

Railway Group Standard

GM/RT2142

Issue Four

Date December 2014

Resistance of Railway Vehicles to Roll-Over in Gales

Synopsis

This document mandates requirements to be applied to railway vehicles so that the vehicles can operate under gale conditions in Great Britain. The objective is to minimise the likelihood of vehicle roll-over.

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Issue record

Issue	Date	Comments
One	June 1994	Original document
Two	October 2000	Replaces issue one
Three	01 August 2009	Replaces issue two
Four	06 December 2014	Replaces issue three This document has been re-issued to take into account the revision of the minimum acceptable intrinsic roll-over wind speed for freight and other vehicles not designed to carry people.

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Superseded documents

The following Railway Group documents are superseded, either in whole or in part as indicated:

Superseded documents	Sections superseded	Date when sections are superseded
GM/RT2142, issue three, August 2009 Resistance of Railway Vehicles to Roll-Over in Gales	All	07 March 2015

GM/RT2142 issue three ceases to be in force and is withdrawn as of 07 March 2015.

Supply

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Resistance of Railway Vehicles to Roll-Over in Gales

Part 1 Purpose and Introduction

1.1 Purpose

- 1.1.1 This document mandates requirements to be applied to railway vehicles so that the vehicles can operate safely in the prevailing wind conditions in Great Britain (GB). The objective is to minimise the likelihood of vehicle roll-over.
- 1.1.2 This document also supports the Locomotives and Passenger Rolling Stock Technical Specification for Interoperability (LOC & PAS TSI) for new vehicles.

1.2 Introduction

1.2.1 Background

- 1.2.1.1 The underlying principle of this document is that all vehicles are required to meet or exceed a minimum acceptable intrinsic roll-over wind speed, as set out in clause 2.1 of this document. The minimum acceptable intrinsic roll-over wind speed should not be viewed as an actual maximum wind speed that a vehicle will experience in service conditions. It is a reference wind speed on straight track that, when used in the method described, will ensure that the vehicle can operate safely in the prevailing wind conditions in GB.
- 1.2.1.2 Appendix A of this document sets out the method to be used to calculate the intrinsic roll-over wind speed for a vehicle.
- 1.2.1.3 Further guidance on the technical background to clause 2.1, clause 2.2 and Appendix A of this document is given in Appendix B. Appendix C provides a calculated example.
- 1.2.1.4 For trains travelling at higher than conventional cant deficiencies, GC/RT5021 requires a probability assessment to be carried out to determine the enhanced permissible speeds of the train on each curve on a route. GC/RC5521 sets out a methodology for undertaking the required probability assessment. The aerodynamic characteristics of critical vehicles within the train formation are a key factor in the probability assessment. Section 2.2 of this document therefore requires information about vehicle characteristics to be determined and recorded so that the information can be supplied to the infrastructure manager as part of checking compatibility between the vehicle and the infrastructure on the specific route (GE/RT8270) and for the infrastructure manager to take suitable mitigation actions as necessary. Further recommendations relating to this aspect are provided in GM/RC2542.
- 1.2.1.5 Additional background information about rail vehicle roll-over in gales is given in BS EN 14067-6:2010.
- 1.2.1.6 The LOC & PAS TSI mandates the provision of data describing characteristics of cross wind used when designing a rail vehicle. However, the TSI does not set out specific limits / constraints associated with cross wind (speed) that need to be used in the design of a rail vehicle. The requirements in this document supplement the requirements for cross wind (speed) in the LOC & PAS TSI by setting the cross wind (speed) limits needed in order to maintain compatibility of a vehicle with existing infrastructure on the GB mainline railway.

1.2.2 Related requirements in other documents

- 1.2.2.1 GM/RT2141 sets out the design requirements for rail vehicles to ensure acceptable resistance against flange climbing derailment and against roll-over induced by over speeding.

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1.2.3 Supporting documents

1.2.3.1 The following Rail Industry Approved Code of Practice supports this Railway Group Standard:

GM/RC2542 Recommendations for Determination of Aerodynamic Rolling Moment Coefficient.

1.3 Approval and authorisation of this document

1.3.1 The content of this document was approved by Rolling Stock Standards Committee on 03 October 2014.

1.3.2 This document was authorised by RSSB on 27 October 2014.

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Part 2 Requirements to Minimise the Risk of Vehicle Roll-Over in Gales

2.1 Design criteria

2.1.1 Minimum acceptable intrinsic roll-over wind speed

2.1.1.1 The intrinsic roll-over wind speed ($v_{w,int}$) for a vehicle running in tare condition, within a train formation at its maximum design operating speed on straight and level track, shall not be less than the following minimum acceptable intrinsic roll-over wind speeds:

- a) 36.5 m/s for vehicles designed to carry people, including passengers and crew.
- b) 26.3 m/s for freight and other vehicles not designed to carry people.

2.1.1.2 The intrinsic roll-over wind speed ($v_{w,int}$) shall be determined in accordance with Appendix A.

2.1.2 Vehicles not required to operate over exposed routes

2.1.2.1 Where a vehicle is not designed or required to be operated over exposed routes it is permissible to reduce the minimum acceptable intrinsic roll-over wind speed. In this case it is permissible to apply a reduction factor of 0.92 to the minimum acceptable intrinsic roll-over wind speeds set out in clause 2.1.1.1.

2.1.2.2 Where the requirements set out in 2.1.2.1 are applied, any limitations of use shall be recorded in the Technical File for the vehicle and identified clearly on any associated acceptance certification produced for the vehicle.

2.1.3 Variations in vehicle condition

2.1.3.1 Vehicles shall meet the requirements of this document over the full range of variations in vehicle condition that are likely to be experienced. As a minimum, variations in vehicle condition shall include tolerances in vehicle dimensions, mass distributions and wheel loadings, suspension characteristics, normal variations in vehicle maintenance condition and wear, and any other relevant variables.

2.2 Vehicle characteristics for vehicles operating above conventional cant deficiencies

2.2.1 Vehicle characteristics required for determining maximum enhanced permissible speeds

2.2.1.1 The following characteristics for a vehicle designed to carry people that operates at cant deficiencies greater than 6°, or a freight vehicle that operates at cant deficiencies greater than 4.25°, shall be determined and recorded:

- a) Maximum design operating speed.
- b) Total projected side area of vehicle or side area used to determine its aerodynamic rolling moment coefficient about the lee rail from tests as set out in A.5.1.
- c) Vehicle mean longitudinal roof height above axle centreline or height used to determine its aerodynamic rolling moment coefficient about the lee rail from tests as set out in A.5.1.

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- d) Vehicle aerodynamic rolling moment coefficient about the lee rail over the range of yaw angles from 15° to 90°, taking account of the position of the vehicle in the train. Two sets of data are required (except for freight vehicles), one for the leading vehicle and one for a trailing vehicle in the train.
- e) Vehicle tare mass.
- f) Height of vehicle centre of gravity above rail level and the effects the suspension characteristics may have on the vehicle centre of gravity including changes due to the tilting of the vehicle.

2.2.2 Conditions for the determination of vehicle characteristics

- 2.2.2.1 The vehicle characteristics in clause 2.2.1 shall be those present under the most unfavourable conditions of loading, generated from the conditions described in clause 2.1.3.1. For vehicles that tilt, these shall be combined with unfavourable tilt conditions including credible failure modes of tilt, that is, the case where the roll-over resistance is lowest.

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Part 3 Application of this document

3.1 Scope

- 3.1.1 Except as set out in section 3.2.1, the requirements of this document apply to all new rail vehicles, including on-track machines (OTMs) in running mode, designed up to a maximum design speed of 250km/h. Requirements of the LOC & PAS TSI section 4.2.6 also apply.
- 3.1.2 When vehicles are undergoing major modifications that have the potential to affect compliance with the requirements in this document then the requirements of this document are applicable.
- 3.1.3 Action to bring existing railway vehicles into compliance with the requirements of this document is not required.

3.2 Exclusions from scope

- 3.2.1 The requirements in the document are not applicable to the following types of vehicles:
 - a) General Contract of Use (GCU) wagons.
 - b) Vehicles designed to operate in excess of 250km/h.

3.3 General compliance date

- 3.3.1 This Railway Group Standard comes into force and is to be complied with from 07 March 2015, except as specified in clause 3.4.1. Where the date specified in clauses 3.4.1 below is later than the above date, this is to allow sufficient time to achieve compliance with the specified exceptions.
- 3.3.2 After the compliance date, or the date by which compliance is achieved if earlier, compliance with the requirements set out in this Railway Group Standard is to be maintained. Where it is considered not reasonably practicable to comply with the requirements, permission to comply with a specified alternative is sought in accordance with the Railway Group Standards Code.

3.4 Exceptions to general compliance date

- 3.4.1 It is permissible for vehicles to continue to be built to the same design as a vehicle having an authorisation for placing into service or a Certificate of Engineering Acceptance, but which does not comply with the requirements of this document, until 05 September 2017.

3.5 Health and safety responsibilities

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

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Appendix A Calculation of Intrinsic Roll-Over Wind Speed

The content of this appendix is mandatory

A.1 Methodology for the calculation of intrinsic roll-over wind speed

A.1.1 The intrinsic roll-over wind speed for a vehicle shall be calculated using the following process. This process is illustrated by the flow chart in clause A.1.2. Further explanation is provided in Appendix B and an example calculation is provided in Appendix C.

- a) Start by determining the restoring moment due to vehicle weight (M_R):

$$M_R = m \cdot g \cdot b_A - M_0 \quad (\text{Eq 1})$$

Where:

$$m = m_0 + m_1 + m_2 \quad (\text{Eq 2})$$

And where the moment due to body lateral and roll displacements is:

$$M_0 = g \cdot (m_0 \cdot y_0 + m_1 \cdot y_1 + m_2 \cdot y_2) \quad (\text{Eq 3})$$

- b) Set the range for the resultant wind angle (β) to between 10° and 40° and start at 10° .

- c) Evaluate the resultant wind speed relative to the train (v_a) from:

$$v_a = \sqrt{\frac{M_R}{\frac{1}{2} \cdot \rho \cdot A \cdot H \cdot C_{Mx,lee}(\beta)}} \quad (\text{Eq 4})$$

- d) Evaluate the wind angle (ϕ) from:

$$\phi = \tan^{-1} \left(\frac{v_a \cdot \sin(\beta)}{v_a \cdot \cos(\beta) - v_{tr}} \right) \quad (\text{Eq 5})$$

- e) Evaluate the roll-over wind speed (v_w) from:

$$v_w = \frac{v_a \cdot \sin(\beta)}{\sin(\phi)} \quad (\text{Eq 6})$$

- f) Record the value of the roll-over wind speed (v_w) for the wind angle (ϕ) and resultant wind angle (β) used for this iteration.

- g) Repeat from step c) for the whole range of resultant wind angles (10° to 40°). The step interval chosen shall allow the worst case resultant wind angle (β) to be determined to an accuracy of 0.1° . It may be necessary to extend the resultant wind angle range above 40° to obtain the smallest roll-over wind speed.

- h) From the set of all the calculated values of roll-over wind speeds at the different wind angles, the minimum value determined and rounded down to one decimal place is the vehicle's intrinsic roll-over wind speed, $v_{w,int}$, for the purpose of determining conformity with clause 2.1.1.1.