

Railway Group Standard

GC/RT5021

Issue Five

Date December 2011

Track System Requirements

Synopsis

This document mandates requirements for track geometry, track system, track components and switches and crossings (S&C) to provide for the safe guidance and support of rail vehicles.

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Railway Group Standard**GC/RT5021****Issue** Five**Date** December 2011**Track System Requirements****Issue record**

Issue	Date	Comments
One	April 2000	Original document Superseded Railway Group Standard GC/RT5010 and GC/RT5017 with some further additions.
Two	October 2003	Replaces issue one Incorporated changes advised in GC/GN5523 and requirements held in GC/RT5011 issue two, GC/RT5014 issue one and GC/RT5024 issue one.
Three	April 2007	Replaces issue two Incorporates requirements held in GC/RT5014 issue two, GC/RT5022 issue two, and GI/RT7004 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that do not meet the risk scope test set out in the Railway Group Standards Code (issue two, 2006) have been withdrawn.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 Section 4.2 is deleted (requirement withdrawn).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 Withdrawn Appendix: Appendix A on rail profile 60 E 2 is withdrawn.

Amended sections or revised pages have been marked by a vertical black line in the adjacent margin.

Superseded documents

The following Railway Group documents are superseded, either in whole or in part as indicated:

Superseded documents	Sections superseded	Date when sections are superseded
GC/RT5021, issue four, December 2009 Track System Requirements	All	03 March 2012

GC/RT5021 issue four ceases to be in force and is withdrawn as of 03 March 2012.

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Supply

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Railway Group Standard**GC/RT5021****Issue** Five**Date** December 2011**Track System Requirements****Part 1 Purpose and Introduction****1.1 Purpose**

- 1.1.1 This document mandates requirements for track geometry, track system, track components and S&C to provide for the safe guidance and support of rail vehicles.

1.2 Introduction**1.2.1 Principles**

- 1.2.1.1 The requirements of this document are based on one or more of the following principles:
- a) This document mandates those requirements that define the interface and the need for cooperation between different categories of duty holders to manage risk safely.
 - b) This document mandates requirements that are necessary to support an open point in a TSI and meet an essential requirement of the relevant European Directive.
 - c) This document contains 'open points', that is, requirements that have not yet been specified, but which are within scope of the document. These are listed in Appendix A, which also indicates where additional information on industry practice relating to each open point may be found.

1.2.2 Related requirements in other documents

- 1.2.2.1 The following Railway Group Standards contain requirements that are relevant to the scope of this document:
- a) GC/RT5033 sets out requirements for buffer stops, arresting devices and end walls for terminal tracks.
 - b) GC/RT5212 mandates requirements for monitoring and maintaining clearances. It also mandates requirements for new, altered and temporary infrastructure relating to clearances; gauging conditions for passage of exceptional loads; standard vehicle gauges; and data relating to gauging and clearances, to be provided to Railway Group members and their suppliers. This document includes the requirements for position of check rails, guard rails and other equipment in the lower sector area.
 - c) GE/RT8012 mandates the means by which Tilting Trains may be operated at higher speeds than non-tilting trains around curves.
 - d) GI/RT7016 mandates requirements for the design and maintenance of station platforms for their safe interface with trains.
 - e) GK/RT0028 mandates the interface requirements to ensure that train detection systems provide the signalling system with adequate information regarding the position and movement of trains to permit safe control of the railway.
 - f) GM/RT2141 mandates requirements for rolling stock to ensure acceptable resistance against flange climbing derailment and against roll-over induced by overspeeding.
 - g) GM/RT2466 mandates requirements for the design, manufacture and maintenance of wheelsets and their components.

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- h) GM/TT0088 prescribes design and maintenance requirements for traction and rolling stock and for on-track plant to ensure that interactive forces and stresses generated between vehicles and track are limited to acceptable levels. Vehicle performance limits relating to wheel loads, wheel diameters, unsprung masses and suspension characteristics are specified.

1.2.3 Supporting documents

- 1.2.3.1 GC/RC5521 sets out an approved method of calculating enhanced permissible speeds for tilting trains.

1.3 Approval and authorisation of this document

- 1.3.1 The content of this document was approved by Infrastructure Standards Committee on 14 September 2011.
- 1.3.2 This document was authorised by RSSB on 24 October 2011.

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Part 2 Requirements for Track Geometry**2.1 Normal limiting design values and exceptional limiting design values**

- 2.1.1 This section sets out normal limiting design values and exceptional limiting design values for track geometry parameters.
- 2.1.2 Where site conditions allow, normal limiting design values shall be used for all parameters.
- 2.1.3 Where the speed requirements cannot be met by using normal limiting design values it is permissible to use exceptional limiting design values. The reason and implications for their use shall be justified.
- 2.1.4 When a design value is quoted without being described as either normal or exceptional, it is the only limiting value and no exceptional limiting value is permitted.
- 2.1.5 Exceptional limiting design values shall not be exceeded.

2.2 General horizontal alignment requirements

- 2.2.1 On running lines, horizontal alignments shall consist of circular curves and straight track connected where necessary by transition curves. The minimum length of each geometrical element shall be appropriate to the length and characteristics of vehicles likely to use the track.
- 2.2.2 Restrictions on the location of station platforms in relation to the horizontal alignment of track are set out in GI/RT7016.
- 2.2.3 The requirements for the alignment of track at buffer stops and arresting devices are set out in GC/RT5033.

2.3 Permissible speed

- 2.3.1 The permissible speed on a curve shall be 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.
- 2.3.2 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.

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2.4 Enhanced permissible speed

2.4.1 Calculation of enhanced permissible speed

- 2.4.1.1 The conditions under which trains are permitted to travel at an enhanced permissible speed are set out in GE/RT8012.
- 2.4.1.2 The enhanced permissible speed shall be calculated for each type of train on each curve. The speed on each track of a double or multiple line shall be considered separately. On bi-directional tracks, the speed in each direction shall be considered separately.
- 2.4.1.3 A procedure shall be in place for calculating enhanced permissible speeds. The procedure shall set out the method of gaining technical approval for the calculated enhanced permissible speed.
- 2.4.1.4 The calculation of enhanced permissible speed shall take account of the factors listed in 2.3.1 together with the following additional factors:
- a) The maximum cant deficiency at which the train is designed to travel.
 - b) The dynamic roll-over resistance of the train (see GM/RT2141).
 - c) The maintenance tolerances on cant (the amount by which, in practice, the applied cant could be less than its design value).
 - d) The maintenance tolerances on curvature (the amount by which, in practice, the curve radius could be less than its design value).
 - e) The expected local wind conditions.
 - f) The effect of wind on the train, taking into account the characteristics of the train (see GM/RT2142).
 - g) The system adopted for controlling the speed of the train and the extent to which overspeed can occur (see GE/RT8012).
 - h) A safety margin equivalent to no less than 50 mm of cant deficiency.
- 2.4.1.5 The enhanced permissible speed shall ensure that the likelihood of overturning is within tolerable limits.

2.4.2 Enhanced permissible speed for S&C

- 2.4.2.1 Enhanced permissible speeds shall not be permitted on the turnout route of S&C.

2.5 Circular curves

2.5.1 Minimum radii

- 2.5.1.1 Horizontal curve radii shall be selected to take account of the curving characteristics of vehicles likely to use the track.
- 2.5.1.2 The normal minimum radius on passenger running lines shall be 200 m.
- 2.5.1.3 The exceptional minimum radius on passenger running lines shall be 150 m.
- 2.5.1.4 The normal minimum radius on non-passenger running lines shall be 150 m.
- 2.5.1.5 The exceptional minimum radius on non-passenger running lines shall be 125 m.

Railway Group Standard**GC/RT5021****Issue** Five**Date** December 2011**Track System Requirements****2.5.2 Reverse curves**

2.5.2.1 A length of straight track not less than 3 m long shall be provided between the reverse curves if one of the curves has a radius of less than 160 m.

2.5.3 Normal limiting design values for cant

2.5.3.1 The normal limiting design values for cant shall be:

- a) 110 mm adjacent to station platforms.
- b) 110 mm on fixed obtuse crossings.
- c) 150 mm elsewhere.

2.5.4 Exceptional limiting design values for cant

2.5.4.1 The exceptional limiting design values for cant shall be:

- a) 130 mm adjacent to station platforms.
- b) 110 mm on fixed obtuse crossings (unchanged from normal limiting design value).
- c) 180 mm elsewhere.

2.5.5 Cant on curves with radii less than 320 m

2.5.5.1 The cant on curves with radii less than 320 m shall not exceed $C_{\max}$, where $C_{\max}$ is given by 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) $C_{\max}$ = the normal limiting design value set out in 2.5.3.

2.5.6 Negative cant

2.5.6.1 Negative cant shall only be permitted on the turnout route through S&C and in the plain line immediately adjoining the S&C. On fixed obtuse crossings the normal limiting design value for negative cant shall be zero and the exceptional limiting design value shall be 65 mm. Elsewhere negative cant shall not exceed 80 mm.

2.5.7 Normal limiting design values for cant deficiency at permissible speed

2.5.7.1 The normal limiting design values for cant deficiency shall be:

- a) 110 mm on plain line on continuous welded rail (CWR).
- b) 110 mm on the through route of S&C designed for use in CWR without adjustment switches.
- c) 110 mm on the turnout route of S&C where designed to accommodate this value of cant deficiency.
- d) 75 mm on fixed obtuse crossings.
- e) 90 mm elsewhere.

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2.5.8 Exceptional limiting design values for cant deficiency at permissible speed

- 2.5.8.1 An exceptional limiting design value for cant deficiency on plain line jointed track of 110 mm is permissible for diesel multiple units with axle weights less than 13 t design mass under normal payload (as set out in BS EN 15663:2009) and fitted with bogies and air suspension, provided:
- a) The intrinsic track quality has been assessed and is considered suitable.
 - b) The condition of rail joints has been assessed and is considered suitable.
- 2.5.8.2 An exceptional limiting design value for cant deficiency on plain line CWR of 150 mm is permissible for vehicles, other than freight vehicles, accepted for running at this cant deficiency, provided no features likely to contribute to lateral misalignment are situated on the transition or circular curve. Features considered likely to contribute to lateral misalignment shall include catch points, adjustment switches, level crossings, longitudinal timbers and directly fastened track on bridges.

2.5.9 Normal limiting design values for cant deficiency at switch toes

- 2.5.9.1 It is permissible for the theoretical cant deficiency at switch toes to exceed the normal limiting design values set out in 2.5.7 but shall not exceed the values set out in Table 1. In order to assess the permissible speed it is necessary to calculate the radius at the switch toe. The radius shall be obtained by calculating the offset at the toe based on a 12.2 m chord centred about the switch toe.

2.5.10 Exceptional limiting design values for cant deficiency at switch toes

- 2.5.10.1 It is permissible for the theoretical cant deficiency at switch toes to exceed the exceptional limiting design values set out in 2.5.8 but shall not exceed the values set out in Table 1. In order to assess the permissible speed it is necessary to calculate the radius at the switch toe. The radius shall be obtained by calculating the offset at the toe based on a 12.2 m chord centred about the switch toe.

Turnout speed	Maximum theoretical cant deficiency at switch toes (mm)
Up to 70 km/h (43 mph)	120
Between 70 and 170 km/h (105 mph)	105
Between 170 km/h and 200 km/h (125 mph)	85

Table 1 Maximum theoretical cant deficiency at switch toes

- 2.5.10.2 It is permissible for turnout speeds up to 170 km/h (105 mph) to have a maximum cant deficiency of 125 mm for existing designs of switches.

2.5.11 General requirements for cant deficiency on plain line at enhanced permissible speed

- 2.5.11.1 Cant deficiencies exceeding those set out in 2.5.7 and 2.5.8 are permissible on plain line CWR, provided no features likely to contribute to lateral misalignment are situated on the transition or circular curve. Features considered likely to contribute to lateral misalignment shall include catch points, adjustment switches, level crossings, longitudinal timbers and directly fastened track on bridges.
- 2.5.11.2 The normal and exceptional limiting design values set out in 2.5.12 and 2.5.13 shall be reduced where necessary to meet the requirements of 2.4.

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2.5.12.1 The normal limiting design values for cant deficiency at enhanced permissible speed shall be:

- a) 110 mm for curves under 400 m radius.
- b) 185 mm for curve radii less than 700 m but greater than or equal to 400 m.
- c) 265 mm for curve radii greater than or equal to 700 m.

2.5.13 Exceptional limiting design values for cant deficiency on plain line at enhanced permissible speed

2.5.13.1 The exceptional limiting design values for cant deficiency at enhanced permissible speed shall be:

- a) 150 mm for curves under 400 m radius.
- b) 225 mm for curve radii less than 700 m but greater than or equal to 400 m.
- c) 300 mm for curve radii greater than or equal to 700 m.

2.5.14 Normal limiting design values for cant deficiency on the through route of S&C at enhanced permissible speed

2.5.14.1 The normal limiting design values for cant deficiency on the through route of S&C shall be the same as those at permissible speed set out in 2.5.7. Exceptionally, a cant deficiency higher than the normal limiting design value is permissible on S&C designed for use in CWR without adjustment switches, up to a limit of 200 mm, provided the radius is greater than or equal to 400 m.

2.5.14.2 Where cant deficiency above 110 mm is proposed, the use of S&C requiring adjustment switches is not permitted.

2.5.14.3 Where cant deficiency above 150 mm is proposed, additional special features shall be incorporated that eliminate discontinuities at crossings.

2.5.15 Exceptional limiting design values for cant deficiency on the through route of S&C at enhanced permissible speed

2.5.15.1 The exceptional limiting design values for cant deficiency on the through route of S&C shall be the same as those at permissible speed set out in 2.5.8. Exceptionally, a cant deficiency higher than the exceptional limiting design value is permissible on S&C designed for use in CWR without adjustment switches, up to a limit of 200 mm, provided the radius is greater than or equal to 400 m.

2.5.15.2 Where cant deficiency above 110 mm is proposed, the use of S&C requiring adjustment switches is not permitted.

2.5.15.3 Where cant deficiency above 150 mm is proposed, additional special features shall be incorporated that eliminate discontinuities at crossings.

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2.6 Transition curves

2.6.1 General requirements for transition curves

- 2.6.1.1 Where possible, a transition curve shall be provided between two circular curves or between a circular curve and straight track. Curvature shall increase (or decrease) regularly over the whole length of the transition curve.
- 2.6.1.2 Where it is not possible to provide a transition curve, the permissible speed shall be calculated assuming a virtual transition 12.2 m long.
- 2.6.1.3 Designs of transition curves shall take the permissible speed and any enhanced permissible speeds into account, together with the cant and radius on adjoining curves.
- 2.6.1.4 On all transition curves, cant shall be proportional to the instantaneous curvature. The instantaneous cant gradient at any point shall not exceed the value set out in 2.6.4.
- 2.6.1.5 There are a large number of differing transition curve forms. Whichever form is chosen, curvature shall increase (or decrease) regularly over the whole length of the transition curve.
- 2.6.1.6 On transitions between reverse curves with no intervening straight, the point of zero cant shall coincide with the reverse point (point of zero curvature). Where possible, the rates of change of cant, cant deficiency and curvature shall be approximately the same on either side of the reverse curve. The same type of transition shall be used on either side of the reverse curve.

2.6.2 Particular requirements for clothoid spiral transition curves

- 2.6.2.1 The clothoid spiral (or its close approximation, the cubic parabola) is the usual form of transition curve used on the mainline railway. The limiting values for rates of change of cant and rates of change of cant deficiency set out in 2.6.5 to 2.6.9 assume a clothoid spiral transition curve.

2.6.3 Particular requirements for forms of transition curves other than clothoid spiral

- 2.6.3.1 A transition curve other than a clothoid spiral is only permissible if a compatibility assessment demonstrates that the chosen form of transition curve is compatible with vehicle tilting mechanisms.
- 2.6.3.2 The peak rate of change of cant and the peak rate of cant deficiency shall be specified to suit the degree of smoothing offered by the form of the transition curve. The average rate of change of cant deficiency through the transition curve shall comply with the values set out in 2.6.5 to 2.6.8, but it is permissible for the peak rate of change of cant deficiency to exceed the quoted values. However, the peak rate of change of cant deficiency shall not exceed these values by more than 33%.

2.6.4 Cant gradient

- 2.6.4.1 The steepest permitted designed cant gradient shall be 1 in 400.
- 2.6.4.2 The deflection of the track at skew underbridges during the passage of trains shall be taken into account when proposing to install cant gradients approaching 1 in 400.

2.6.5 Rate of change of cant at permissible speed

- 2.6.5.1 The normal limiting design value for rate of change of cant shall be 55 mm/s.
- 2.6.5.2 The exceptional limiting design value for rate of change of cant shall be 85 mm/s.

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2.6.6.1 The normal limiting design value for rate of change of cant shall be 75 mm/s.

2.6.6.2 The exceptional limiting design value for rate of change of cant shall be 95 mm/s.

2.6.7 Normal limiting design values for rate of change of cant deficiency at permissible speed

2.6.7.1 The normal limiting design values for rate of change of cant deficiency shall be:

- a) 55 mm/s on plain line.
- b) 80 mm/s on S&C designed to accommodate this value.
- c) 55 mm/s on other S&C.

2.6.7.2 It is permissible to disregard the rate of change of cant deficiency at the switch toes.

2.6.8 Exceptional limiting design values for rate of change of cant deficiency at permissible speed

2.6.8.1 Exceptional limiting design values for rate of change of cant deficiency shall be:

- a) 70 mm/s on plain line.
- b) 95 mm/s on S&C designed to accommodate this value.
- c) 55 mm/s on other S&C (unchanged from the normal limiting design value).

2.6.8.2 It is permissible to disregard the rate of change of cant deficiency at the switch toes.

2.6.9 Transition curves - rate of change of cant deficiency at enhanced permissible speed

2.6.9.1 The normal limiting design value for rate of change of cant deficiency shall be 110 mm/s on plain line.

2.6.9.2 The exceptional limiting design value for rate of change of cant deficiency shall be 150 mm/s on plain line.

2.6.9.3 The limiting design values for rate of change of cant deficiency on S&C shall be the same as those at permissible speed set out in 2.6.7 and 2.6.8.

2.7 Vertical alignment**2.7.1 General requirements for vertical alignment**

2.7.1.1 On running lines, vertical alignments shall consist of lengths of track at constant gradient connected by parabolic vertical curves. The minimum length of each geometrical element shall be appropriate to the length and characteristics of vehicles likely to use the track.

2.7.2 Track gradients

2.7.2.1 Design of track gradients shall take account of the following factors:

- 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.

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- d) The combined effect of gradient and horizontal curvature where the gradient coincides with a small radius horizontal curve.

2.7.2.2 Guidance on the design value for track gradient is given in Appendix B.

2.7.3 Normal limiting design value for track gradient

- 2.7.3.1 The normal limiting design value for track gradient on running lines shall be 1 in 80 (12.5 mm/m).

2.7.4 Exceptional limiting design values for track gradient

- 2.7.4.1 The exceptional limiting design values for track gradient shall be:
 - a) 20 mm/m (1 in 50) for sections up to 3 km (1.9 miles) in length.
 - b) 35 mm/m (1 in 28.6) for sections up to 0.5 km (0.3 miles) in length where trains are not intended to stop and start in normal operation.
 - c) 35 mm/m (1 in 28.6) for passenger only lines where:
 - i) The slope of the moving average profile over 10 km (6.2 miles) is less than or equal to 25 mm/m.
 - ii) The maximum length of continuous 35 mm/m gradient does not exceed 6 km (3.7 miles).

2.7.5 Vertical curves

- 2.7.5.1 The maximum vertical acceleration experienced in a vehicle due to the effect of the vertical curve shall be 0.06 g.
- 2.7.5.2 The design of vertical curves shall take account of the following factors:
 - 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.

2.7.6 Normal limiting design value for vertical curves

- 2.7.6.1 The normal limiting design value for vertical curve radii shall be 1000 m, subject to the factors listed in 2.7.5.2.

2.7.7 Exceptional limiting design value for vertical curves

- 2.7.7.1 The exceptional limiting design value for vertical curve radii shall be 600 m over a convex curve (hog) and 900 m in a concave curve (hollow) subject to the factors listed in 2.7.5.2. Where radii less than 1000 m are used, there shall be at least 30 m constant gradient between reverse vertical curves.

2.8 Track geometry requirements for sidings**2.8.1 Horizontal alignment**

- 2.8.1.1 Horizontal curves shall be designed to take account of the curving characteristics of vehicles likely to use the siding.
- 2.8.1.2 The normal minimum radius on sidings shall be 150 m.
- 2.8.1.3 The exceptional minimum radius on sidings shall be 125 m.