RAIL SAFETY AND STANDARDS BOARD

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Size of Vehicles and Position of Equipment

This document sets out Great Britain (GB) requirements in scope of National Technical Rules for the methods of determining the swept envelope of rail vehicles. It includes specific gauge requirements for the lower sector and specific items of equipment on the rolling stock, and minimum requirements for the recording of vehicle gauging data.

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Synopsis

This document sets out Great Britain (GB) requirements in scope of National Technical Rules for the methods of determining the swept envelope of rail vehicles. It includes specific gauge requirements for the lower sector and specific items of equipment on the rolling stock, and minimum requirements for the recording of vehicle gauging data.

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Issue record

Issue	Date	Comments
One	December 2015	Original document. Supersedes GMRT2149 issue three. Requirements for Defining and Maintaining the Size of Railway Vehicles.
Two	June 2019	Revisions to GMRT2173, clause 2.2.4.6 and Appendix A, to reflect changes to platform height requirements within GIRT7020, issue one (formerly contained within GIRT7016, issue five). Cross-referencing to GIRT7016 (withdrawn) changed to GIRT7020 and RIS-7016-INS throughout.
Three	December 2019	Revisions to GMRT2173. Addition of section 3.5 'Pantograph encroachment' based on guidance in GEGN8573. Clause 3.5.6 has been added to highlight that there is no nationally agreed requirement to address technical compatibility of the pantograph in its design operating state with all non-TSI compliant electrification infrastructure on the GB mainline network. The title and synopsis have also been updated to reflect current style rules. Clause 3.2.1 amended by replacing 'stepping distance' with 'step position relative to the target platform'. The note to Clause 3.2.1 has been amended. Clause 3.3.1 amended to reflect changes to CCS requirements. Appendix A updated to align with the footstep position from the GB specific case in the PRM TSI.

Issue	Date	Comments
Four	June 2022	Replaces issues three. Requirements that are not National Technical Rules have been removed as requirements from this document. The format of the document has been updated to include rationale and guidance to support requirements. The maximum vehicle overhang length has been revised to permit the use of a 4.2 m overhang has been increased from 3.226 m. A new, informative appendix has been added to include outputs from RSSB Research Project T1196 - Development of a Suite of Pantograph Gauges. A new, informative appendix containing benchmark suspension information from T1109 has been added.
4.1	March 2025 [proposed]	Transfer of Appendix C - T1109 Benchmark Suspension Characteristics to GERT8073 Issue Five.

Revisions have been marked by a vertical black line in this issue.

Superseded documents

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

Superseded documents	Sections superseded	Date when sections are superseded
GMRT2173 Issue Four Size of Vehicles and Position of Equipment	All	March 2025 [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:

a) sets out requirements for defining the swept envelope of rail vehicles and the recording of vehicle data;
b) defines swept envelopes for specific equipment that is required to interact with the infrastructure; and
c) supports the compatibility assessment process for vehicles built in accordance with the applicable National Technical Specification Notices (NTSNs), and existing routes.

1.2 Introduction

1.2.1 Background

1.2.1.1 The overall gauging compatibility process includes the following aspects:

a) The safe operation of a rail vehicle on the infrastructure. This is dependent upon maintaining adequate clearance between the vehicle and adjacent structures, and on maintaining adequate passing clearance between the vehicle and other vehicles operating on adjacent tracks. The adequacy of the clearances is established by the proximity of structures or other vehicles on the route.
b) The swept envelopes of the vehicle are determined by identification of the relative movements of the vehicle with reference to track, at various speeds and under conditions appropriate to the route or routes on which it is to operate.

1.2.2 Key requirements

1.2.2.1 The key requirements set out in this document are:

a) Identification of the parameters that are required to define the vehicle swept envelope containing all dynamic movements and static deflections relative to the track of a rail vehicle or combination of vehicles, over the permitted range of operating conditions.
b) Identification of the permissible processes by which the swept envelope can be defined.
c) Identification of the position for specific items that are required to interact with the infrastructure, including pantographs.
d) Identification of the position for footsteps.
e) Definition of a suitable format of the data for gauging compatibility assessment.
f) Compliance with the declared swept envelope throughout the operational life of the vehicle or combination of vehicles.

1.2.2.2 This document defines the position of the footsteps relative to the nominal platform position. This document does not define how the stepping distance for the passengers to platforms on any particular route is calculated. Information pertaining to the calculation of stepping distances is set out in RIS-8273-RST.

1.2.3 Principles

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

1.2.3.2 This document sets out requirements that meet the characteristics of National Technical Rules (NTRs) and are applicable to the GB mainline railway system. Compliance with NTRs is required under the Railways (Interoperability) Regulations 2011 (as amended).

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

a) To support the NTSNs.
b) To achieve technical compatibility between:
   i) Vehicles that conform to the requirements of the NTSNs, and the existing control, command and signalling, infrastructure and/or energy subsystem(s) or vehicles.
   ii) Control, command and signalling, infrastructure and/or energy subsystem(s) that conform to the requirements of the NTSNs, and existing vehicles.

1.2.4 Structure of this document

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

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

1.2.5 Related requirements in other documents

1.2.5.1 The following Railway Group Standards (RGSs) contain requirements that are relevant to the scope of this document:

a) GERT8073 - defines standard vehicle gauges and the associated application rules for rolling stock and infrastructure. GERT8073 also defines lower sector vehicle gauge (LSVG).
b) GIRT7020 - sets out the nominal height for new, extended and altered platforms.
c) GIRT7073 – defines the lower sector infrastructure gauge and requires the infrastructure manager to keep, maintain and make gauging capability information and generic track quality data available to railway undertakings and their suppliers.
d) GLRT1210 – sets out the requirements for the AC energy system and the interfaces to rolling stock operating over the AC electrified railway.
e) GLRT1212 – sets out the requirements for the DC energy system and the interfaces to rolling stock operating over the DC electrified railway.
f) GMRT2111 – sets out requirements for all rolling stock operating over the alternating current (AC) electrified railway.
g) GMRT2113 – defines the interface requirements to the DC conductor rail energy system for all rolling stock operating over the DC electrified railway.

1.2.6 Supporting documents

1.2.6.1 The following Railway Group documents support this Railway Group Standard:

a) GMGN2615 – gives guidance on interpreting the requirements of the Conventional Rail Locomotives and Passenger Rolling Stock National Technical Specification Notice (CR LOC & PAS NTSN), including guidance on gauging requirements that apply in GB.
b) GMGN2641 – gives guidance on meeting the requirements of GMRT2141 'Permissible Track Forces and Resistance to Derailment and Roll-Over of Railway Vehicles' and BS EN 14363:2016 'Railway applications. Testing and Simulation for the acceptance of running characteristics of railway vehicles. Running behaviour and stationary tests' in respect of vehicle static testing.
c) RIS-2773-RST – provides a standard format for recording the vehicle data to generate a swept envelope for the purposes of compatibility assessment when undertaking absolute or comparative gauging. The data in this format can also be used for the purposes of assessment against standard dynamic vehicle gauges.
d) RIS-8270-RST – sets out requirements and responsibilities for the assessment of technical compatibility at route level for vehicles and infrastructure.
e) RIS-8273-RST - Gauging and Stepping Distances - sets out specific requirements and responsibilities for the assessment of gauge compatibility and stepping distances between rolling stock and infrastructure.
f) RIS-7016-INS – sets out requirements for the design and maintenance of station platforms for their safe interface with trains, track and buffer stops.

1.3 Approval and authorisation of this document

1.3.1 The content of this document will be approved by Rolling Stock Standards Committee on 07 November 2024 [proposed].

1.3.2 This document will be authorised by RSSB on 10 January 2025 [proposed].

Part 2 Process to describe vehicle size

2.1 Defining the swept envelope

2.1.1 Vehicles with established or benchmark suspensions shall have a swept envelope determined or have compliance assessed against a standard vehicle gauge as set out in GERT8073.

2.1.2 Vehicles without established or benchmark suspensions shall have a swept envelope determined.

2.1.3 The swept envelope data, or confirmation of the compliance of the vehicle with the standard vehicle gauge or comparator vehicle, shall be made available in the form of a gauging portfolio as set out in *Part 4* and is to be included in the technical file.

Rationale

G 2.1.4 The swept envelope allows gauging compatibility to be assessed.

Guidance

G 2.1.5 There are three distinct processes available for the gauging of new or modified vehicles, with a fourth option being to use any combination of the first three:

a) Use of a standard vehicle gauge;
b) Comparative gauging;
c) Absolute gauging; and
d) Hybrid gauging.

The simplest process is to compare a vehicle with a standard vehicle gauge. Comparative gauging compares the swept envelope of the new vehicle to an existing vehicle to enable the new vehicle to operate over the same routes as the existing vehicle. Absolute gauging involves comparing the vehicle swept envelope to the measured infrastructure for a complete route. Hybrid gauging is when any combination of the previous three processes is used.

G 2.1.6 Alternative methods can be used to determine a vehicle's swept envelope as part of absolute gauging such as from probabilistic calculations.

G 2.1.7 The vehicle profile is defined for an upper and a lower sector with respect to the plane of the rails.

G 2.1.8 The processes listed in *G 2.1.5* are set out in RIS-8273-RST in more detail.

2.2 Determining vehicle swept envelopes

2.2.1 The swept envelope shall be determined relative to the nominal centreline of the track and the plane of the rails.

2.2.2 Where the vehicle can be operated either separately or when joined to other vehicles, the vehicle shall be considered in accordance with the requirements of this document both individually and when forming part of a train.

2.2.3 When the vehicle only operates joined to other vehicles forming an operationally inseparable rake, the rake as a whole and the rake as part of a train shall meet the requirements of this document.

2.2.4 To allow for the calculation of swept envelopes for any combination of track and operating conditions, data, as set out in *4.6 a)*, *c)* and *d)* shall be used.

2.2.5 The following shall be taken into account when determining the vehicle's swept envelope:

a) The full range of operating speeds and cant excess and deficiency for which the vehicle has been designed;
b) Aerodynamic loads experienced on the route(s) required for service caused by ten-minute mean cross-wind speeds up to 22 m/s acting over the whole height of the vehicle, and any higher crosswind speed limit for particularly exposed locations, as set out in GIRT7073.

2.2.6 The range of track and rail configurations, features and track quality applicable to the route or routes required for gauging purposes shall be obtained from the infrastructure manager.

2.2.7 The swept envelopes shall take into account, as a minimum:

a) Tolerances in vehicle dimensions;
b) Normal mass distributions and wheel loadings;
c) Suspension characteristics;
d) Normal variations in vehicle maintenance condition and wear;
e) Vehicle cross-sectional profiles at significant planes along the vehicle length, including all protrusions;
f) Quasi-static sway, roll, drop and lift arising from steady-state curving forces (cant deficiency and cant excess);
g) Dynamic sway, roll, drop and lift in response to short wavelength track cross-level errors;
h) Dynamic sway, roll, drop and lift in response to track irregularities;
i) Static vertical displacements caused by payload variations, wheel wear, and suspension stiffness tolerances;
j) Dynamic vertical deflections of the vehicle body or frame under all conditions of load, taking account of the factors set out in *2.2.7 i)*;
k) Vehicle displacements associated with likely suspension failure modes and other relevant factors, including hard overtilt failure or other system failures where applicable;
l) Lateral and vertical vehicle overthrow on curves, including information to enable the calculation of overthrows on curve lengths shorter than the vehicle wheel base or bogie centres;
m) Wheel-rail clearance, including flange wear, but not rail wear;
n) Vehicles with unconventional wheel arrangements or articulation, on continuous, reverse and compound curvature; and
o) Dynamic sway in response to the ten minute mean cross-wind speeds, as set out in *2.2.5 b)*.

2.2.8 The swept envelopes shall also indicate the area swept by pantographs where fitted, in the lowered or locked down modes.

2.2.9 The worst case scenarios and their probabilities of occurrence shall be identified taking account of normal and failure conditions of operation.

2.2.10 Movements that have a statistically significant probability of occurrence shall be included in the swept envelopes.

2.2.11 When the swept envelopes are determined by vehicle dynamic calculations the maximum movements shall be taken as:

a) the mean + 2.12 standard deviations of lateral, vertical and roll or
b) it is permitted to use an alternative methodology to the mean + 2.12 standard deviation method described in GMRT2173, provided that it can be demonstrated to offer an equivalent or improved level of accuracy.

2.2.12 Dynamic models used to derive movements and displacements for vehicle swept envelopes shall be validated to a level appropriate for the level of gauging risk.

Rationale

G 2.2.13 The vehicle swept envelope allows gauging compatibility to be assessed.

G 2.2.14 There are various external factors to be included in the creation of a vehicle swept envelope.

G 2.2.15 In the development of vehicle swept envelopes, the statistically significant deflections and movements are calculated.

G 2.2.16 The worst cases will not necessarily be failure cases or occur at maximum speed, and may be different for various speeds.

G 2.2.17 The track and rail configurations, features and quality are provided by the infrastructure manager so that the developed vehicle swept envelopes are relevant to the route(s) for which they are generated.

G 2.2.18 The vehicle swept envelopes capture statistically significant movements generated by the vehicle over representative track. The requirements to generate swept envelopes no longer mandate the use of mean + 2.12 standard deviations to allow the use of other calculation methods to generate the swept envelopes.

Guidance

G 2.2.19 All infrastructure positional tolerances and allowances for rail wear are included in the calculation of clearances set out in GIRT7073.

G 2.2.20 An industry-agreed process for recording the data and the associated level of detail required is set out in RIS-2773-RST.

G 2.2.21 A set of track irregularity files, named 'Track for Gauging' (TfG) can be obtained from Network Rail.

G 2.2.22 Swept envelopes are not mandatory when demonstrating compatibility with a standard vehicle gauge. However, where swept envelopes are used to demonstrate compliance with standard vehicle gauges, the requirements apply as for absolute gauging.

G 2.2.23 Where compatibility is shown by compliance to a standard vehicle gauge, the rules for the appropriate gauge are set out in GERT8073.

G 2.2.24 The swept envelope can be determined by calculations, dynamic simulations, experiments or tests.

G 2.2.25 It is good practice to ensure that the process and level of accuracy achieved is appropriate for the level of clearance to be determined (such as normal, reduced or special reduced), and this may vary for different locations along the route.

G 2.2.26 GMRT2173 issue three and earlier issues of this document have set out the use of mean + 2.12 standard deviations to calculate the maximum movements to determine the vehicle's swept envelope.

G 2.2.27 Hybrid gauging is used, when appropriate, as an alternative to using a single defined process to demonstrate gauge compatibility. This is set out in RIS-8273-RST.

G 2.2.28 GIRT7073 sets out requirements for the calculations of aerodynamic loads experienced on the routes as per *2.2.5 b)*.

G 2.2.29 GMGN2641 contains guidance for vehicle testing and multibody simulation (MBS) model validation.

2.3 The lower sector

2.3.1 For a new build or a new design of vehicle that is not registered on the Rolling Stock Library in R2, or not using an established or benchmark suspension, the swept envelope of the vehicle in the lower sector shall remain within the LSVG, as set out in GERT8073.

2.3.2 For a new build or a new design of vehicle, either of which uses established or benchmark suspensions, the swept envelope of the vehicle in the lower sector shall remain within either the LSVG or W6a lower gauge.

2.3.3 It is permissible to demonstrate compliance with W6a lower gauge without the use of a swept envelope for vehicles with an established or benchmark suspension, as set out in GERT8073.

2.3.4 New equipment fitted to existing vehicles which affects the swept envelopes shall remain within the LSVG or the existing vehicle's stated lower gauge, such as W6a.

2.3.5 In a failure mode, such as suspension failure, it is permissible to exceed the LSVG and clearance requirements are set out in GIRT7073.

Rationale

G 2.3.6 The LSVG includes any elements (components) of the swept envelope that go below a height of 1100 mm measured from the plane of the rails, and has been shown to be compatible with a large majority of route sections on the mainline network.

Guidance

G 2.3.7 Parts of the swept envelope which exceed the LSVG may also be shown to be compatible by comparison with appropriate upper gauges (where applicable), comparison with other vehicles or by absolute gauging as set out in RIS-8273-RST.

G 2.3.8 An example of parts of the swept envelope which exceed the LSVG, as described in *G 2.3.7*, can include passenger footsteps.

G 2.3.9 Further information on the interface between the upper and lower sectors, and established suspension are set out in GERT8073.

2.4 The upper sector

2.4.1 The swept envelope for the upper sector shall include any parts of the vehicle that could go above 1100 mm measured from the plane of the rails.

2.4.2 Any part of the swept envelope below 1100 mm measured from the plane of rails shall be subject to the lower sector requirements in *2.3*, unless it can be demonstrated that the swept envelope is compatible by compliance with an appropriate upper gauge, or by absolute gauging.

Rationale

G 2.4.3 Any part of the vehicle above 1100 mm measured from the plane of the rails is considered to be part of the vehicle's upper sector for inclusion in the development of the swept envelope.

Guidance

G 2.4.4 An example of an appropriate upper gauge is the W6a upper gauge, which is defined down to 1000 mm measured from the plane of rails.

2.5 Use of comparator vehicle

2.5.1 The methodology used to determine the swept envelope of the comparator vehicle(s) shall be the same as that used for the candidate vehicle, or shall be demonstrated to be equivalent.

2.5.2 The vehicle loading condition of the candidate vehicle shall be compared to that of the comparator vehicle or vehicles to ensure that the gauging risks of the two are comparable.

2.5.3 The candidate vehicle in normal operational mode shall not be compared to a comparator vehicle in any degraded or failure mode.

2.5.4 Where elements of the swept envelopes for the candidate vehicle fall outside those of the comparator vehicle, each individual excursion shall be documented in the gauging portfolio, and identified in the Technical File for subsequent evaluation of the consequences under the gauging compatibility process.

Rationale

G 2.5.5 Comparative gauging is where a vehicle's swept envelope is compared against the swept envelope for another vehicle that is currently accepted for operation on the same route.

Guidance

G 2.5.6 More information on selecting a comparator vehicle is set out in RIS-8273-RST.

G 2.5.7 RIS-8273-RST also sets out information related to the evaluation of consequences under the gauging compatibility process.

2.6 Guidance on vehicle loading

Guidance

G 2.6.1 BS EN 15663:2017 sets out definitions for mass and vehicle load conditions.

G 2.6.2 The terms 'tare', 'laden', and 'crush' are defined terms.

G 2.6.3 Table *1* is a summary of terms used for vehicle load conditions in this document and BS EN 15663:2017.

GMRT2173	BS EN 15663	Definition
-	Dead mass	Vehicle "as built" without consumables and staff
Tare	Mass in working order	Dead mass + design consumables
Laden	Mass under normal payload	Design mass in working order + payload
Crush	Mass under exceptional payload	Design mass in working order + exceptional payload

Table 1: Vehicle load condition

G 2.6.4 Generally, a laden vehicle with a higher centre of gravity will result in a larger swept envelope compared to a vehicle in tare.

G 2.6.5 Wagons carrying empty containers will have an impact on the deck height and centre of gravity.

G 2.6.6 Wagons carrying empty containers could be more susceptible to increased roll due to wind loads, caused by the increase in the height of centre of gravity and the reduced mass compared to laden containers.

G 2.6.7 Consideration is given for wagons that are carrying empty containers on one end of the wagon, as this can also have an impact on the wagon's response to gales.

Part 3 Equipment required to interface with the infrastructure

3.1 Footsteps

3.1.1 The static step position relative to the nominal platform shall not exceed the parameters defined in Figure 1 for platforms on curves with radii down to 160 m.

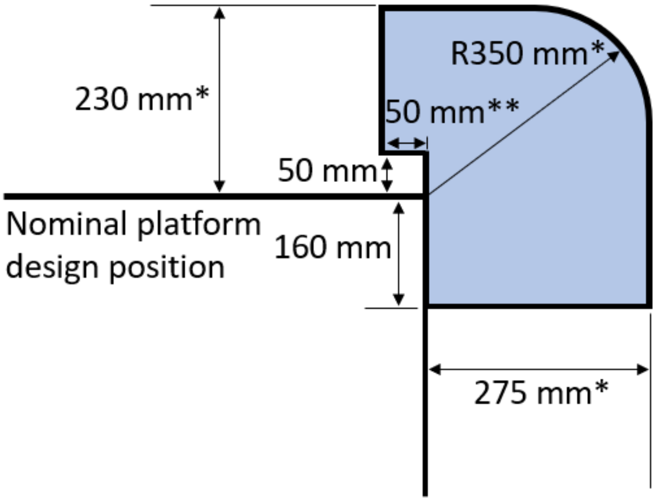


Figure 1: Footstep position

* Dimensions are worst-case maxima and shall be minimised as far as practicable.
** Maximum overlap allowable for platforms on curves down to 160 m radius.

Rationale

G 3.1.2 This requirement allows passengers to step safely on to the train from a station platform and vice versa, by ensuring that the step is not too high or far away from a platform.

G 3.1.3 GIRT7073 sets out clearance requirements and is relevant in determining clearances to footsteps that are not retractable.

Guidance

G 3.1.4 The box represents the limiting area within which the front edge of the step can be positioned, relative to the nominal platform design position for all curve radii down to 160 m, when the train is stationary.

G 3.1.5 Industry practice is to not include track cant when assessing the footstep position.

G 3.1.6 The horizontal step gap can be reduced by making maximum use of step oversail of the platform by up to 50 mm for platforms on curves.

G 3.1.7 Retractable footsteps that exceed the 50 mm limit are interlocked to prevent the vehicle from moving with the steps in the extended position.

G 3.1.8 The dimensions for a nominal platform design position are set out in GIRT7020.

G 3.1.9 Additional guidance on deployable gap fillers is provided in RIS-8273-RST.

3.2 Pantographs

3.2.1 The pantograph sway displacement relative to the centreline of the track shall be assessed against the benchmark limit values, as set out in Table 2 and Table 3.

3.2.2 Trains designed to operate at cant deficiency values higher than 150 mm and at speeds higher than permissible speed shall have pantograph sway values which do not exceed the benchmark values applicable at 150 mm of cant deficiency.

3.2.3 The method that shall be used to determine the pantograph sway values for comparison with Table 2 and Table 3 is set out in Appendix A.

Wind Speed (m/s)	Cant Deficiency (mm)							
	0	25	50	75	100	125	150	>150
22	166	166	180	190	200	208	216	216
17	145	145	160	174	184	195	203	203
15	137	137	151	166	179	189	199	199
10	112	112	131	149	164	176	187	187
No wind	77	77	100	121	144	159	171	171

Table 2: Pantograph sway limit values at 4.3 m above plane of rail

Wind Speed (m/s)	Cant Deficiency (mm)							
	0	25	50	75	100	125	150	>150
22	198	198	214	227	239	250	260	260
17	172	172	189	207	220	233	244	244
15	161	161	178	196	213	226	238	238
10	131	131	155	176	194	210	223	223
No wind	90	90	117	143	169	187	203	203

Table 3: Pantograph sway limit values at 5.3 m above plane of rail

Rationale

G 3.2.4 By assessing against the benchmark limit values, which have been agreed with industry, there is an agreed approach to calculating pantograph sway.

Guidance

G 3.2.5 The pantograph sway displacements relative to the centreline of the track set out in Table 2 and Table 3 are calculated using the wind speed, as defined in the UK National Annex to BS EN 1991-1-4:2005+A1:2010, at the location of the site, corrected by a reference height factor of 0.793. Pantograph sway limit values are determined using only the corrected wind speed and the average cant deficiency at the site.

G 3.2.6 The equivalent values for wind speed set out in BS EN 1991-1-4:2005, Eurocode 1, Wind Actions are shown in Table 4.

Wind speed values in Tables 2 and 3 (m/s)	10.0	12.0	14.0	15.0	16.0	17.0	18.0	20.0	22.0
BS EN 199-1-4 wind speed (m/s)	12.6	15.1	17.7	18.9	20.2	21.4	22.7	25.2	27.7

Table 4: Equivalent wind speed values

G 3.2.7 The wind speeds set out in Table 2 and Table 3 have no relevance for trains passing in tunnels. The pressure pulse due to trains passing is considered to have a negligible effect on pantograph sway.

G 3.2.8 Sway values can be linearly interpolated for intermediate heights.

G 3.2.9 RSSB Research Project, T1196 (2020) - Suite of Pantograph Gauges, to define a series of infrastructure gauges for pantographs to accommodate the parameters defined in Railway Group Standards and European Standards (ENs), for use on GB mainline railways has been completed and information on this project is set out in Appendix B.

3.3 Compatibility with train detection systems

3.3.1 The following limiting vehicle dimensions shall be achieved:

a) Maximum spacing between adjacent axles of 17.51 m;
b) Minimum bogie axle spacing of 1.6 m;
c) Minimum axle spacing for non-bogied vehicles of 2.6 m; and
d) Maximum axle spacing for non-bogied vehicles of 11 m.

3.3.2 Where a vehicle has an overhang dimension greater than 3.226 m, the circumstances shall be risk assessed to confirm that the hazard of a safety margin of less than 1.654 m is suitably managed.

Rationale

G 3.3.3 The dimensions set out in 3.3.1 are specified to enable the rolling stock to achieve technical compatibility with legacy train detection infrastructure.

G 3.3.4 Rolling stock with a vehicle overhang length exceeding 3.226 m will result in a safety margin that is less than the reference system safety margin of 1.654 m. Risk assessment is used to confirm that a reduced safety margin is acceptable.

Guidance

G 3.3.5 The requirements for legacy train detection systems are set out in GKRT0028.

G 3.3.6 RIS-0728-CCS sets out information on the operation of rolling stock with infrastructure-based train detection systems.

G 3.3.7 Some guidance from RIS-0728-CCS is as follows:

a) A clearance point dimension of 4.88 m is used on GB infrastructure;
b) A vehicle overhang of 3.226 m will result in a safety margin of 1.654 m; and
c) A vehicle with an overhang value of 4.2 m (the maximum value set out in the CCS NTSN) will result in a safety margin of 0.68 m.

G 3.3.8 Clause G 2.1.9 of RIS-0728-CCS Issue 1.1 states:

> Where a planned change to the railway has the potential to reduce the safety margin, either of the following can be used in the application of the common safety method on risk evaluation and assessment (CSM RA) as controls against the hazard of a vehicle obstructing the fouling point:
>
> a) The historic value of 1.654 m can be applied as a reference system.
> b) A reduced safety margin can be justified through explicit risk estimation.

Part 4 Recording vehicle data for the gauging portfolio

4.1 Information required for creating the gauging portfolio

4.1.1 The documentation containing the vehicle data to generate the swept envelope, or confirmation of the compliance of the vehicle with the standard vehicle gauge or comparator vehicle, shall be made available in the form of a gauging portfolio.

4.1.2 The gauging portfolio shall include:

a) A vehicle diagram, giving an overview of the vehicle concerned;
b) A vehicle profile summary drawing, identifying the location of the body plan view and cross-sectional profiles;
c) Vehicle body plan view;
d) Vehicle cross-sectional profiles, (for absolute and comparative gauging only);
e) Data for the calculation of swept envelopes for each significant track configuration and location relevant to the route(s) along which the vehicle is expected to operate, (for absolute and comparative gauging only);
f) Details of the validation process of the swept envelope model, including the revision / issue status of the data, (for absolute and comparative gauging only) ;
g) Details of any approved deviations specific to gauging; and
h) Reference to the specific track files used.

Rationale

G 4.1.3 A gauging portfolio provides interested parties consistent information regarding the gauge of a vehicle.

Guidance

G 4.1.4 RIS-2773-RST issue two sets out methods for recording items *d)* and *e)* in *4.1.2*.

G 4.1.5 Further requirements for the list in *4.1.2* are set out in *4.2* to *4.6*.

G 4.1.6 It is good practice for drawings, documents to have unique identification reference numbers.

4.2 Vehicle diagram

4.2.1 The vehicle diagram shall clearly identify the name of the vehicle manufacturer, the vehicle class and any additional distinguishing marks.

4.2.2 The vehicle diagram shall comprise a plan, a side and an end elevation of each vehicle. It shall include the principal dimensions on each elevation.

4.2.3 The dimensions on the vehicle diagram shall include, at least:

a) The maximum body length over body ends;
b) The body length over buffers and / or couplers;
c) The maximum overhangs of the body outboard of the bogie pivots or axle centres;
d) The maximum body width;
e) The bogie pivot spacings or, for two axle vehicles, the axle centres;

f) The bogie wheelbase or wheelbases;
g) The nominal wheel diameter or diameters;
h) The door positions;
i) The footstep positions; and
j) The pantograph (where present) positions.

4.2.4 The diagram shall also include a summary of operating characteristics and features of the vehicle that affects its swept envelope.

Rationale

G 4.2.5 The vehicle diagram includes important information related to the vehicle's dimensions and key features that will affect its swept envelope.

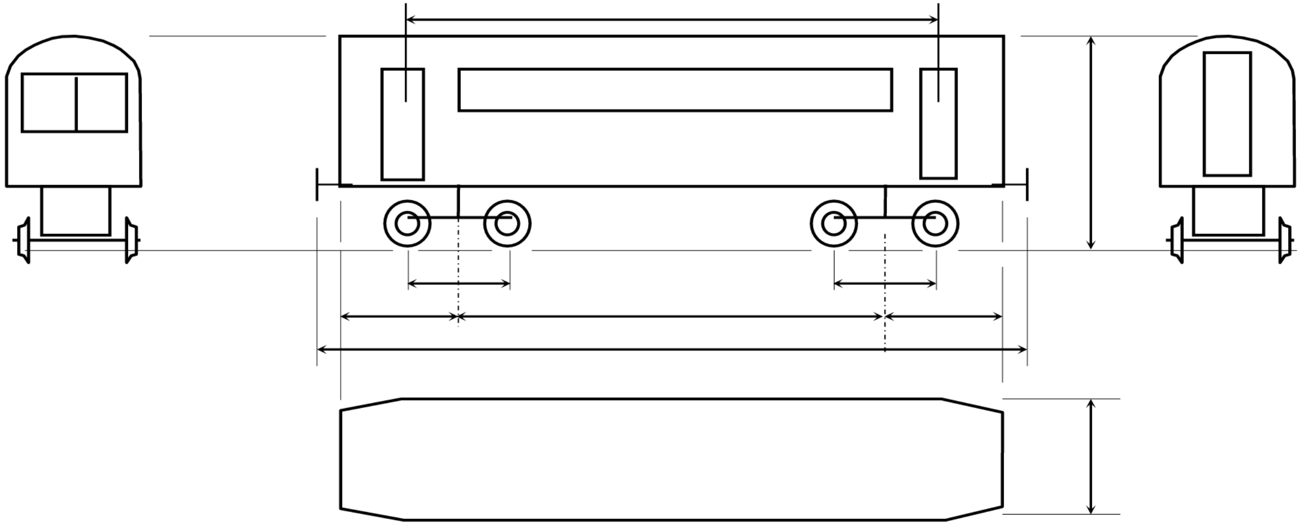
Guidance

G 4.2.6 Examples of key features of the vehicle include:

a) Maximum design speed in tare and laden load conditions (and in the deflated air–suspension condition, if applicable);
b) Maximum design cant deficiency;
c) The presence of tilting mechanisms;
d) The type of suspension;
e) Coupler type; and
f) An indication of the standard vehicle gauge or comparator vehicle against which the swept envelopes have been determined, where appropriate.

G 4.2.7 An example illustration of the format of the vehicle diagram is shown in Figure *2*.

Vehicle Diagram For Class (type) Vehicles



Vehicle Data Panel	Gauging Process Data
A1. Class of vehicle …………………………. A2. Manufacturer …………………………. A3. Vehicle Weight Tare ………Tonnes Laden ………Tonnes A4. Maximum Design Speed ………km/h Tare ………km/h Laden A5. Wheel Diameter (nominal) ………mm A6. Particular Features: (e.g. tilting, active suspension) A7. Coupler Type:	B1. Train Operator……………………….. B2. Basis of Gauging 1. Absolute Gauging 2. Standard Vehicle Gauge 3. Comparison with other vehicle B3. Reference (if 2 or 3 above) ………………….. B4. Routes: B5. Maximum design cant deficiency:

Figure 2: Vehicle diagram format

4.3 Vehicle summary drawing

4.3.1 The vehicle summary drawing, comprising a plan, a side and an end elevation, shall contain the following information:

a) The location of the reference datum point(s) longitudinally, laterally and vertically; and
b) The location of each longitudinal and lateral profile, cross-referenced to the appropriate drawing of that profile.

Rationale

G 4.3.2 The vehicle summary drawing provides an overview of information related to the vehicle's dimensions.

Guidance

G 4.3.3 Where additional information is provided, additions to the summary drawing can be beneficial to the gauging calculations.

4.4 Vehicle body plan view

4.4.1 The body plan view shall contain dimensions of the vehicle and give sufficient detail to clearly define the longitudinal and lateral profiles.

4.4.2 Details that define the limits of the swept envelope shall be included.

4.4.3 The vertical location of each profile shall be clearly stated and cross-referenced with the associated vehicle summary drawing.

Rationale

G 4.4.4 The vehicle body plan view shows information related to the vehicle's dimension as viewed from above.

Guidance

G 4.4.5 A non-exhaustive list of examples of elements that can affect the swept envelope include:

a) Body end tapers;
b) Roof equipment;
c) End profiles, including noses;
d) Door indicators; and
e) Bodyside cameras.

4.5 Vehicle cross sectional profiles

4.5.1 The cross-sectional profiles shall contain dimensions of the vehicle and give sufficient detail to clearly define the cross-sectional profile at significant points along the length of the vehicle. Separate drawings showing sections through the vehicle at these locations shall be provided.

4.5.2 Details that define the limits of the swept envelope, such as footsteps, yaw damper brackets, roof equipment (including pantographs) and nose end profiles shall be included.

4.5.3 The longitudinal location of each profile shall be clearly stated and cross-referenced with the associated vehicle summary drawing.

Rationale

G 4.5.4 The vehicle cross sectional profiles show information on the vehicle's dimensions and features when viewed along the longitude.

G 4.5.5 The movements for each cross sectional profile are affected by its longitudinal position along the vehicle body.

Guidance

G 4.5.6 It is good practice for the vehicle drawings and cross-sectional profiles to contain the same level of detail defined in the RIS-2773-RST VGD workbook.

4.6 Vehicle swept envelopes

4.6.1 Data shall be provided which allows the calculation of swept envelopes for any combination of track and operating conditions, as set out in *2.2* and *4.6.2 a)*, *c)* and *d)*.

4.6.2 The vehicle cases considered shall include:

a) All vehicle types and variants;
b) For units operating in multiple it is permissible to consider the single vehicle presenting the largest profile in all respects, or a composite vehicle gauge representing the aggregate of the most significant features of all vehicle types and variants in a formation;
c) Normal operating conditions, including at least:
    i) Tare and laden load conditions;
    ii) Additional cases, where appropriate, for example, freight vehicles carrying empty containers.
d) Appropriate combinations of failure modes and extreme conditions, including where applicable:
    i) Deflated air suspension systems;
    ii) Tilt failure modes ;
    iii) Active suspension system failures;
    iv) Crush loading;
    v) Failures of other vehicle systems, which are capable of influencing the size of the vehicle swept envelopes.

4.6.3 The data provided for swept envelope calculation shall describe the statistical properties of all dynamic movements, static deflections and overthrows that may reasonably be expected to occur under the vehicle's respective combination of track and environmental conditions.

4.6.4 The vehicle lateral, vertical and roll movements shall be derived.

4.6.5 The operating conditions and features shall be clearly referenced, and the related track and operating conditions shall be identified.

Rationale

G 4.6.6 Multiple inputs are used as part of the calculations to generate a vehicle swept envelope.

Guidance

G 4.6.7 Swept envelopes are not mandatory when demonstrating compatibility with a standard vehicle gauge.

G 4.6.8 The lateral, vertical, and roll movement data are used in the RIS-2773-RST workbook.

G 4.6.9 Mean and standard deviation are examples of statistical properties that describe the vehicle swept envelope.

Part 5 Application of this document

5.1 Scope

5.1.1 The requirements of this document shall apply to all new and existing vehicles when the swept envelope of the vehicle is being determined.

5.1.2 The requirements of this document shall apply to all work that affects the swept envelope of the vehicle whether new or an alteration.

5.2 Exclusions from scope

5.2.1 The requirements in this document are not applicable to on-track plant (OTP).

5.2.2 There are no other exclusions from the scope specified in *5.1*.

5.3 General compliance date

5.3.1 The requirements in this document enter into force from 08 March 2025 [proposed].

5.4 Applicability of requirements for projects already underway

5.4.1 When this document enters into force the Office of Rail and Road can be contacted for clarification on the applicable requirements where a project seeking authorisation for placing into service is already underway.

5.5 Deviations

5.5.1 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 Standards Code.

5.5.2 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).

5.6 User's responsibilities

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

5.6.2 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:

a) reliance by any specific person or organisation; and

b) application or use in all possible operational or working environments.

5.6.3 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.

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Appendices

Appendix A Method of assessment for pantograph sway

A.1 Basic principle

A.1.1 The pantograph sway shall be calculated using a multi-body simulation (MBS) model for the pantograph vehicle travelling at up to maximum speed on straight track over a range of installed cants ranging between 0 mm to the maximum cant deficiency.

A.1.2 The pantograph sway calculations shall be repeated to include the effects of a range of ten minute mean cross-wind speeds (10 m/s, 15 m/s, 17 m/s and 22 m/s) and the results included within the gauging portfolio for the vehicle.

A.1.3 The pantograph sway values of the candidate vehicle shall be equal to or lower than the benchmark vehicle values for both the 22 m/s mean wind speed and the no wind case.

Rationale

G A.1.4 The method of assessment is based on a comparison between the pantograph sway values of the candidate vehicle and those of benchmark vehicles with a safe history of operation in GB.

Guidance

G A.1.5 The intermediate mean cross-wind results are for information only, except as permitted in *A.2.13*.

A.2 Dynamic simulation

A.2.1 Vehicle model

A.2.1.1 An MBS model of the candidate pantograph vehicle shall be set up in the loading condition that leads to the largest pantograph sway.

A.2.1.2 The dynamic model shall be set up with nominal suspension stiffness parameters.

A.2.1.3 The dynamic model shall be validated against full-scale test data to the same level comparable to that used for the model used for generating the vehicle's swept envelope.

Rationale

G A.2.1.4 It is important to determine the worst case loading condition to make sure the sway movements are not underestimated. The benchmark vehicle models represent the nominal suspension stiffness parameters so, to maintain a fair comparison, the candidate vehicle model is set up in the same way.

A.2.2 Track irregularity files (track roughness)

A.2.2.1 The TfG track irregularity files shall be used.

A.2.2.2 All of the track quality speed bands up to the maximum operating speed of the vehicle shall be used.

Rationale

G A.2.2.3 The benchmark vehicle limits are validated for the versions of the TfG files set out in the references section of this document.

G A.2.2.4 All of the different speed bands are used to determine the worst-case speed as it is not always the highest speed that produces the worst case.

Guidance

G A.2.2.5 The files consist of 20 km of track recording car data segments with lateral and vertical alignment standard deviation levels that are at the maintenance intervention level for the appropriate line speed.

A.2.3 Track design files (installed cant)

A.2.3.1 The track design files shall consist of straight track for the entire length with a suitable transition into the required level of installed cant.

A.2.3.2 Separate files shall be used for each level of installed cant in steps of 25 mm from 0 mm to 150 mm.

Rationale

G A.2.3.3 Transitions are required for the cant input to avoid unrealistic dynamic movements at the start of the simulation.

A.2.4 Contact conditions

A.2.4.1 The wheel profile shall be the design profile that is to be used for the candidate vehicle.

A.2.4.2 The rail profile shall be a design BR113A inclined at 1 in 20.

A.2.4.3 The nominal track gauge shall be 1435 mm.

A.2.4.4 The flange back spacing shall be 1360 mm.

A.2.4.5 The wheel to rail coefficient of friction shall be 0.3 for all contact points.

Rationale

G A.2.4.6 Use of design wheel-rail contact conditions is consistent with the benchmark limits.

Guidance

G A.2.4.7 Examples of wheel profiles that can be used include P8, P12, or S1002.

A.2.5 Vehicle speed

A.2.5.1 The simulations shall be made for speeds from 100 km/h up to the maximum operating speed of the vehicle to determine the vehicle speed that leads to the highest pantograph sway.

A.2.5.2 The relevant vehicle speed shall be used for each TfG file.

Rationale

G A.2.5.3 A range of speeds is required to determine the worst case for pantograph sway which is not always the maximum speed, as the track input is larger at lower speeds.

A.2.6 Wind modelling

A.2.6.1 The simulations shall be made:

a) Without wind loads (no wind).
b) With wind loads on the vehicle generated by mean wind speeds of 10 m/s, 15 m/s, 17 m/s and 22 m/s. These wind loads consist of a horizontal side force, a vertical lift force and a rolling moment.

A.2.6.2 The wind loads shall be calculated from the aerodynamic force and moment coefficients as follows:

$$v_a^2 = v_w^2 + v_{tr}^2$$

and

$$\beta = \tan^{-1}\left(\frac{v_w}{v_{tr}}\right)$$

Forces $F(\beta) = 0.5 \quad \rho \quad A \quad v_a^2 \quad C_F(\beta)$

Moment $M_x(\beta) = 0.5 \quad \rho \quad A \quad H \quad v_a^2 \quad C_{Mx}(\beta)$

Where:

v_w	Mean wind speed at a wind angle of 90˚ to track (m/s).
v_{tr}	Train speed (m/s).
v_a	Resultant wind speed relative to train (m/s).
F	Aerodynamic side or lift force (N).
F_y	Aerodynamic side force at the centre of gravity of the secondary sprung mass (N).
F_z	Aerodynamic lift force at the centre of gravity of the secondary sprung mass (N).
M_x	Aerodynamic rolling moment at the plane of rail about the track centreline (Nm).
ρ	Density of air (1.225 kg/m^3).
A	Vehicle side area (m^2) as defined in GMRT2142.
H	Mean longitudinal roof height (m) as defined in GMRT2142.

Z_{cgs}	Height of the vehicle secondary sprung mass above the plane of rail (m).
$C_{Mx}(\beta)$	Aerodynamic rolling moment coefficient at the plane of rail about the track centreline.
$C_F(\beta)$	Aerodynamic side force coefficient acting at the centre of gravity height, Z_{cgs}, or lift force coefficient acting through the centre of gravity of the vehicle's secondary sprung mass at yaw angle β.
β	Resultant wind angle relative to the train (rad), (also called 'yaw angle').

A.2.6.3 M_x shall be transformed to the vehicle secondary sprung mass centre of gravity (see Figure 3). The modified moment about the secondary mass centre of gravity, M'_x, is given by: $M'_x = M_x - F_y \quad Z_{cgs}$

A.2.6.4 The aerodynamic forces and moment shall be applied to the vehicle body as a side force, a lift force and a roll moment.

A.2.6.5 The calculated forces and moment shall be constant and applied for the whole length of the analysis.

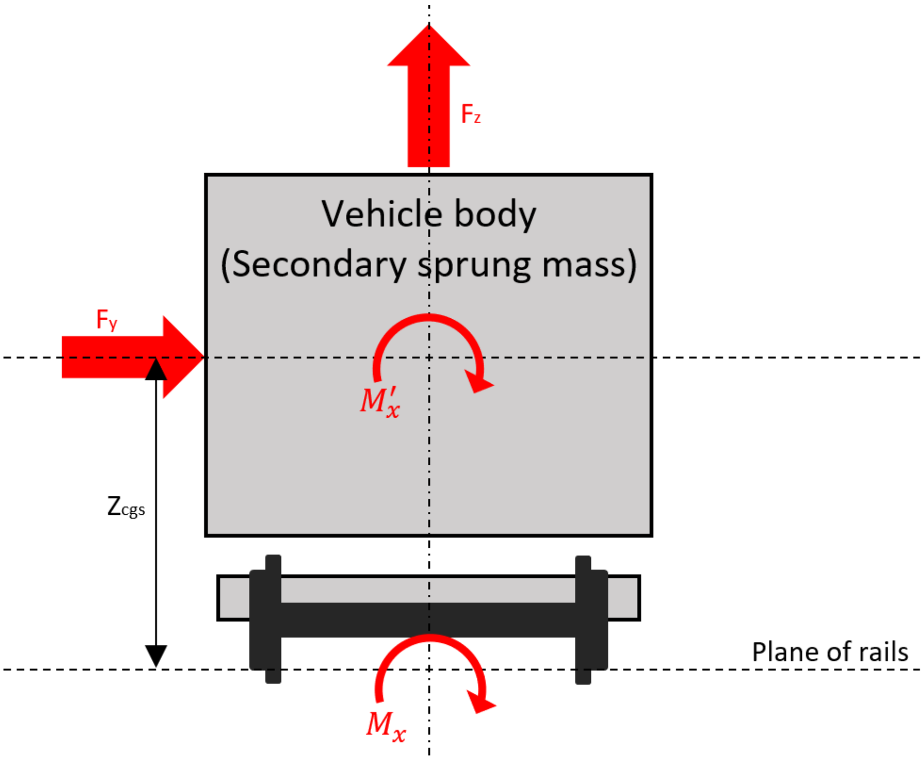


Figure 3: Definition of the vehicle aerodynamic forces and moments

Rationale

G A.2.6.6 The defined wind loads and method of analysis are consistent with the benchmark limits.

A.2.7 Aerodynamic coefficient data

A.2.7.1 The values for side force, C_{Fy} , lift force, C_{Fz}, and rolling moment coefficients, C_{Mx}, for streamlined, intermediate and unstreamlined leading and trailing vehicles (as defined in GMRT2142) shall be determined from Tables *5* and *6*, unless more accurate values of the aerodynamic coefficients for the candidate vehicle are obtained from specific wind tunnel tests, or are inferred from existing data for aerodynamically similar vehicles.

Note: x = β/100	**Yaw angle range**
Roof cross sectional profile	**$10^\circ \leq \beta \leq 40^\circ$**
Streamlined	$C_{Fy}(\beta) = -7.5604x^3 + 4.3109x^2 + 0.8435x$ $C_{Fz}(\beta) = 0.6353x^3 + 2.0957x^2 + 0.2292x$ $C_{Mx}(\beta) = -10.792x^3 + 7.4326x^2 - 0.355x$
Intermediate	$C_{Fy}(\beta) = -12.336x^3 + 6.9201x^2 + 1.2616x$ $C_{Fz}(\beta) = -13.447x^3 + 9.1138x^2 - 0.15x$ $C_{Mx}(\beta) = -6.983x^3 + 3.8216x^2 + 0.6458x$
Unstreamlined	$C_{Fy}(\beta) = -6.4877x^3 + 5.4248x^2 + 1.4715x$ $C_{Fz}(\beta) = -12.193x^3 + 7.2087x^2 + 0.2096x$ $C_{Mx}(\beta) = -5.5768x^3 + 3.6228x^2 + 0.8594x$

Table 5: Leading vehicle aerodynamic coefficient equations

Note: $x = \beta/100$	Yaw angle range
Roof cross sectional profile	**$10^{\circ} \le \beta \le 40^{\circ}$**
Streamlined	$C_{Fy}(\beta) = -0.372x^3 + 2.037x^2 + 0.3786x$ $C_{Fz}(\beta) = -0.6594x^3 + 1.5087x^2 + 0.4022x$ $C_{Mx}(\beta) = 1.6437x^3 - 0.9359x^2 + 0.4782x$
Intermediate	$C_{Fy}(\beta) = -8.1537x^3 + 5.7138x^2 + 0.2396x$ $C_{Fz}(\beta) = 2.6367x^3 - 1.1915x^2 + 0.9766x$ $C_{Mx}(\beta) = -4.3581x^3 + 2.7885x^2 + 0.2208x$
Unstreamlined	$C_{Fy}(\beta) = -4.8658x^3 + 4.0686x^2 + 1.1036x$ $C_{Fz}(\beta) = -9.1446x^3 + 5.4065x^2 + 0.1572x$ $C_{Mx}(\beta) = 4.206x^3 + 2.7313x^2 + 0.6442x$

Table 6: Trailing vehicle aerodynamic coefficient equations

Rationale

G A.2.7.2 The defined coefficients are consistent with the benchmark limits.

A.2.8 Matrix of run cases

A.2.8.1 The pantograph sway shall be assessed with the vehicle running in both directions (pantograph leading and trailing).

A.2.8.2 Where the candidate vehicle's maximum permitted cant deficiency is less than 150 mm, then only cant deficiency values up to the maximum shall be assessed.

A.2.8.3 The run cases set out in Table 7 shall be undertaken.

Train speed	Cant deficiency (mm)
From 100 km/h (on 60 mph TfG file) up to the train's maximum operating speed	0, 25, 50, 75, 100, 125, 150

Table 7: Required run cases

A.2.8.4 Linear interpolation shall be used on the benchmark values in Tables 2 and 3 to determine the limit where the vehicle's maximum cant deficiency is not one of the listed values (for example 110 mm).

Rationale

G A.2.8.5 The pantograph sway assessment is undertaken in both directions to ensure that the worst case conditions are captured.

A.2.9 Required predictions

A.2.9.1 The pantograph lateral displacements relative to the centreline of the track shall be determined at the centre position of the pantograph head on the vehicle.

A.2.9.2 The pantograph sway time-histories over the 20 km track file shall be recorded for the leading and trailing positions at two different heights for all of the simulation runs.

A.2.9.3 The pantograph displacement outputs that shall be produced are:

a) Pantograph lateral displacement relative to centreline of track at 4.3 m above plane of rail – pantograph leading;
b) Pantograph lateral displacement relative to centreline of track at 4.3 m above plane of rail – pantograph trailing;
c) Pantograph lateral displacement relative to centreline of track at 5.3 m above plane of rail – pantograph leading; and
d) Pantograph lateral displacement relative to centreline of track at 5.3 m above plane of rail – pantograph trailing.

Rationale

G A.2.9.4 These values are required for comparison with the benchmark limits.

A.2.10 Post-processing

A.2.10.1 For each simulation, the following statistics shall be output for all four pantograph positions set out in *A.2.9.3*:

a) Mean;
b) Standard deviation; and
c) Mean + 2.12 standard deviations.

A.2.10.2 Any transition length required to enable the vehicle model to traverse onto the constant installed cant and to settle after the wind force has been applied, shall be omitted from the statistics post-processing.

Rationale

G A.2.10.3 These values are required for comparison with the benchmark limits.

A.2.11 Benchmark limit values

Guidance

G A.2.11.1 The benchmark limit values are shown graphically in Figures *4* and *5* for illustrative purposes. The tabulated limit values are set out in Tables *2* and *3*.

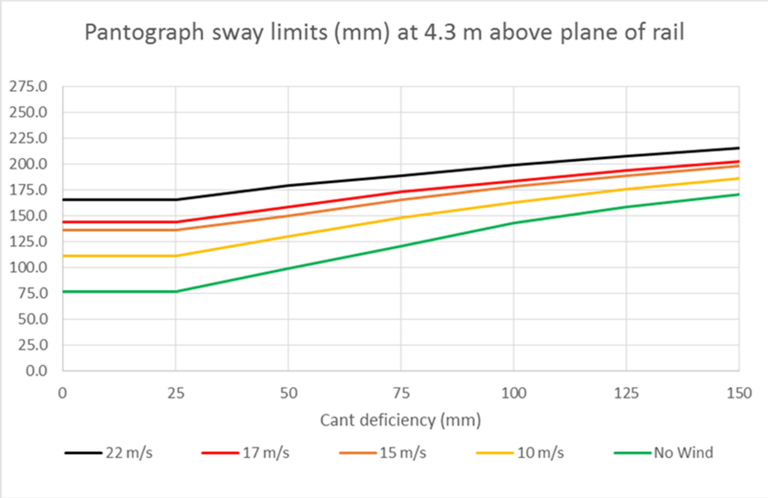


Figure 4: Benchmark limit values at 4.3 m above plane of rail

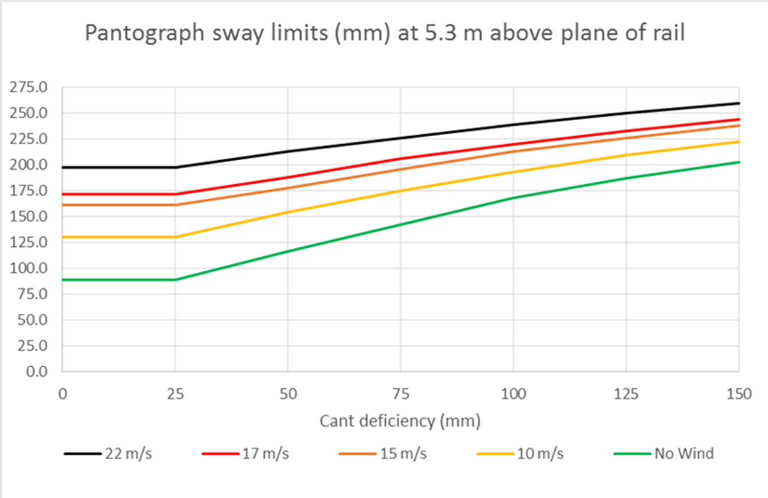


Figure 5: Benchmark limit values at 5.3 m above plane of rail

A.2.12 Comparison of pantograph sway

A.2.12.1 The largest calculated values of the mean + 2.12 standard deviations pantograph sway values for the candidate vehicle shall be compared with the benchmark limit values set out in *3.2*.

Rationale

G A.2.12.2 The benchmark limit values are based on vehicles with a safe history of application in GB.

Guidance

G A.2.12.3 The candidate vehicle meets the pantograph sway requirements and is compatible with the generic characteristics of the GB mainline railway when the candidate vehicle's pantograph sway values are less than or equal to the 22 m/s mean wind speed and the No Wind benchmark limit values set out in Tables *2* and *3*.

A.2.13 Limited compatibility for less wind exposed routes

A.2.13.1 Where the candidate vehicle shall not be operating over routes exposed to the highest wind speeds, compliance can be demonstrated to one of the lower mean wind speed benchmark limit lines (17 m/s, 15 m/s or 10 m/s). This will limit the vehicle to only operate over routes that are subjected to the chosen lower wind speed.

A.2.13.2 The applicable wind speed for a given route shall be determined by applying a reference height correction factor of 0.793 to the values of wind speed, vb,map, given in Figure NA.1 in the National Annex (NA) to BS EN 1991-1-4:2005. In addition, a correction for route altitude shall be applied as detailed in NA.2.5.

Rationale

G A.2.13.3 Some routes are less exposed to strong winds than others.

A.2.14 Comparative pantograph sway assessment using other existing vehicles

A.2.14.1 It is permissible to compare the pantograph sway with an existing pantograph vehicle operating on a specific route.

A.2.14.2 The existing vehicle shall be shown to be suitable using a process equivalent to that described for comparative gauging in RIS-8273-RST.

A.2.14.3 The existing vehicle shall have operated on the route without any incidents of dewirement, collision with overhead line equipment infrastructure or electrical flashover, which have been attributed to excessive pantograph sway.

A.2.14.4 In this case, pantograph sway values for the existing vehicle operating on the chosen route shall be calculated according to the methodology set out in this Appendix, together with those for the candidate vehicle.

A.2.14.5 The largest calculated values of the mean + 2.12 standard deviations for the pantograph sway values for the candidate vehicle shall be compared with the largest calculated values for the existing pantograph vehicle.

A.2.14.6 The candidate vehicle shall be deemed to meet the pantograph sway requirements to run over the specific route only if the candidate vehicle pantograph sway values at each value of cant and applicable maximum wind speed are less than or equal to the corresponding values of the existing pantograph vehicle.

Rationale

G A.2.14.7 Comparison with an existing comparator vehicle is an alternative method that may be useful for a specific route.

A.2.15 Candidate vehicle characteristics

A.2.15.1 The following shall be taken into account when assessing the candidate vehicle when declaring the pantograph sway:

a) The pantograph head profile complies with the LOC & PAS NTSN - 4.2.8.2.9.2.1 which specifies: EN 50367:2012 - 5.3.2.2, UK specific case 'P' Annex B.2, Fig B.6;

Note: Note 3 in Figure B.6 of EN 50367:2012 may be disregarded for the purposes of calculating pantograph sway in accordance with this RGS.

b) The pantograph structure is considered to be rigidly fixed to the vehicle body and lateral flex can be ignored;
c) The pantograph head is considered to be rigid, and roll or skew due to uplift forces can be ignored; and
d) The longitudinal position of the pantograph head is nominally above one of the bogie pivot centres, so overthrow effects on curves can be ignored.

A.2.15.2 Any additional movements and novel features of the candidate vehicle shall also be taken into account when declaring the pantograph sway.

Rationale

G A.2.15.3 The benchmark pantograph sway limits are based on vehicles having the characteristics set out in *A.2.15.1*.

Appendix B Guidance on T1196 - Suite of Pantograph Gauges

B.1 Background and aim

Guidance

G B.1.1 A multitude of static pantograph gauges exist, having been used for different electrification schemes in GB.

G B.1.2 RSSB Research Project T1196 (2020) established a series of infrastructure gauges for pantographs to accommodate the parameters defined in Railway Group Standards and European Standards (ENs), for use on GB mainline railways.

Note: RSSB Research Project T1196 was undertaken with "Development of a Suite of Pantograph Gauges" as its working title. Following discussions at V/S SIC, it was determined that "infrastructure gauge for pantographs" is a more suitable term for the outputs of T1196 and this term will be used in the contents of this appendix.

G B.1.3 The T1196 review evaluated the following five pantograph gauges:

a) Route Wide Gauges:
   i) Network Rail Pantograph Gauges;
   ii) British Rail Pantograph Gauges.
b) Project Specific:
   i) Edinburgh Glasgow Improvement Programme Gauge;
   ii) West Coast Route Modernisation Gauge;
   iii) Great Western Electrification Programme Gauge.

G B.1.4 From the review of gauges, the development of the infrastructure gauges for pantographs included the following factors:

a) Final contact wire height;
b) Static contact wire height ;
c) OLE vertical tolerances ;
d) Contact wire wear ;
e) Uplift ;
f) Contact wire stagger; and
g) Installed cant.

G B.1.5 The developed infrastructure gauges for pantographs incorporate a balance of the complexities involved in pantograph dimensions and movements.

G B.1.6 The research has:

a) Collated and evaluated historic pantograph gauging tolerances, allowances and assumptions;
b) Developed new gauges using the information supplied in the new standards and the information rationalised from historic gauges.;
c) Verified the new gauges against existing pantographs and infrastructure including overhead electrification equipment; and

d) Provided guidance on the application of the infrastructure gauges for pantographs.

G B.1.7 The output of T1196 is a new process for the creation of infrastructure gauges for pantographs including an interactive spreadsheet to allow a simple, quick creation appropriate to their situation.

B.2 Impacts and benefits

Guidance

G B.2.1 The infrastructure gauges for pantographs produced by this project supports:

- Design, installation or maintenance of electrification systems, track or structures;
- Positioning electrification equipment, to ensure appropriate physical (mechanical) clearance between the hardware and pantograph;
- Positioning track, to ensure appropriate electrical (passing) clearance is maintained between the infrastructure and pantograph;
- Ensuring appropriate passing clearance is maintained between structure and pantograph; and
- Support the requirements set out in GMRT2173 and BS EN 50367:2012 compliant vehicles and pantographs.

G B.2.2 The outputs of T1196 can be used by industry:

- At the feasibility stage of future electrification projects to remove unnecessary conservatism – maximizing use of available space for the pantograph prior to site-specific analysis; and
- To design, commission and maintain OLE with adequate clearance to current and future floating and rigid head pantographs.

B.3 Findings

Guidance

G B.3.1 T1196 included considerations of the BR pantograph profile (see Figure B.6 in BS EN 50367:2012) related to head roll, horn lift (where attached to the pantograph frame), and carbon wear. Additional factors including head roll, horn lift, and pantograph carbon wear were also included.

G B.3.2 T1196 produced a calculator that can be used to undertake an assessment for the movement limits for pantographs and to understand the boundaries for the position of electrification equipment.

G B.3.3 The infrastructure gauges for pantographs produced are site-specific and can include the effects of wind.

G B.3.4 The infrastructure gauges for pantographs produced in T1196 combine:

- The static (non-independently sprung) BR pantograph head profile including carbon wear;

- The rolled BS EN 50367:2012 compliant BR pantograph head profile including carbon wear; and
- And a BR pantograph head profile that captures the effect of horn lift.

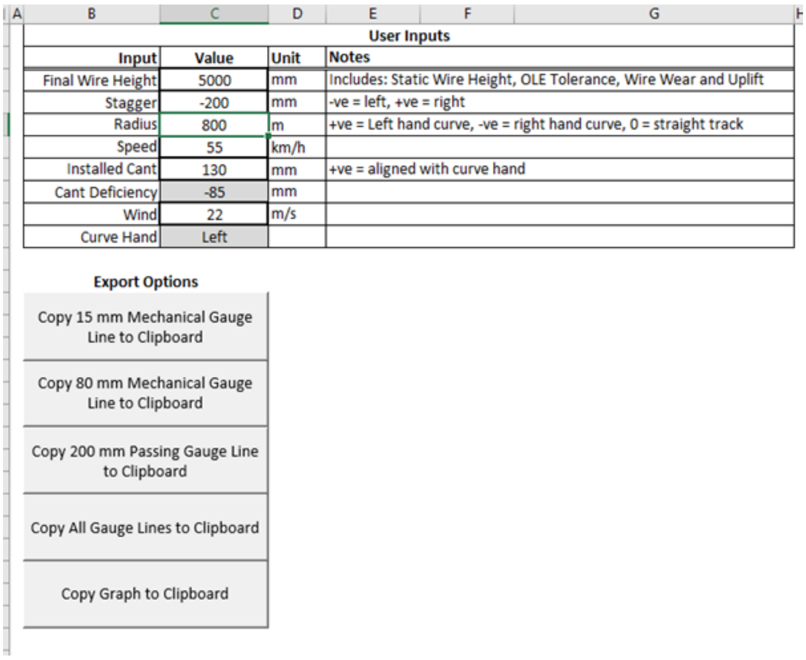
G B.3.5 The output infrastructure gauges for pantographs are accessible via an interactive spreadsheet.

B.4 Gauge calculator spreadsheet

Guidance

G B.4.1 Figure 6 shows the section of the calculator spreadsheet with inputs and export options.

G B.4.2 The input variables are labeled along with units and notes for the user to insert inputs into the "Value" column.

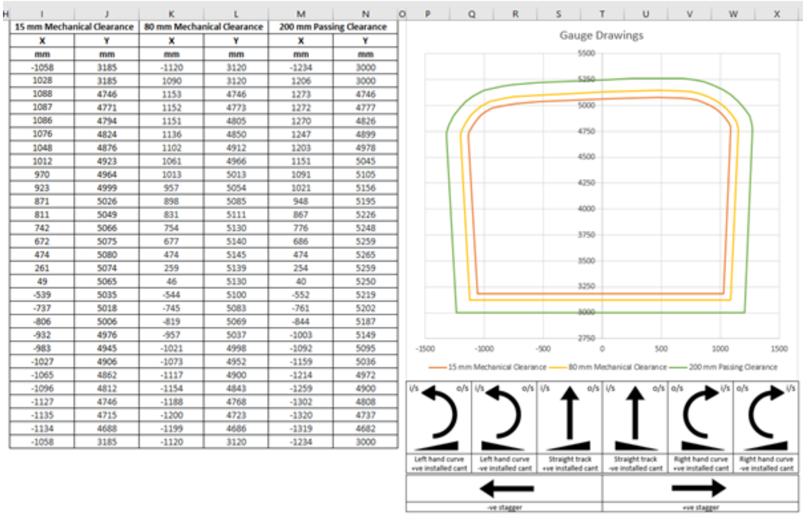


User Inputs			
Input	Value	Unit	Notes
Final Wire Height	5000	mm	Includes: Static Wire Height, OLE Tolerance, Wire Wear and Uplift
Stagger	-200	mm	-ve = left, +ve = right
Radius	800	m	+ve = Left hand curve, -ve = right hand curve, 0 = straight track
Speed	55	km/h	
Installed Cant	130	mm	+ve = aligned with curve hand
Cant Deficiency	-85	mm	
Wind	22	m/s	
Curve Hand	Left		

Figure 6: Calculator input and export options

G B.4.3 Figure 7 shows the gauge drawings as example output generated based on inputs in Figure 6.

G B.4.4 X, Y coordinates can be exported for further calculations such as undertaking a clearance analysis.



15 mm Mechanical Clearance		80 mm Mechanical Clearance		200 mm Passing Clearance	
X	Y	X	Y	X	Y
mm	mm	mm	mm	mm	mm
-1058	3185	-1120	3120	-1234	3000
1028	3185	1090	3120	1206	3000
1088	4746	1153	4746	1273	4746
1087	4771	1152	4773	1272	4777
1086	4794	1151	4805	1270	4826
1076	4824	1136	4850	1247	4899
1048	4876	1102	4912	1203	4978
1012	4923	1061	4966	1151	5045
970	4964	1013	5013	1091	5105
923	4999	957	5054	1021	5156
871	5026	898	5085	948	5195
811	5049	831	5111	867	5226
742	5066	754	5130	776	5248
672	5075	677	5140	686	5259
474	5080	474	5145	474	5265
261	5074	259	5139	254	5259
49	5065	46	5130	40	5250
-539	5035	-544	5100	-552	5219
-737	5018	-745	5083	-761	5202
-806	5006	-819	5069	-844	5187
-932	4976	-957	5037	-1003	5149
-983	4945	-1021	4998	-1092	5095
-1027	4906	-1073	4952	-1159	5036
-1065	4862	-1117	4900	-1214	4972
-1096	4812	-1154	4843	-1259	4900
-1127	4746	-1188	4768	-1302	4808
-1135	4715	-1200	4723	-1320	4737
-1134	4688	-1199	4686	-1319	4682
-1058	3185	-1120	3120	-1234	3000

Figure 7: Example output

Definitions

absolute gauging	Absolute gauging of a vehicle is a full assessment of clearances on a section of track between the vehicle and fixed infrastructure, and between the vehicle and vehicles on adjacent tracks.
articulation	An articulated vehicle is a vehicle which has a permanent or semi-permanent pivoting joint in its construction excluding that required to permit a bogie to rotate.
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. For the purposes of this document, cant deficiency is always the cant deficiency at the rail head not that experienced within the body of a vehicle.
cant excess	The extent by which the cant on curved track exceeds that required for the gravitational component acting parallel with the plane of the rails to exactly counterbalance the centrifugal forces acting on a vehicle in the same plane. It equates to a negative value of cant deficiency.
clearance	The minimum calculated distance between the swept envelope of a vehicle and fixed infrastructure or between swept envelopes of two vehicles on adjacent tracks.
comparative gauging	The process of comparing the swept envelopes of a vehicle new to a route, with the swept envelopes of a vehicle or vehicles which have been demonstrated to be able to use the proposed route.
crush	Design mass under exceptional payload (passenger vehicles).
exposed location	An exposed location is an existing railway location for which the value of the fundamental basic wind velocity ($v_{b,map}$) before the altitude correction is applied, is greater than or equal to 22 m/s. The '$v_{b,map}$' is given in Figure NA.1 in the National Annex (NA) to BS EN 1991-1-4:2005.
gauge	Used to refer to a vehicle gauge or structure gauge where the context makes it clear which is meant. See ‘Vehicle gauge’.
gauging	The process by which swept envelopes of a vehicle or a standard vehicle gauge are used to determine clearances on a section of track between the vehicle and fixed infrastructure and between the vehicle and vehicles on adjacent tracks.
hybrid gauging	A combination of standard vehicle gauges, comparative or absolute gauging.
infrastructure	Compare with ‘Structure’. For the purpose of this document, track and structures in combination.
laden	Design mass under normal payload.

load	For the purposes of this document, a load is defined as the physical size of the payload carried by a wagon.
lower gauge	That part of the vehicle gauge for items adjacent to low-lying structures, such as platforms, with a requirement for proximity. The lower gauge is not limited to 1100 mm above the plane of the rails. See also 'Upper gauge'.
lower sector	The area up to and including 1100 mm above the plane of the rails. See also 'Upper sector'.
normal clearance	A clearance between a structure and a vehicle or between passing vehicles on adjacent tracks which does not require specific controls on the position of the track, but which does require the relative locations of structures and adjacent tracks to be monitored and maintained.
National Technical Specification Notices (NTSNs)	National Technical Specification Notice, published by the Secretary of State on 01 January 2021 pursuant to regulation 3B of the Railways (Interoperability) Regulations 2011. This NTSN replaces and substantially reproduces the provisions of Commission Regulation (EU) No 1299/2014 of 18 November 2014 and includes relevant amendments made by Commission Implementing Regulation (EU) 2019/776 which came into force in June 2019.
on-track plant (OTP)	A rail-borne machine used for infrastructure maintenance or inspection that is only permitted inside a possession. (See RIS-1530-PLT.)
overthrow	A geometric projection of a vehicle when on curved track.
pantograph sway	The pantograph sway is the lateral displacement of the pantograph in response to: a) Track layouts, discrete features and irregularities. b) Vehicle speeds and cant deficiency / excess. c) Wind forces. d) Suspension performance and condition (including tolerances and wear of suspension components, and likely failure modes). e) Active suspension. **Note:** Track positional tolerances and wear of rails are excluded.
pantograph sway - Multi-Body Simulation (MBS) output	The pantograph sway in plan view is defined relative to the track centreline defined by the track files and also the lateral channel in the track files. In end view the axis system rolls with the track installed cant defined in the track files and so is aligned to the plane of the rails. Vertically, the axis system follows the track vertical inputs from the track files. The pantograph sway is therefore referenced to the displaced track position, thus avoiding a double count of track irregularities and track positional tolerances.

passing clearance	The minimum calculated distance between the swept envelopes of two specific types of rail vehicle as they pass on adjacent tracks at nominated speeds, taking account of appropriate track tolerances and accuracy of measurement.
plane of the rails	An imaginary surface coplanar with the top of both rails of a track.
reduced clearance	A clearance, less than a normal clearance, which requires special measures to maintain tracks relative to adjacent tracks and structures.
reference datum point	A single point within the vehicle from which all principal linear dimensions may be referenced longitudinally, laterally and vertically.
route	The physical path of a journey to be undertaken by a vehicle or a collection of vehicles, where the path is comprised of a number of track sections, each of which has individually defined characteristics.
section of track	Track bounded by identified limits such as junctions, terminals or points at which there is a significant change in traffic flow or permissible speed.
special reduced clearance	A clearance, less than a reduced clearance, which requires a specific risk assessment to be undertaken and the implementation of appropriate controls to demonstrate that risks have been reduced to as low as reasonably practicable (ALARP).
standard vehicle gauge	An outline drawing or specification of a notional vehicle, which prescribes maximum permissible vehicle and loading dimensions, certain suspension displacements, and certain curve overthrow limitations, for example, W6a gauge.
structure	Compare with ‘Infrastructure’. An element of the infrastructure adjacent to, or crossing over, a railway track. So far as this document is concerned ‘structures’ include, but are not limited to: a) Train control and communications equipment, for example, signals. b) Station platforms. c) Overhead line equipment supporting structures at earth potential, but excluding insulators. d) Civil engineering structures such as retaining walls, tunnels and bridges. e) Other isolated structures. f) Temporary works.
swept envelope	A cross-sectional profile, taken at right angles to the track, enclosing all dynamic movements, static deflections and overthrows of all points along the surface of the vehicle that can reasonably be expected to occur under the appropriate range of operating conditions as it sweeps past a theoretical track location.

	A family of swept envelopes is required to define a vehicle's behaviour on a route. The swept envelopes referred to within this document exclude the effects of track tolerance and rail sidewear previously included in kinematic envelopes developed under GMRT2149 issue one or earlier documents.
tare	Design mass in working order.
technical file	As defined by the Railways (Interoperability) Regulations 2011.
ten minute mean wind speed	Speed of the instantaneous wind averaged over 10 minutes, as defined in BS EN 1991-1-4:2005, Eurocode 1, wind actions.
upper gauge	That part of the vehicle gauge for items above low-lying structures, which are not constrained by a requirement for proximity. See also 'Lower gauge'.
upper sector	The area above 1100 mm above the plane of the rails. See also 'Lower sector'.
vehicle gauge	The maximum envelope that a vehicle conforming to the gauge is permitted to occupy statically and dynamically, which prescribes maximum permissible vehicle and loading dimensions, certain suspension displacements, and certain curve overthrow limitations; for example, W6a gauge.
vehicle profile	The static cross-sectional envelope of a vehicle (and its payload).

References

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

RGSC 01	Railway Group Standards Code
RGSC 02	Standards Manual

Documents referenced in the text

Railway Group Standards

GERT8073	Requirements for the Application of Standard Vehicle Gauges
GIRT7020	GB Requirements for Platform Height, Platform Offset and Platform Width
GIRT7073	Requirements for the Position of Infrastructure and for Defining and Maintaining Clearances
GKRT0028	Infrastructure Based Train Detection Interface Requirements
GLRT1212	DC Conductor Rail Energy Subsystem and Interfaces to Rolling Stock Subsystem
GMRT2111	AC Energy Subsystem and Interfaces to Rolling Stock Subsystem
GMRT2142	Resistance of Railway Vehicles to Roll-Over in Gales
GMRT2149	Requirements for Defining and Maintaining the Size of Rail Vehicles [Superseded]

RSSB documents

GEGN8573	Guidance on Gauging and Platform Distances [Superseded]
GMGN2615	Guidance on the Locomotives and Passenger Rolling Stock TSI
GMGN2641	Guidance Note on Vehicle Static Testing
RIS-1530-PLT	Rail Industry Standard for Technical Requirements for On-Track Plant and Their Associated Equipment and Trolleys
RIS-2773-RST	Format and Methods for Defining Vehicle Gauging Data
RIS-7016-INS	Interface between Station Platforms, Track, Trains and Buffer Stops
RIS-8270-RST	Route Level Assessment of Technical Compatibility between Vehicles and Infrastructure
RIS-8273-RST	Assessment of Compatibility of Rolling Stock and Infrastructure - Gauging and Stepping Distances
RSSB Research Report T1196 (2020)	Development of a Suite of Pantograph Gauges

Other references

BS EN 50367:2012 +A1:2016	Railway applications - Current collection systems - Technical criteria for the interaction between pantograph and overhead line (to achieve free access)
LOC & PAS NTSN	Locomotives and Passenger Rolling Stock NTSN - Replaces and substantially reproduces the provisions of Commission Regulation (EU) 1302/2014 (the LOC&PAS TSI), which were in effect until 23:00 on 31 December 2020.
PRM NTSN	Persons with Reduced Mobility TSI Regulation - Replaces and substantially reproduces the provisions of Commission Regulation (EU) 1300/2014 (the PRM TSI) which were in effect until 23:00 on 31 December 2020.
Railways (Interoperability) Regulations 2011	
Track for gauging files (TfG)	VTT_60mph_Vampire_iss2.dat – 15/05/2007 VTT_70mph_Vampire_iss3.dat – 12/06/2009 VTT_90mph_Vampire_iss2.dat – 15/05/2007 VTT_100mph_Vampire_iss2.dat – 15/05/2007 VTT_125mph_Vampire_iss2.dat – 15/05/2007 VTT_140mph_Vampire_iss2.dat – 15/05/2007