

Railway Group Standard

GMRT2045

Issue Four

Date March 2016

Compatibility Requirements for Braking Systems of Rail Vehicles

Synopsis

This document defines the compatibility and performance requirements for the braking systems of rail vehicles for operation in trains on the mainline railway.

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 GMRT2045**

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Issue record

Issue	Date	Comments
One	October 2008	Original document Supersedes GMTT0168
Two	April 2000	Replaces issue one
Three	September 2011	Replaces issue two
Four	March 2016	GMRT2045 has been revised to consolidate all the requirements from the various Great Britain (GB) braking standards into one document and align with the revised TSIs

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Superseded documents

The following Railway Group documents are superseded, either in whole or in part as indicated:

Superseded documents	Sections superseded	Date when sections are superseded
GMRT2040 issue one Calculation of Brake Force Data for Rolling Stock Library	All	04 June 2016
GMRT2041 issue two Braking System Requirements and Performance for Trailer Coaching Stock	All	04 June 2016
GMRT2042 issue two Braking System Requirements and Performance for Traction Units	All	04 June 2016
GMRT2043 issue two Braking System and Performance for Freight Trains	All	04 June 2016
GMRT2044 issue four Braking System Requirements and Performance for Multiple Units	All	04 June 2016
GMRT2045 issue three Braking Principles for Rail Vehicles	All	04 June 2016
GMRT2046 issue one Braking System Requirements and Performance for Trains which Operate above 125 mile/h	All	04 June 2016
GMGN2615 issue one Guidance on the Conventional Rail Locomotives and Passenger Rolling Stock TSI	G 2.1.83 to G 2.1.132 inclusive	04 June 2016
GMGN2688 issue two Guidance on Designing Rail Freight Wagons for use on the GB Mainline Railway	G 2.15.3, G 2.16 to G 2.19 inclusive and G 3.2.31	04 June 2016

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GMRT2040 issue one, GMRT2041 issue two, GMRT2042 issue two, GMRT2043 issue two, GMRT2044 issue four, GMRT2045 issue three and GMRT2046 issue one, cease to be in force and are withdrawn as of 04 June 2016.

The relevant sections of GMGN2615 issue one and GMGN2688 issue two are to be withdrawn as of 04 June 2016.

Supply

The authoritative version of this document is available at www.rssb.co.uk/railway-group-standards. Enquiries on this document can be forwarded to enquirydesk@rssb.co.uk.

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Part 1 Purpose and Introduction

1.1 Purpose

- 1.1.1 This document mandates requirements for brake systems of rail vehicles for operation in trains on the Great Britain (GB) mainline railway.

1.2 Introduction

1.2.1 Background

- 1.2.1.1 This document defines the principles of operation and the performance of the braking systems fitted to rail vehicles. It includes requirements and guidance for the brake systems and is intended to be read in conjunction with the Rolling Stock Technical Specifications for Interoperability (TSI) 'Locomotives and Passenger' (LOC & PAS) TSI and 'Freight Wagons' (WAG) TSI.
- 1.2.1.2 The requirements set out in the LOC & PAS TSI and WAG TSI are developed to complement the requirements in other TSIs. For braking requirements, these are essentially those associated with the European Train Control System (ETCS) set out in the Control, Command and Signalling (CCS) TSI.
- 1.2.1.3 The existing rail system is predominantly signalled by lineside signals with established signal spacing, and the braking performance of vehicles when operating in train formations needs to be sufficient to ensure they can stop within such signal spacing. The braking performance requirements mandated by this standard are intended to achieve the compatibility between the signal spacing and the braking performance of rail vehicles when operating in train formations.

1.2.2 Principles

- 1.2.2.1 The requirements of this document are based on the following principles.
- 1.2.2.2 This document sets out National Technical Rules (NTRs) for the mainline railway in GB. Compliance with NTRs is required under the Railways Interoperability Regulations 2011 (RIR 2011) (as amended).
- 1.2.2.3 The NTRs in this document are used for the following purposes:
- a) To support UK specific cases in TSIs.
 - b) To set out requirements to maintain compatibility between existing subsystems and / or vehicles that do not conform to the requirements in TSIs and new, upgraded or renewed subsystems and / or vehicles conforming to TSIs.
- 1.2.2.4 This document sets out the NTRs supporting the specific cases permitted by the LOC & PAS TSI, associated with emergency braking rates and drivers' brake controller ergonomics.
- 1.2.2.5 This document also sets out the NTRs associated with braking performance of rail vehicles when operating in train formations which are needed to maintain technical compatibility with existing signal spacing.
- #### 1.2.3 Structure of this document
- 1.2.3.1 This document sets out a series of requirements that are sequentially numbered.
- 1.2.3.2 This document also sets out the rationale for the requirement. The rationale explains why the requirement is needed and its purpose. Where relevant, guidance supporting the requirement is also set out in this document. The rationale and the guidance are indicated by prefixing the clause number with the letter 'G'.

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1.2.3.3 The national rules relating to relevant TSI parameters have been identified, together with the relevant clause from the TSI.

1.2.3.4 The clause order of the document follows the section headings in Chapter 4 of the LOC & PAS TSI relating to the operation, performance and interface requirements of rail vehicle brake systems.

1.2.4 Related requirements in other documents

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

- a) GERT8075 - AWS and TPWS Interface Requirements.
- b) GKRT0075 - Lineside Signal Spacing and Speed Signage.
- c) GMRT2111 - Rolling Stock Subsystem and Interfaces to AC Energy Subsystem.
- d) GMRT2113 - Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem.
- e) GMRT2400 - Engineering Design of On-Track Machines in Running Mode.
- f) GMRT2461 - Sanding Equipment Fitted to Multiple Units and On-Track Machines.
- g) GORT3056 – Working Manual for Rail Staff Freight Train Operations

1.2.5 Supporting documents

1.2.5.1 The following Rail Industry Guidance Notes support this Railway Group Standard:

- a) GEGN8628 - Guidance on Preparation for and Operation during Winter.
- b) GMGN2607 - Guidance on the Braking Requirements for Hauling Unbraked Multiple Units in Freight Trains.
- c) GMGN2615 - Guidance on the Conventional Rail Locomotives and Passenger Rolling Stock TSI.
- d) GMGN2688 - Guidance on Designing Rail Freight Wagons for use on the GB Mainline Railway.
- e) GMGN2695 - Guidance on Testing of Wheel Slide Protection Systems Fitted on Rail Vehicles.

1.3 Approval and authorisation of this document

1.3.1 The content of this document was approved by Rolling Stock Standards Committee on 04 December 2015.

1.3.2 This document was authorised by RSSB on 12 February 2016.

Part 2 Requirements for Brake Systems

2.1 General

2.1.1 Except where otherwise required by this document, the braking requirements applicable to rail vehicles of either the LOC & PAS TSI or the WAG TSI shall apply as if they were requirements mandated by this document.

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- G 2.1.1.1 **Rationale for 2.1.1:** The technical requirements of the LOC & PAS TSI and WAG TSI are also applicable to modifications to the brake system where the vehicle is deemed not to be new, renewed or upgraded as defined in RIR 2011 (as amended). These requirements will help achieve compatibility with the TSI and the non-TSI compliant parts of the existing railway system.
- G 2.1.1.2 This document includes additional requirements and guidance for the braking systems for rail vehicles and is intended to be read in conjunction with the LOC & PAS TSI and WAG TSI. The exceptions to the LOC & PAS TSI and WAG TSI are set out in this document.
- G 2.1.1.3 This document also contains the NTRs applicable to rail vehicle brake systems when operating on the GB mainline network. This document provides a set of requirements to follow such that compatibility with the existing rail system is maintained.
- G 2.1.1.4 The majority of the braking requirements in both the LOC & PAS TSI and WAG TSI are set out in section 4.2.4 of the respective documents. Guidance on the braking requirements of the LOC & PAS TSI and WAG TSI are set out in Appendix F of this document.
- G 2.1.1.5 Where Euronorms (ENs) are considered complete and a suitable substitute for RGSSs, reference to the EN is made.
- G 2.1.1.6 The brake system(s) fitted to the rail vehicles performs four functions:
- a) Emergency brake achieved using the automatic and continuous power brake fitted to all rail vehicles.
 - b) Service brake used to control the speed of the train, including to a stop.
 - c) Holding brake to secure the train at standstill during a stop in a station and to secure the train on a gradient during a hill start.
 - d) Parking brake used to immobilise the rail vehicle / train.
-

2.2 Brake command

2.2.1 General

2.2.1.1 From the active driving cab, it is permitted to push the brake control lever(s) forwards to increase the service brake demand and for the emergency brake position to be furthest from the driver.

-
- G 2.2.1.1.1 **Rationale for 2.2.1.1:** This requirement supports the specific case for 'Driver's Desk – Ergonomics (4.2.9.1.6(4) of the LOC & PAS TSI)' applicable to the GB mainline network, permitted by in clause 7.3.2.19 of the LOC & PAS TSI.

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- G 2.2.1.1.2 The GB specific case permits the continuation of the GB convention for controlling the brake in the majority of driving cabs on the GB mainline railway. In this situation the brake controller (or combined traction brake controller) is arranged to apply the brake when the handle is moved forwards / away from the driver and release the brakes when the handle is moved backwards / towards the driver.
 - G 2.2.1.1.3 This direction of movement also applies to any separate brake controllers provided for the dynamic brake and direct brake. The direct brake is also known as the independent brake or straight air brake.
 - G 2.2.1.1.4 The direction of movement of the brake controller was originally selected by British Rail (BR) on the basis that an incapacitated driver was considered more capable of pushing the brake controller and thereby chose this direction to apply the brake.
 - G 2.2.1.1.5 The installation of train protection and driver vigilance systems provide alternative and independent means to apply the brake in the event a driver becomes incapacitated.
 - G 2.2.1.1.6 The LOC & PAS TSI adopted the general continental practice (also used by some GB operators), which is to apply the brake when the handle is moved backwards / towards the driver and release the brakes when moved forwards / away from the driver.
 - G 2.2.1.1.7 The GB specific case in clause 7.3.2.19 of the LOC & PAS TSI is not a condition of access to the GB mainline railway. Where it is preferred that the brake controllers comply with the LOC & PAS TSI directions of movement, consideration needs to be given for safe operation on the GB mainline railway. Factors to be considered in the assessment include:
 - a) Whether drivers will be required to work totally on rail vehicles of one particular type or are required to interwork with other GB fleets.
 - b) The ability to retrain existing drivers from the GB standard direction of control.
 - c) The proposed duty of the train.
-

2.2.2 Emergency brake command

2.2.2.1 On existing (ex-BR) disc braked multiple units that were retrospectively modified to provide the enhanced emergency braking capability, the control systems shall incorporate a deterrent feature to discourage the use of this brake by a driver in non-emergency situations.

- G 2.2.2.1.1 **Rationale for 2.2.2.1:** This requirement is additional to the requirements of the LOC & PAS TSI clause 4.2.4.4.1. The enhanced emergency brake on the retrospectively modified rail vehicles generates higher forces in bogie and brake equipment that are above those used for the original brake design.
 - G 2.2.2.1.2 To reduce the risk of mechanical failure the general use of the enhanced emergency brake needs to be restricted. The generally adopted deterrent following a driver initiated enhanced emergency brake application is for the brake control system to prevent the driver releasing the brake until the train is at a standstill.
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G 2.2.2.1.3 Alternative deterrent measures are permitted provided they address the risk of mechanical failure to bogie and brake equipment.

2.2.3 Service brake command

2.2.3.1 On existing GB multiple units fitted with a 3 step service brake control it is permitted to retain this feature.

G 2.2.3.1.1 **Rationale for 2.2.3.1:** This requirement is an exemption to the requirements of the LOC & PAS TSI clause 4.2.4.4.2, to maintain operational compatibility between existing GB multiple units fitted with 3 step service brake control.

G 2.2.3.1.2 This is not an exemption for new vehicles from the LOC & PAS TSI clause 4.2.4.4.2 which sets out a requirement for graduated application and release with a minimum 6 steps of service brake application.

G 2.2.3.1.3 In those situations where it is intended to couple and operate a TSI compliant unit with an existing unit with a 3 step service brake control, the provision of a 'brake translator' is one means to generate the relevant electrical command signals at the ends of the unit.

2.2.4 Holding brake command

2.2.4.1 The application of the holding brake shall be possible by the direct brake or combined with a service brake initiated automatically or by the driver.

G 2.2.4.1.1 **Rationale for 2.2.4.1:** This requirement is additional to the requirements of the LOC & PAS TSI clause 4.2.4.4 to prevent unauthorised movement (roll back of the train).

G 2.2.4.1.2 The LOC & PAS TSI is silent on the provision of the holding brake function. In order to permit hill starts it is necessary to apply traction while using a partial brake application. This feature is considered necessary when a combined traction / brake controller is fitted.

G 2.2.4.1.3 The holding brake can be configured to release after:

- a) A certain tractive effort has been developed.
- b) A period of time following the traction command.
- c) A manual command.

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2.3 Braking performance

2.3.1 General

2.3.1.1 The braking performance for rail vehicles when operating in train formations shall be achieved with rail vehicles in:

- a) The design mass in working order.
- b) Any loading conditions up to, and including, the maximum permitted for the vehicles.

G 2.3.1.1.1 **Rationale for 2.3.1.1:** This requirement is additional to the requirements of the LOC & PAS TSI and WAG TSI for compatibility with existing GB signalling systems on routes not operating with ETCS supervision.

G 2.3.1.1.2 GKRT0075 sets out the requirements for the minimum signalling distances. GKRT0075 also includes the rules to extend and reduce the individual signalling distances, depending on the local gradient of the line.

G 2.3.1.1.3 This standard sets out the level track full service braking performance requirements for rail vehicles when operating in train formations for compatibility with the GB signalling distances.

G 2.3.1.1.4 The brake performance of individual rail vehicles needs to consider the intended train formations in which the rail vehicles are to be operated. Factors to be considered include:

- a) Any propagation delay of the brake command signals arising from increasing length of train formation.
- b) The sharing of the braking duty between different brake systems and rail vehicles in the train formation.

G 2.3.1.1.5 The train formation braking performance requirements set out in this document incorporate a safety margin to cover for speedometer error and the random reduction in nominal adhesion.

G 2.3.1.1.6 The definition of design mass in working order is set out in BS EN 15663:2009.

2.3.1.2 The braking performance of on-track machines (OTMs) capable of being driven independently on the mainline railway shall comply with locomotive braking performance requirements.

2.3.1.3 The braking performance of OTMs that operate as hauled rail vehicles on the mainline railway shall comply with freight wagon braking performance requirements.

G 2.3.1.3.1 **Rationale for 2.3.1.2 and 2.3.1.3:** These requirements are additional to the requirements of the LOC & PAS TSI and WAG TSI. The braking performance requirements of OTMs in their 'running mode' depends on whether they are capable of operating independently or require to be hauled on the network in a freight train.

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2.3.2 Emergency braking

2.3.2.1 Except for degraded modes, the emergency braking performance of the automatic and continuous brake shall not exceed the maximum permitted full service stopping distance requirements in 2.3.3 of this document.

G 2.3.2.1.1 **Rationale for 2.3.2.1:** This requirement is additional to the requirements of the LOC & PAS TSI, in order to maintain compatibility with existing GB requirements for the traffic operation and management subsystem. For compatibility with the GB operational requirements the emergency braking performance for locomotives and passenger vehicles is to be equal to or better than the full service brake.

2.3.2.2 Disc braked multiple units shall be fitted with an enhanced emergency braking capability. The brake forces used to achieve the enhanced emergency brake application shall be increased above that used for a full service brake application by:

- a) A nominal 30%, provided that the adhesion limits permitted for emergency braking are not exceeded.
- b) If the above is not achievable then a minimum of 15%, even if the adhesion limits for emergency braking are exceeded.

2.3.2.3 On multiple units fitted with enhanced emergency braking, this shall be applied when there is an emergency brake request by the on-board CCS systems.

G 2.3.2.3.1 **Rationale for 2.3.2.2 and 2.3.2.3:** These requirements are additional to the requirements of the LOC & PAS TSI. The provision of enhanced emergency braking capability is required for compatibility with the GB Class B Train Protection and Warning System (TPWS), as set out in GERT8075.

G 2.3.2.3.2 Passenger train TPWS settings were developed to exploit the higher enhanced emergency brake retardation rates available on disc braked multiple units.

2.3.2.4 The requirement to fit enhanced emergency braking does not apply to existing (ex-BR) disc braked multiple units where they are not already fitted.

G 2.3.2.4.1 **Rationale for 2.3.2.4:** These requirements are additional to the requirements of the LOC & PAS TSI. For existing Classes 158, 159, 313, 314, 442, 507 and 508 their full service / emergency braking performance and operational duty for these units did not justify their modification to provide enhanced emergency braking.

2.3.2.5 Individual freight vehicles with a maximum operating speed of either 60 mile/h (96 km/h) with brakes in goods timing, or 75 mile/h (120 km/h) with brakes in passenger timing, shall have an emergency stopping distance not exceeding 951 m.

2.3.2.6 Individual freight vehicles that are to be operated at 75 mile/h (120 km/h) in freight trains from 690 m up to 750 m in length, with brakes in passenger timing, shall have an emergency stopping distance not exceeding 890 m.

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- G 2.3.2.6.1 **Rationale for 2.3.2.5 and 2.3.2.6:** These requirements are additional to the requirements of the WAG TSI for compatibility with existing GB signalling systems on routes not operating with ETCS supervision.
 - G 2.3.2.6.2 The specified stopping distances are such that a train of compliant freight vehicles is capable of satisfying the full service brake performance requirements set out in 2.3.3.1 of this document.
 - G 2.3.2.6.3 Individual freight vehicles have traditionally been assessed in terms of their emergency braking performance (slip brake testing).
-

2.3.3 Service braking

- 2.3.3.1 Freight trains containing freight vehicles that are required to operate over routes signalled in accordance with GKRT0075 Appendix A shall not exceed the stopping distances defined by Curve V in Figure 1 of this document.
- 2.3.3.2 Freight trains that consist entirely of rail vehicles that meet the stopping distance defined in 2.3.2.5 of this document are permitted to be operated up to the following lengths and speeds:
 - a) 750 m and operating up to 60 mile/h (96 km/h) with brakes in goods timing.
 - b) 690 m and operating up to 75 mile/h (120 km/h) with brakes in passenger timing.
- 2.3.3.3 Freight trains longer than 690 m with brakes in passenger timing can be operated if all the individual freight vehicles meet the stopping distances defined in 2.3.2.6 of this document.
- 2.3.3.4 Locomotives required to operate over routes signalled in accordance with GKRT0075 Appendix A, shall have the following braking performance:
 - a) Existing (ex-BR) locomotives shall not exceed the stopping distances defined by Curve 'A1' in Figure 1 of this document.
 - b) New locomotives capable of operating at speeds not exceeding 110 mile/h (176 km/h) shall not exceed the stopping distances defined by Curve 'A2' in Figure 1 of this document.

-
- G 2.3.3.4.1 **Rationale for 2.3.3.1 to 2.3.3.4:** These requirements are additional to the requirements of the LOC & PAS TSI, in order to maintain compatibility with existing infrastructure. Lines signalled to GKRT0075 Appendix A permit the operation of all types of trains.
 - G 2.3.3.4.2 Longer signalling distances below 85 mile/h (compared to GKRT0075 Appendix B) are provided for freight train operation.
-

- 2.3.3.5 Locomotives, locomotive hauled passenger trains and fixed formation passenger trains required to operate over routes signalled in accordance with GKRT0075 Appendix A or Appendix B shall have the following braking performance:
 - a) For trains containing any existing (ex-BR) rail vehicles the stopping distances shall not exceed those defined by Curve 'B1' in Figure 2 of this document.
 - b) For trains composed entirely of new rail vehicles capable of operating at speeds not exceeding 110 mile/h (176 km/h) the stopping distances shall not exceed those defined by Curve 'B2' in Figure 2 of this document.

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- c) For trains composed entirely of new rail vehicles capable of operating at speeds exceeding 110 mile/h (176 km/h) and not exceeding 125 mile/h (200 km/h), the stopping distances shall not exceed those defined by Curve 'C1' in Figure 3 of this document.
- 2.3.3.6 Tread braked multiple units with a maximum speed of 100 mile/h (160 km/h) required to operate over routes signalled in accordance with GKRT0075 Appendix A or Appendix B, shall have the following braking performance:
- a) The stopping distances of trains containing any existing (ex-BR) rail vehicles shall not exceed those defined by Curve 'B1' in Figure 2 of this document.
- b) The stopping distances of trains composed entirely of new rail vehicles shall not exceed those defined by Curve 'B3' in Figure 2 of this document.
-
- G 2.3.3.6.1 **Rationale for 2.3.3.5 and 2.3.3.6:** These requirements are additional to the requirements of the LOC & PAS TSI. Lines signalled to GKRT0075 Appendix B permit the operation of all types of passenger trains. The signalling distances up to 100 mile/h (160 km/h) were derived from locomotive hauled trains fitted with cast iron tread brakes.
-
- 2.3.3.7 Disc braked multiple units with a maximum speed of 100 mile/h (160 km/h) required to operate over routes signalled in accordance with GKRT0075 Appendix A or Appendix B, shall not exceed the stopping distances defined by Curve 'B3' in Figure 2 of this document.
-
- G 2.3.3.7.1 **Rationale for 2.3.3.7:** This requirement is additional to the requirements of the LOC & PAS TSI. It sets out the nominal 7%g full service braking performance to permit operation at the line speed signed in accordance with GKRT0075 Appendix B.
- G 2.3.3.7.2 To enable disc braked multiple units to exploit higher differential line speeds (signed in accordance with GKRT0075 Appendix C) the brake performance will need to comply with 2.3.3.9.
-
- 2.3.3.8 Disc braked locomotive hauled passenger trains and fixed formation trains required to operate over routes signalled (or with differential speeds signed) in accordance with GKRT0075 Appendix C shall not exceed the stopping distances defined by Curve 'C1' in Figure 3 of this document.
- 2.3.3.9 Disc braked multiple units required to operate over routes signalled (or with differential speeds signed) in accordance with GKRT0075 Appendix C shall not exceed the stopping distances defined by Curve 'C2' in Figure 3 of this document.
-
- G 2.3.3.9.1 **Rationale for 2.3.3.8 to 2.3.3.9:** These requirements are additional to the requirements of the LOC & PAS TSI. Lines signalled to GKRT0075 Appendix C permit the operation of passenger trains which have a nominal 9%g full service braking capability.
-
- 2.3.3.10 On GB mainline railway routes permitting operation above 125 mile/h (200 km/h) but not exceeding 155 mile/h (250 km/h), the trains braking performance above 125 mile/h (200 km/h) shall not exceed the stopping distances defined by Curve 'D1' in Figure 4 of this document.

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G 2.3.3.10.1 **Rationale for 2.3.3.10:** This requirement supports the specific case in clause 7.3.2.7 of the LOC & PAS TSI not to comply with the requirements of point (9) of clause 4.2.4.5.2 for GB domestic trains with a design maximum speed higher than or equal to 155 mile/h (250 km/h).

2.3.4 Thermal capacity

2.3.4.1 The minimum thermal capacity for general operation of freight vehicles is defined by the operation over the route between Perth and Inverness, 22 miles at 60 mile/h (96 km/h) on a 1 in 70 (15‰) falling gradient.

G 2.3.4.1.1 **Rationale for 2.3.4.1:** This requirement is additional to the requirements of the WAG TSI clause 4.2.4.3.3 in order to maintain compatibility with existing infrastructure.

G 2.3.4.1.2 The brake thermal capacity is a means of declaring the capability of the brake systems on rail vehicles to maintain a constant operating speed on a falling gradient. It is declared in terms of the maximum line gradient, associated length and operating speed for the load condition maximum braking load.

G 2.3.4.1.3 The reference cases in the LOC & PAS TSI clause 4.2.4.5.4 and WAG TSI clause 4.2.4.3.3 are to permit operation over the Alpine gradients. For GB domestic rail vehicles it is not necessary to have this high thermal capacity.

2.3.5 Parking brake

2.3.5.1 For compatibility with the GB mainline railway, locomotives shall be fitted with a parking brake that is capable of holding the locomotive alone, in the design mass in working order, stationary on a minimum gradient on 1 in 30 (33‰).

2.3.5.2 For compatibility with GB mainline railway, each multiple unit or fixed formation passenger train shall be fitted with a parking brake that is capable of holding the unit / formation, in the design mass in working order, stationary on a minimum gradient of 1 in 30 (33‰).

2.3.5.3 Passenger trailer vehicles (coaches) with a driving cab shall be fitted with a parking brake. The performance of the parking brake shall be specified in terms of the total unbraked mass which can be held stationary by the trailer vehicle fitted with parking brakes in addition to the mass of the braked vehicle. The train formation, in the design mass in working order, shall be capable of being parked on a gradient at least as steep as 1 in 100 (10‰), or where there is an operating requirement, on a steeper gradient.

G 2.3.5.3.1 **Rationale for 2.3.5.3:** This requirement is additional to the requirements of the LOC & PAS TSI clause 4.2.4.5.5 to permit passenger trailer vehicles (coaches) not to be fitted with parking brakes when operating on the GB mainline railway.

G 2.3.5.3.2 The use of scotches is permitted if the passenger train formation is to be immobilised on steeper gradients than the design capability of the parking brake and the appropriate number of scotches are carried on the train.

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- 2.3.5.4 On freight vehicles the parking brake, where fitted, shall be capable of holding the vehicle, in the design mass under normal payload (fully laden), stationary on a minimum gradient of 1 in 40 (25‰). In the case of the semi-permanently coupled vehicles, those with a parking brake shall be capable of holding stationary all the vehicles that are semi-permanently coupled together.

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- G 2.3.5.4.1 **Rationale for 2.3.5.4:** This requirement is additional to the requirements of the WAG TSI clause 4.2.4.3.2.2, in order to provide the operational flexibility to detach defective vehicles from freight trains and to immobilise them with the parking brake.
- G 2.3.5.4.2 The changes in load state of the rail vehicle and suspension movements need to be considered when designing parking brake systems, principally the impact on parking brake performance and the ability to release the parking brake.
- G 2.3.5.4.3 For the purpose of designing the parking brake the maximum force that can be applied by a manual operator is 500 N at the mechanical interface (hand brake wheel or lever).
- G 2.3.5.4.4 The use of scotches is permitted if the freight train formation is to be immobilised on steeper gradients than the capability of the available parking brake and the appropriate number of scotches are carried on the train.
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2.4 Wheel slide protection system

- 2.4.1 Disc braked locomotives and passenger vehicles shall be fitted with wheel slide protection (WSP) systems.

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- G 2.4.1.1 **Rationale for 2.4.1:** This requirement is additional to the requirements of the LOC & PAS TSI clause 4.2.4.6.1 for compatibility with GB infrastructure. To minimise the risk of wheelset damage, and to optimise the braking performance during low adhesion conditions, all GB locomotive and passenger vehicles fitted with disc brakes have WSP equipment fitted regardless of their nominal adhesion requirement.
- G 2.4.1.2 The LOC & PAS TSI sets out requirements for WSP fitment to tread braked vehicles designed to utilise high adhesion values. The WAG TSI also sets out requirements for WSP fitment to freight vehicles designed to utilise high adhesion values.
- G 2.4.1.3 WSP systems compliant with BS EN 15595:2009+A1:2011 are considered sufficient to comply with the LOC & PAS TSI. The EN includes testing of rail vehicles on simulated low adhesion conditions generated using detergents applied to the railhead.
- G 2.4.1.4 GB experience has shown that this level of compliance is insufficient for satisfactory operation on the variable low adhesion conditions that are experienced on the GB mainline railway. This is reflected in the GB national foreword to BS EN 15595:2009+A1:2011. Further guidance for assessing WSP systems for operation in GB adhesion conditions is given in GMGN2695.
- G 2.4.1.5 It is good industry practice to arrange the WSP system so that there is control of the brake force on a per wheelset basis on a vehicle of a multiple unit, except on wheelsets that are coupled by a mechanical drive system.
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| G 2.4.1.6 | The brake energy supply needs to be sufficient for the intended train formations and all combinations of brake applications, including the effect of WSP operation. Where the brake systems are designed to utilise high levels of adhesion the effect of WSP activity, when operating on low adhesions, will influence the amount of energy required on the train formation. For additional guidance see Appendix K of this document. |
| G 2.4.1.7 | The interaction of the cross blending of the friction brake and the dynamic brake with powered and unpowered wheelsets needs to be considered during low adhesion events. Suspension of the dynamic brake, in response to the onset of significant wheelslip / slide, can assist in the reducing the wheelset adhesion demand and the extension in stopping distances. |
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2.5 Brake requirements for rescue purposes

2.5.1 Where rail vehicles are to be capable of being rescued by GB domestic locomotives the vehicle end air connections shall be compatible with:

- a) Brake pipe coupling (red) to BS EN 15807:2011 Figure 2.
 - b) Main reservoir pipe coupling with valve (yellow) to BS EN 15807:2011 Figure 8.
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| G 2.5.1.1 | Rationale for 2.5.1: This requirement is additional to the requirements of the LOC & PAS TSI clause 4.2.4.10. The ability to move a disabled train by a rescuing locomotive requires the provision of a means to release and subsequently control the brakes on the disabled train. |
| G 2.5.1.2 | On multiple units this has typically required a hose connection to the unit's main reservoir pipe to release the spring applied air release parking brakes. This alleviates the need to manually release the individual parking brake units and allows the unit to be stabled with the parking brake applied after the rescue move. |
| G 2.5.1.3 | Spring applied air release parking brakes are generally fully released when supplied with a pressure of 5 bar. Connecting the locomotive brake pipe to the multiple unit's main reservoir pipe could also provide a limited means to control a brake on the unit being rescued. This method is more applicable for multiple units up to 200 tonnes when most of the braking can be provided by the rescuing locomotive and the train formation is moved at reduced speeds. |
| G 2.5.1.4 | When it is intended to use the brake pipe pressure to release the spring applied parking brakes, reducing the volume of the multiple unit's main reservoir system avoids compromising the brake pipe control from the locomotive. This can be achieved by isolating air systems from the multiple unit's main reservoir pipe (including air reservoirs and air suspension systems). |
| G 2.5.1.5 | Where normal operating speeds are required during rescue operations, there needs to be provision for the multiple unit's brakes to be controlled by a locomotive. Suitable options are: <ul style="list-style-type: none"> a) The provision of a parallel or integrated pneumatically controlled brake system that is compatible with the locomotive brake system permits locomotive haulage of train formations fitted with electrically controlled brake systems. |

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- b) Use of a 'translator' at the unit ends to convert the brake pipe command pressures into the relevant electrical signals. This would, however, require the provision of electrical power on the unit during the rescue move. The 'translator' control being configured so that loss of electrical power on the unit being rescued initiates a brake application on the rescuing locomotive.

- G 2.5.1.6 For additional guidance on hauling un-braked multiple units in freight trains see GMGN2607.
- G 2.5.1.7 The compatibility of the main reservoir systems on the assisting vehicle and the train formation being rescued needs to be checked prior to coupling the main reservoir systems.
- G 2.5.1.8 British Rail historically adopted a main reservoir pipe pressure of 7 bar for hauled coaching stock and multiple units. More recent multiple units have followed the continental UIC practice with the main reservoir pipe pressure between 9 and 10 bar. The brake system components on GB rail vehicles are generally designed to tolerate 10 bar pressures.
- G 2.5.1.9 On some multiple unit classes, the air system safety valves are set to open at 8.5 bar. To avoid the safety valves continuously trying to vent the excess pressure in their air system, it is recommended that the reservoir pipe on these multiple units are not connected to air systems charged to greater than 7 bar when being rescued.
- G 2.5.1.10 The LOC & PAS TSI is silent on the identification of the inter-vehicle air connections. British Rail adopted the colours, red for the brake pipe and yellow for the main reservoir pipe, when air braked vehicles were introduced to the GB mainline railway.

2.6 Environmental conditions

- 2.6.1 For operation on the GB mainline railway, rail vehicle brake systems shall be designed to operate within the ambient temperature range T1 (-25°C to +40°C).

- G 2.6.1.1 **Rationale for 2.6.1:** This requirement specifies the option in the LOC & PAS TSI clause 4.2.6.1.1 and WAG TSI clause 4.2.5 for the ambient temperature range that is considered to be sufficient for brake equipment used on the GB mainline railway.
- G 2.6.1.2 Solar gain and heating from other equipment may lead to localised higher temperatures and these will need to be considered in design of the brake equipment.
- G 2.6.1.3 Where the emergency and full service brake applications rely on the exhausting of compressed air, consideration needs to be given to the provision of protection from blockage of the exhaust outlets, particularly by ice or frozen snow. The exhaust outlets from individual brake command devices are to be kept separate.
- G 2.6.1.4 The use of automatic slack adjuster mechanism permits a close clearance to be maintained between the braking surface on the disc or wheel and the friction material, which minimises the build-up of ice on these surfaces.

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| G 2.6.1.5 | Isolation of the blended dynamic brake by the driver, when operating in adverse weather conditions, permits the friction brake to be used to prevent the build-up of snow and ice on the brake equipment. For additional guidance on operation during winter weather conditions, see GEGN8628. |
| G 2.6.1.6 | Where full compliance with the requirements of this standard cannot be achieved, or the rail vehicles are subjected to ambient conditions beyond those specified, control measures, such as operating restrictions or special maintenance arrangements, need to be considered. |
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2.7 Interface with energy subsystem

2.7.1 Regenerative braking

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| 2.7.1.1 | For compatibility with the GB mainline railway, the requirements for regenerative braking into the AC energy subsystem are set out in GMRT2111. |
| 2.7.1.2 | For compatibility with the GB mainline railway, the requirements for regenerative braking into the DC energy subsystem are set out in GMRT2113. |

2.8 Interface with infrastructure subsystem

2.8.1 Maximum average deceleration

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| 2.8.1.1 | The maximum average deceleration requirements of the infrastructure subsystem developed with all brakes in use, including brakes independent of wheel / rail adhesion are satisfied by compliance with this standard. |
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2.9 Interface with operation subsystem

2.9.1 Braking performance

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| 2.9.1.1 | For compatibility with the GB mainline railway, the braking performance requirements of the operation subsystem are satisfied by compliance with this standard. |
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2.10 Interface with control, command and signalling subsystem

2.10.1 Train detection

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| 2.10.1.1 | For compatibility with the train detection systems of the GB mainline railway, the sanding criteria during braking for multiple units and OTMs are set out in GMRT2461. |
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| G 2.10.1.1.1 | Rationale for 2.10.1.1: This requirement is additional to the requirements of the LOC & PAS TSI clause 4.2.3.3.1 for compatibility with GB train detection systems based on track circuits. |
| G 2.10.1.1.2 | The LOC & PAS TSI only mandates the recording of the rolling stock characteristics in the European Register of Authorised Types of Vehicles (ERATV) where they comply with CCS TSI Index 77. |
| G 2.10.1.1.3 | The CCS TSI Index 77 document incorporates a series of target rolling stock characteristics for use when designing train detection system(s) (track circuits, axle counters, and loop equipment). |
| G 2.10.1.1.4 | The LOC & PAS TSI does not mandate compliance with the rolling stock characteristics set out in Index 77. Alternative interface criteria are permitted and for compatibility with GB train detection systems based on track circuits the isolating emission compatibility of sanding systems are covered by compliance with GMRT2461. |
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2.10.2 European Rail Traffic Management System (ERTMS) equipped routes

2.10.2.1 On rail vehicles fitted with the on-board ETCS, the brake control system shall incorporate interfaces to initiate an emergency brake application.

G 2.10.2.1.1 **Rationale for 2.10.2.1:** The on-board ETCS equipment calculates a series of intervention curves based on the braking characteristics of the train. Should the train speed exceed any of these intervention curves the on-board ETCS equipment will request a brake application.

G 2.10.2.1.2 Depending on the configuration of the on-board ETCS additional brake control system interfaces may be provided to initiate service brake applications.

2.10.3 GB Class B signalling systems (non-ERTMS) equipped routes

2.10.3.1 On rail vehicles fitted with on-board GB CCS systems (for example TPWS as set out in GERT8075, and trip-cocks as set out in GERT8018), the brake control system shall incorporate interfaces to initiate, as a minimum, a full service brake application.

G 2.10.3.1.1 **Rationale for 2.10.3.1:** On GB vehicles fitted with an automatic air brake system the GB CCS initiated brake application is achieved by a controlled venting of the brake pipe that replicates a full service brake application made by the driver.

G 2.10.3.1.2 On multiple units fitted with enhanced emergency braking, this is applied when there is a brake request by the GB CCS systems.

2.11 Interface with other on-board systems

2.11.1 Passenger alarm system

2.11.1.1 The brake system interface with the passenger alarm system shall initiate at least a full service brake application. For passenger alarm activations during platform departures the resulting brake application shall be at the enhanced emergency rate (where fitted).

G 2.11.1.1.1 **Rationale for 2.11.1.1:** This requirement is additional to the requirements of the LOC & PAS TSI clause 4.2.5.3 and sets out the braking criteria when the passenger alarm system requests a brake application.

G 2.11.1.1.2 LOC & PAS TSI compliant passenger alarm systems are primarily a communication system between the passenger and the driver. The principal exception being during station departures when the risk to passenger safety means the brakes are immediately applied. Outside station areas acknowledgement of the passenger alarm activation by the driver suspends / overrides a brake request from the passenger alarm system. Compliance with BS EN 16334:2014 is deemed to satisfy these requirements.

G 2.11.1.1.3 Historically, on GB hauled passenger vehicles, activation of the passenger alarm was configured to initiate a brake application by locally venting the brake pipe to below 2 bar. An override feature to cancel the passenger alarm brake request is fitted to Mk4 coaches when operated with compatible driving cabs (Class 91 locos and Mk4 Driver Van Trailers (DVTs)).

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2.11.2 Train safety systems

2.11.2.1 The brake control system shall provide interfaces for train safety systems to initiate an emergency brake application. It is permitted to initiate an enhanced emergency brake application (where fitted).

G 2.11.2.1.1 Examples of on-board safety systems with interfaces with the brake system include:

- a) Driver's activity control function.
- b) Direction control (prevents selection of neutral or change of direction when moving).
- c) Detection of hot axle boxes and bogie instability.
- d) Emergency door release interlock.

2.12 Conformity assessment

2.12.1 Verification of the emergency and service braking performance of locomotive and passenger vehicles shall be assessed by stopping distance tests in train formations that represent the intended use of the rail vehicles. The train formations used for these tests shall be recorded as part of the technical information.

G 2.12.1.1 **Rationale for 2.12.1:** Stopping distance testing is the accepted means of verifying the brake performance calculations.

G 2.12.1.2 The results of the stopping distance tests are assessed on the basis of a mean stopping distance curve derived from the individual stopping distances. Factors to take into consideration include:

- a) Testing from different brake entry speeds to generate a stopping distance curve.
- b) At least two stopping distance tests at each nominal test speed.
- c) The mean stopping distance curve derived using a suitable mathematical process.
- d) The mean stopping distance curve being less than or equal to the target stopping distance.
- e) Brake force build-up time.
- f) Any fade associated with the increase in temperature of a friction material that may arise during any brake application, including drag braking.
- g) Tolerances on equipment settings.
- h) Any degradation in braking performance between maintenance or during the bedding in of new components.
- i) The environmental conditions prevailing during the testing.