requirements for rails, rail gaps and rail fastenings)

5.2 Exclusions from scope

5.2.1 There are no exclusions from the scope.

5.3 General enter into force date

5.3.1 The requirements in this document enter into force from 2 March 2024.

5.4 Exceptions to general enter into force date

5.4.1 There are no exceptions to the general enter into force date.

5.5 Applicability of requirements for projects already underway

5.5.1 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.

5.6 Deviations

5.6.1 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.

5.6.2 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).

5.7 User's responsibilities

5.7.1 Industry experts representing railway industry stakeholders are involved in the process for settling the content of documents which are prepared in accordance with the procedures set out in the Railway Standards Code and Manual.

5.7.2 Users of documents published by RSSB are expected to be competent or should take specialist advice before following or applying any practices or principles contained within them and are reminded of the need to consider their own responsibilities to ensure safe systems of work and operation, health and safety at work and compliance with their own duties under health and safety legislation. While documents published by RSSB can be used to help inform and devise safe practices and systems of work, their content has not been designed or prepared for:

- reliance by any specific person or organisation;
- application or use in all possible operational or working environments.

5.7.3 No representation, warranty, guarantee, confirmation or other assurance is given or made (whether expressly or implicitly) 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.

5.7.4 Users and duty holders remain responsible at all times for assessing the suitability, adequacy and extent of any measures they choose to implement or adopt and RSSB does not accept, and expressly disclaims, all and any liability and responsibility except for any liability which cannot legally be limited.

Definitions

abrupt change of cant deficiency	An abrupt change of cant deficiency occurs where there is a change of curvature without a geometrical transition.
adjustment switch	A scarf joint installed at the junction of continuous welded rail and jointed track to accommodate expansion of CWR track. Adjustment switches are also used to protect track features such as S&C not designed for use in CWR and at the ends of some types of bridges. An adjustment switch is a particular type of expansion device and is also known as an expansion switch.
ballast	Nominally single–sized granular material of specified properties, placed on the blanket (where provided), subgrade or structure to provide vertical and lateral support to the sleepers or bearers.
bearer	A transverse beam that provides vertical and lateral support to S&C, usually cut from hardwood or softwood or made of steel or pre–stressed concrete.
buffer stop	An assembly provided at the end of a terminal track which is designed to arrest a rail vehicle. This will be designed to accommodate the impact of a train at buffer or coupling height and up to a set speed.
Butterworth Filter	The Butterworth Filter is often used on the track recording vehicles to process the raw track measured data and to produce the track traces by removing all the design alignment elements and other long wavelength data.
cant	Expressed as the design difference in level, measured in millimetres, between rail head centres (generally taken to be 1500 mm) of a curved track.
cant deficiency	The difference between actual cant and the theoretical cant that would have to be applied to maintain the resultant of the weight of the vehicle and the effect of centrifugal force, at a nominated speed, such that it is perpendicular to the plane of the rails.
cant gradient	The rate at which cant changes in a specific length.
check gauge	The distance between the running edge of a running rail and the bearing face of the opposite check rail, measured at right angles to the rails in a plane 14 mm below their top surface.
check rail	A rail or special section provided alongside a running rail at a specified dimension inside gauge to provide a flangeway, to give guidance to wheelsets by restricting lateral movement of the wheels.
clothoid spiral (transition curve)	A transition curve between a straight and a curve where the curvature (the reciprocal of the radius) is proportional to the distance along the curve from its tangent point with the straight.

crossing	A cast or fabricated portion of the track layout which enables the rails of the two tracks to cross each other, while still providing support and guidance for smooth passage of the vehicle's wheels.
crossing vee	Two rails which are joined at an acute angle.
curvature	The reciprocal of the radius of a curve.
cyclic top	Cyclic top is the term used to describe a series of regular dips in the vertical alignment of one or both rails. They may not always be apparent visually because other top irregularities may obscure the cyclic pattern. Cyclic irregularities in track geometry have the potential, when combined with a vehicle's natural vertical response for a given speed and load, to cause a derailment.
CWR	Abbreviation for continuous welded rail.
design mass under normal payload	The design mass under normal payload as set out in *BS EN 15663:2017+A1:2018*. The design mass under normal payload is the design mass of the vehicle in working order plus the normal design payload. **Note:** There are no exceptional payload reference states for freight vehicles. The payload for freight vehicles is always taken as the maximum payload specified for the freight vehicle.
detection	A mechanism that proves and provides an output to indicate the actual position of a point end (normal or reverse), and that where fitted, the facing point lock is fully engaged.
differential speed	A value of permissible speed or speed restriction that is only applicable to certain trains. Differential speeds include: a) Standard differential speed – Two values of permissible speed, or two different speed values for a temporary speed restriction, each of which is applicable to one of two standard categories of trains, as defined in the Rule Book. b) Non-standard differential speed – A permissible speed for a specific type of train, which is different from that for other types of trains on the same section of line. This comprises 'Permissible speed indicators with letters' and 'Enhanced permissible speed indicators' as described in the Rule Book. Non-standard differential speeds are not applicable to temporary or emergency speed restrictions.
dynamic sleeper support stiffness	The peak load divided by the peak deflection of the underside of a rail seat area of an unclipped sleeper subjected to an approximately sinusoidal pulse load at each railseat; the pulse load

	being representative in magnitude and duration of the passage of a heavy axle load at high speed, typically 20 t at 100 mph. A falling weight deflectometer can be used to measure dynamic sleeper support stiffness directly.
enhanced permissible speed (EPS)	The speed permitted over a section of line that applies to a specific type of train operating at cant deficiencies in excess of those permitted at the permissible speed. There may be more than one enhanced permissible speed applicable to a given section of line.
equivalent conicity	Parameter for characterisation of the wheel/rail contact. For a given wheelset running on given track it equals the tangent of the taper angle of a tapered profile wheelset whose transverse movement has the same wavelength of kinematic yaw as the wheelset under consideration.
flange	The projecting rim of a rail vehicle wheel.
flangeway	The gap provided to permit the passage of the wheel flanges of rail vehicles, for example between a check rail and a running rail. See Appendix F for a diagram depicting the flangeway.
gauge point	The point of intersection of the gauge corner radius and the flat side of the rail head. For 60 E 1 and BS 113A rails this is nominally 14.5 mm below the top of the rail head, measured parallel to the vertical axis of the rail.
head width	The width of the rail head measured perpendicular to the vertical axis of the rail at the gauge point.
jointed track	A method of track construction where rails are joined together by fishplates, with an expansion gap between rail ends.
level crossing	An intersection at the same elevation of a road, footpath or bridleway and one or more rail tracks. Source: *IEV 821-07-01*, modified
legacy CWR	CWR track systems that do not fully meet the specifications for modern CWR.
loss of section	The reduction in the cross sectional area of a rail, compared to that when new.
negative cant	Cant is negative when the inner rail of a curve track is raised above the level of the outer rail. Also known as adverse cant.
modern CWR	CWR track systems comprising strings of long welded rail with a designated section mass of not less than 54 kg/m (or imperial equivalent) laid on concrete sleepers with a nominal spacing of not more than 650 mm and fastened using clips with a designed toe load of 9 kN or greater.
modern CWR S&C	S&C layouts with CEN56E1 rail profile vertically inclined (full depth or shallow depth) on concrete bearers or NR60 rail profile (inclined or vertical) on concrete bearers.

new trackbed	Trackbed layers placed where there was previously no track. Compare with ‘Renewal (of trackbed)’.
non-ballasted track	Track that is not supported on ballast, including concrete slab track, track supported on longitudinal timbers and directly fastened track on bridges.
obtuse crossing	An assembly to permit the passage of wheel flanges where two rails intersect at an obtuse angle.
Open Point	Parameters that have been formally identified as in scope of a NTSN or Railway Group Standard for which no common requirement has been agreed.
overspeed	The amount by which the actual speed of a train could exceed the enhanced permissible speed for any reason.
permissible speed	The maximum permitted speed over a section of line that applies to trains when not operating at an enhanced permissible speed. Permissible speeds are detailed in the Sectional Appendix.
plain line	Track not incorporating S&C. The term ‘plain line’ therefore excludes the through route of S&C.
rail fastenings	Any device used to secure running rails into chairs or baseplates or directly to sleepers, bearers or other rail supports.
rate of change of cant	The rate at which a vehicle experiences the change in design cant measured in millimetres per second.
rate of change of cant deficiency	The rate at which a vehicle experiences the change in design cant deficiency measured in millimetres per second.
renewal (of trackbed)	The replacement of existing trackbed layers or provision of new trackbed layers. For the purposes of this document, renewal includes remodelling, relaying, track lowering and reballasting. The replacement of former trackbed layers or provision of new trackbed layers when track that has been removed is subsequently re–instated is classed as a ‘renewal’ for the purposes of this document, not a ‘new trackbed’.
reverse curve	Two abutting curves of opposite flexure or hand.
running line	A line that is shown in Table A of the Sectional Appendix as a passenger line or a non-passenger line.
sidewear	The loss of head width on the running edge of the rail measured perpendicular to the vertical axis of the rail at the gauge point.
sleeper	A transverse beam that provides vertical and lateral support to plain line running rails, rail fastenings and where appropriate check rails, guard rails, conductor rails and ancillary operating equipment.
SP	Multiple unit which meets the requirements set out in RIS-2711-RST, and which can be permitted to operate to lettered differential speeds signed 'SP'.

standard deviation	Standard deviation is a universally used scientific measure of the variation of a random process. Track profiles have been found to have sufficiently similar statistical properties to random processes to enable a measure of the magnitude of track irregularities to be obtained from the standard deviation of the vertical and horizontal profile data. This form of analysis provides track quality indices.
structure	An element of the infrastructure built to support or retain a railway traffic load including, but not limited to, bridges, culverts, cut and cover structures, structures over or adjacent to the track, earth retaining structures, and earthworks.
swing nose crossing	A common crossing in which the crossing vee can move laterally to close the flangeway to one or other of the wing rails to provide continuous support to wheelsets. This type of crossing does not require the use of check rails. A swing nose crossing counts as one point end.
switch diamonds	A set of switch diamonds consists of two obtuse crossings in which the obtuse point rails are replaced by switch rails and a check rail is not required. A set of switch diamonds counts as two point ends..
switch toe	The end of the switch rail that is traversed first by a vehicle negotiating the switch in the facing direction.
switches	A set of switches consists of two fixed stock rails with their two associated moveable switch rails. A set of switches counts as one point end.
switches and crossings (S&C)	Sometimes points and crossings. All the ironwork associated with a set of points. It covers switch toes, switch rails, heels of switch rails, closure rails, stock rails, crossings and check rails.
through route and turnout route in S&C	In most S&C the through route is the one that carries the majority of traffic and is usually the route through which permissible speed remains unchanged. The turnout route is typically the one that carries less traffic and usually has a permissible speed substantially lower than that of the through route.
tight joint	Non-insulated connection of two rails by means of specially drilled fishplates and rail fastening devices but without an expansion gap between the rail ends.
track fault	A hazardous track geometry condition requiring remedial attention. In this document, the conditions covered by this term include twist (unintentional or non-compliant variation in cross level), track gauge, vertical profile (including cyclic top) and lateral alignment.
track gauge	The distance between the running edges of the running rails in a track, measured at right angles to the rails in a plane 14 mm below their top surface.

track system	The assemblage of rails, rail supports, rail fastenings, sleepers, timbers or bearers and ballast or other forms of support, acting together to provide guidance and support for rail vehicles.
trackbed	A general term referring to the ballast, blanket and subgrade.
transition curve	A curve between a straight and a curve, or between curves of different radius, along which the radius changes in a regular (though not necessarily uniform) manner.
twist fault	A difference in cross-levels over a short distance (usually measured over 3 m) that is greater than a predetermined amount.
unguided length	The length within an obtuse crossing where the wheel has no flange guidance and is dependent on frictional guidnace alone.
vertical curve	A curve joining two track gradients in their vertical alignment.

References

The Standards catalogue gives the current issue number and status of documents published by RSSB: http://www.rssb.co.uk/standards-catalogue.

RGSC 01	Railway Group Standards Code
RGSC 02	Standards Manual

Documents referenced in the text

Railway Group Standards

GIRT7004	Requirements for the Design, Operation and Maintenance of Points (Withdrawn)
GIRT7073	Requirements for the Position of Infrastructure and for Defining and Maintaining Clearances
GKRT0028	Infrastructure Based Train Detection Interface Requirements
GMRT2141	Permissible Track Forces and Resistance to Derailment and Roll-Over of Railway Vehicles
GMRT2142	Resistance of Railway Vehicles to Roll-Over in Gales
GMRT2466	Railway Wheelsets

RSSB documents

RIS-2711-RST	Lettered Differential Permissible Speeds Classification
RIS-7016-INS	Interface between Station Platforms, Track, Trains and Buffer Stops
RIS-7704-INS	Calculation of Enhanced Permissible Speeds for Tilting Trains
RIS-7706-INS	Process for Adding, Removing or Modifying Lettered Differential Permissible Speeds
RIS-7707-INS	Switches and Crossings
RIS-8012-CCS	Controlling the Speed of Tilting Trains through Curves
RSSB Formal Inquiry into the passenger train derailment at Potters Bar, 10 May 2002	Formal Inquiry: Derailment of train 1T60, 1245 hrs Kings Cross to Kings Lynn at Potters Bar on 10 May 2002
RSSB Research Report T1073 (2020)	Loading Requirements for Track Systems

Other references

BS EN 13232-3:2003+A1:2011	Railway applications. Track. Switches and crossings. Requirements for wheel/rail interaction

BS EN 13674-1:2011+A1:2017	Railway applications. Track. Rail. Vignole railway rails 46 kg/m and above
BS EN 13803:2017	Railway applications - Track - Track alignment design parameters - Track gauges 1 435 mm and wider
BS EN 13848-1:2019	Railway applications. Track. Track geometry quality. Characterization of track geometry
BS EN 13848-5:2017	Railway applications. Track. Track geometry quality. Geometric quality levels. Plain line, switches and crossings
BS EN 14363:2016+A1:2018	Railway applications. Testing and Simulation for the acceptance of running characteristics of railway vehicles. Running Behaviour and stationary test
BS EN 15302:2021	Railway applications. Wheel-rail contact geometry parameters. Definitions and methods for evaluation
BS EN 15663:2017+A1:2018	Railway applications. Vehicle reference masses
BS EN 1991-2:2003	Eurocode 1. Actions on structures. Traffic loads on bridges
COF-UOH-59 (2023)	Lateral Loading Requirements for Track Systems (T1073) – WP3: Development of a Draft Framework for Lateral Loading and Proposal for Further Work
INF NTSN	Infrastructure National Technical Specification Notice