Permissible Track Forces for Railway Vehicles

Part A

Synopsis

This document 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.

Approval and authorisation

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Issue / Revision Record

This standard will be updated when necessary by distribution of a complete replacement. Amended or additional parts of revised pages will be marked by a vertical black line in an adjacent margin.

Issue	Rev	Date	Comments
1	A	Oct 93	Original Document

Responsibilities and distribution

This standard applies to BR businesses, private owners and other organisations that operate railway vehicles on BR lines. Businesses shall ensure that the provisions of the standard are communicated to all persons and organisations with responsibilities for vehicles and suspensions in the fields of technical specification, design, development, procurement, testing and maintenance.

Implementation

The provisions of this standard are mandatory. The process of implementation shall begin immediately on receipt of this document. The standard shall be applicable from 1 December 1993 to all new procurement contracts for new vehicles and to all new programmes involving engineering change to existing vehicles.

Supply

Controlled and uncontrolled copies of this standard may be obtained from the TDCC Manager, Central Services, Dovedale House, RTC, Derby.

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Part B

1 Purpose

This standard prescribes design and maintenance performance requirements for railway vehicles and their suspension arrangements to ensure that interactive forces between vehicles and track are acceptable and will ensure operational safety on BR lines.

2 Scope

The requirements of this standard apply to traction and rolling stock vehicles, and also to on-track plant that is required to undertake movements outside possessions. The requirements apply to all new vehicles. The requirements also apply to existing vehicles undergoing engineering change, insofar as it is practicable to incorporate them.

3 Definitions

For the purposes of this document, the following definitions apply**:**

Dynamic Stability

The degree to which a wheelset, bogie or vehicle body avoids the onset of unstable or hunting oscillations in the horizontal plane.

Engineering Change

Any alteration or modification to the design of a vehicle that affects its technical performance, particularly where it influences vehicle ride and track interaction.

On-Track Plant

All types of mobile rail–mounted plant and machinery that are permitted to undertake movements on BR tracks outside possessions.

Definitions (Continued)

P2 Force
The total vertical force generated at the interface between a wheel and a rail, comprising the static gravitational loading on the wheel and the inertia forces associated with the dynamic response of the unsprung masses to variations in the vertical alignment of the rail.

Unsprung Mass

The mass of a wheel, or wheelset, and other associated components which are not dynamically isolated from the track by vehicle suspension arrangements.

4 General Requirements

4.1 Trains that operate on British Railways tracks shall be designed and maintained so that they do not generate excessive forces between wheels and rails, between vehicles and track, and between trains and track infrastructure when operating under normal conditions on those routes where they are permitted to run.

These requirements apply:

(a) over the full normal operating speed range for each vehicle;

(b) over the appropriate range of track and rail configurations, features, and associated tolerances, as defined in references (1) and (2);

(c) over the permissible range of interface geometries between wheels and rails as defined in reference (3).

4.2 Vehicles shall meet the requirements of this standard over the full range of variations in vehicle condition that are likely to be experienced. Account shall be taken of tolerances in vehicle dimensions, masses and suspension characteristics; variations and asymmetries in payload and wheel loadings; normal variations in vehicle maintenance condition and wear; and any other relevant variables.

General Requirements (Continued)

4.3 Vehicles shall be maintained so that the prescribed tolerances for components, assemblies and systems that influence track forces are sustained over the lives of the vehicles. If vehicles are subject to damage that can cause excessive track forces (for example, wheel flats), the safety risk shall be minimised by timely and appropriate action commensurate with the situation.

5 Vertical Static Forces

5.1 Vehicles shall be designed so that the combined effect of static wheel loading, wheel diameter and wheel tread profile does not prejudice safety by causing excessive stresses and deformation in the contact zones between wheel treads and rail heads under all normal track conditions.

5.2 Except as in Clause 5.3, the following requirements apply:

(a) wheel tread profiles shall be selected from those listed in reference (4);

(b) the minimum wheel tread diameter shall not be less than 250 mm and shall meet the requirements of reference (3);

(c) the static wheel load shall not exceed the lower value of the following:

$$Q = 0.130\,D \quad \text{or} \quad Q = 125 \text{ kN}$$

where Q = maximum static wheel load (kN)

D = wheel tread diameter (mm).

5.3 Combinations of static wheel loading, wheel diameter and wheel tread profile that are different from those defined in Clause 5.2 may be used, providing that the wheel–to–rail contact stresses and deformation rates can be maintained within safe limits. In such a case, compliance with Clause 5.1 shall be supported by appropriate technical justification.

Vertical Static Forces (Continued)

5.4 The combination of axleloads and axle spacings for a vehicle, or for an operationally inseparable rake of vehicles, shall be such that the requirements of the Route Availability (RA) System are met for the desired routes of operation. These requirements are prescribed in reference (5), together with the process for deriving the RA number for a vehicle.

5.5 Vehicles shall be designed so that the pattern of axle loadings and spacings between axles along a train do not reinforce the generation of harmonic loading cycles or induce resonances of track infrastructure and bridges. Integer ratios of axle spacings within and between vehicles and rakes of vehicles shall be avoided.

6 Vertical Dynamic Forces

6.1 Vehicles shall be able to run over the normal range of vertical track irregularities at normal operating speeds without generating excessive vertical loads and stresses in the rails and track.

6.2 Except as in Clause 6.3, a vehicle shall be able to negotiate a vertical ramp discontinuity in rail top profile, equivalent to a dipped rail joint on straight track, at its maximum design operating speed without exceeding a total (static plus dynamic) P2 force per wheel of 322 kN.

The P2 force shall be calculated using the following formula:

$$P_2 = Q + (A_z.V_m.M.C.K)$$

where

$$M = \left[\frac{M_v}{M_v + M_z}\right]^{0.5}$$

$$C = 1 - \left[\frac{\pi \,.\, C_z}{4[K_z(M_v + M_z)]^{0.5}}\right]$$

$$K = \left(K_z.M_v\right)^{0.5}$$

Q = maximum static wheel load (N)

V_m = maximum normal operating speed (m/s)

M_v = effective vertical unsprung mass per wheel (kg)

A_z = 0.020 rad
(total angle of vertical ramp discontinuity)

M_z = 245 kg
(effective vertical rail mass per wheel)

C_z = 55.4 x 10^3 Ns/m
(effective vertical rail damping rate per wheel)

K_z = 62.0 x 10^6 N/m

(effective vertical rail stiffness per wheel)

Vertical Dynamic Forces (Continued)

6.3 If it is proposed to operate vehicles which exceed the maximum value of the P2 force as prescribed and calculated in Clause 6.2, compliance with Clause 6.1 shall be supported by appropriate technical justification. This shall include consideration of the alignment quality, strength and dynamic characteristics of the rails and track and the speed, mass and suspension characteristics of the vehicle. Formal clearance to operate shall be obtained on an individual route basis from the technical manager responsible for the safety of infrastructure on that route.

7 Lateral Forces

7.1 Vehicles shall be designed so that under all normal track and operating conditions they do not generate lateral forces which could jeopardise the structural integrity of the rails and track.

7.2 Except as in Clause 7.4, a vehicle shall not subject the track to lateral forces greater than:

$Y = W/3 + 10$

where

Y = lateral force transmitted to track per axle (kN)

W = static axleload (kN)

Only lateral force values that are sustained for distances of 2 metres or more shall be taken into account.

Lateral Forces (Continued)

7.3 Except as in Clause 7.4, a vehicle shall be able to negotiate a lateral ramp discontinuity in track alignment, when travelling on a curve at maximum normal operating speed and at maximum cant deficiency, without exceeding a total lateral force level per axle of 71 kN.

The lateral force shall be calculated using the following formula:

$$Y = W.A_d + A_y.V_m \left[\frac{M_u}{M_u + M_y}\right]^{0.5} . \left[K_y \, . \, M_u\right]^{0.5}$$

where

Y = lateral force per axle (N)

W = static axleload (N)

A_d = maximum normal operating cant deficiency angle (rad)

V_m = maximum normal operating speed (m/s)

M_u = effective lateral unsprung mass per axle (kg)

A_y = 0.0039 rad
(angle of lateral ramp discontinuity)

M_y = 170 kg
(effective lateral rail mass per wheel)

K_y = 25.0×10^6 N/m
(effective lateral rail stiffness per wheel)

7.4 If it proposed to operate vehicles which exceed the maximum values of Y force as prescribed and calculated in Clauses 7.2 and 7.3 above, compliance with Clause 7.1 shall be supported by appropriate technical justification. This shall include consideration of the alignment quality, strength and dynamic characteristics of the rails and track and the speed, mass, suspension and dynamic stability characteristics of the vehicle. Formal clearance to operate shall be obtained on an individual route basis from the technical manager responsible for the safety of infrastructure on that route.

8 Longitudinal Forces

8.1 Vehicles and trains shall not develop excessive longitudinal tractive and braking forces that could damage the structural integrity of rails, track and infrastructure.

8.2 Except as in Clause 8.3, vehicles and trains shall not transmit longitudinal forces to the track greater than those prescribed in references (6) and (7).

8.3 If it is proposed to operate vehicles or trains which exert longitudinal forces greater than those permitted by Clause 8.2, compliance with Clause 8.1 shall be supported by appropriate technical justification. Formal clearance to operate shall be obtained on an individual route basis from the technical manager responsible for the safety of infrastructure on that route.

9 Verification

Compliance with the above requirements shall be verified by calculation, testing, comparison with other vehicles, or by other appropriate means.

Appendix A

References

(1)	GC/EH0003	Design of Railway Curves (Note that until reference (1) is issued, reference should be made to BR 12800, Railway Curves, Civ.Eng.Handbook No.3, Jan 1973)
(2)	GC/EH0005	Track Maintenance Handbook (Note that until reference (2) is issued, reference should be made to BR 12804, Track Maintenance, Civ.Eng.Handbook No.5, Mar 1986)
(3)	GM/TT0089	Geometric Interfaces Between Vehicles and Track
(4)	GM/TT0132	Wheelsets: Off–Vehicle Repair and Overhaul
(5)	GC/TT0138	Route Availability System
(6)	BS 5400: Part 2	Steel, Concrete and Composite Bridges (Specification for Loads)
(7)	BS 153: Part 3A	Steel Girder Bridges (Specification for Loads)

Related Documents

GM/TK0007	Commentary on Permissible Track Forces for Railway Vehicles
TM VTI 023	A Procedure for Predicting Dynamic Lateral Track Forces for Traction & Rolling Stock, BR Research Division, Nov 1985.
	The Effect of Track and Vehicle Parameters on Wheel/ Rail Dynamic Forces, The Railway Engineering Journal, Vol.3 No.1, I.Mech.E. Jan 1974.