Railway Group Standard
GM/RT2045
Issue Three
Date September 2011

Braking Principles for Rail Vehicles

Synopsis
This document defines the principles of operation and performance requirements for the braking systems of rail vehicles for operation on Railtrack controlled infrastructure, in order to ensure safety of operation and safe interworking.

This document contains requirements that are amended under the Railway Group Standards Code (Issue Three) as a small scale change. Reference to the amended requirements is made in the 'Issue record'. All other parts of the document are unchanged from the previous issue.

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Part A

Issue Record

This document 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 the adjacent margin.

Issue	Date	Comments
One	October 1998	Supersedes GM/TT0168
Two	April 2000	Supersedes Issue One
Three	September 2011	Supersedes Issue Two Small scale change amendment to clause 7.1.2 second paragraph. Amendment to cross references in clause 11.6 g) from GK/RT0034 to GK/RT0075 and all clauses that previously referenced GO/RT3000 have been updated to GE/RT8000.

Authorisation

The content of this document was approved by Rolling Stock Standards Committee on 24 June 2011.

This document was authorised by RSSB on 12 July 2011.

Deleted

No longer relevant.

Compliance

This Railway Group Standard comes into force and is to be complied with from 03 December 2011.

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Part B

1 Purpose

The purpose of this document is to define the principles of operation and performance requirements of rail vehicle brake systems to enable safety of operation and safe interworking to take place.

2 Scope

The overall scope of Railway Group Standards is set out in the Railway Group Standards Code.

3 Definitions

Automatic Brake
A braking system where any interruption of the continuity of the brake control system causes an emergency application of the power brake to be made automatically (see also definition of continuous brake).

Brake Application
Where an application of the brake results in a brake force being applied to the vehicle.

Brake Controller
The device operated by the driver at the driving position by which means the demand for a brake application or release is relayed to the brake system.

Brake Force
The force applied to the brake block / pad / braking surface interface.

Brake Force Build Up Time
The elapsed time from when the brake controller handle is moved to signal the requirement for a brake application until the brake force has reached a specified value.

Brake Force Release Time
The elapsed time from when the brake controller handle is moved to signal the release of a brake application until the brake force has fallen to the level at which it is effectively released.

Brake Retarding Force
The resultant force on the vehicle, generated by the brake system, that produces a retardation of the vehicle.

Brake System
All the components and sub-assemblies that provide the means by which brake applications on rail vehicles are made and controlled, including the means by which the energy is provided and / or stored to generate the brake retarding force and the equipment which provides the retarding force.

Brake System Couplings
The inter-vehicle couplings that connect the brake systems on adjacent rail vehicles and transmit the brake control signals that provide the system continuity and, where appropriate, also transmit the energy.

Compatible Brake Systems
Those systems which have the same brake control signals and produce a similar retardation rate on a vehicle for a given position of the brake controller handle.

Continuous
An unbroken series of connections through all individual vehicles in any train formation and where the power brake control system relies on the integrity of these connections for its operation.

Continuous Brake
A power brake that operates on all parts of the train, such that any interruption of the Continuous element of the inter-vehicle connections of the brake control system, results in an emergency application of the power brake being automatically made on all parts of the train, that will bring all parts of the train to a standstill.

Drag Braking
A partial brake application that is sustained for a period of time to hold the speed of a train constant, down a falling gradient for example.

Driving Position
The designated position from which a driver controls the braking of a vehicle or train.

Dynamic Braking
A method of braking where retardation of a vehicle is produced by a method that does not involve friction as the principal means by which the kinetic energy is dissipated.

Emergency Brake Application
A brake application that uses a more direct and separate part of the control system, that as a result may be quicker, to signal the requirement for a brake application, than that used for the full service application. On certain vehicles, the retardation rate may be specified to be higher than that of the full service application and is described as enhanced emergency braking (see GM/RT2044).

Friction Braking System
A system in which friction is used to convert the kinetic energy of the vehicle into heat energy.

Full Service Brake Application
The brake application that gives the minimum retardation rate that meets the performance requirements.

Graduated Brake Application
An application of the brake that results in the value of brake force being controlled incrementally to a particular value that may be less than the maximum value that the system can generate.

Graduated Brake Release
A brake release in which the value of the brake force can be reduced incrementally to a particular value without completely releasing the brake.

Maximum Loaded Condition
A defined condition in excess of the normal fully laden condition that may arise during exceptional operating circumstances. Also commonly known as crush laden.

Multiple Unit
For the purposes of this document a Multiple Unit is a fixed formation of five vehicles or less having a driving position at both outer ends of the formation.

This definition excludes traction units (see GM/RT2042), on-track machines (see GM/RT2400) and freight vehicles (see GM/RT2043).

Note: Fixed formations of more than five vehicles that incorporate traction equipment distributed within the train do not therefore comply with the definition of either a trailer coach (because some vehicles have traction equipment) or a Multiple Unit (more than 5 vehicles). For the purposes of braking performance, these fixed formations may either meet the requirements of GM/RT2044 or the requirements of GM/RT2041. At operating speeds in excess of 125 mile/h, the requirements of GM/RT2046 apply.

Network Rail
Elsewhere in this document, the name 'Railtrack' is used. The name 'Railtrack' should be interpreted as meaning Network Rail.

New Vehicle
A vehicle introduced to Railtrack controlled infrastructure whose procurement contract date between the Railway Group Member and their supplier is after the relevant compliance date of this document or the documents listed in section 5. Such vehicles shall comply with the requirements for new vehicles defined in this document and the relevant document listed in section 5.

On-Track Machine
Any rail mounted machine meeting the requirements of GM/RT2400 and permitted by the Rule Book GE/RT8000 to be moved, either self-propelled or in train formation, outside a possession.

Parking Brake
A brake system designed to hold a rail vehicle stationary for an indefinite period without the addition of further energy to maintain the brake force, provided no additional external force is applied to the vehicle.

Power Brake
A means by which the retardation of a rail vehicle or a train can be achieved by the application of a brake force that is generated by energy stored on the vehicle.

Railway undertaking
Elsewhere in this document, the term 'train operator' is used. 'Train operator' should be interpreted as meaning a railway undertaking.

Stored Energy
Energy that is stored on the rail vehicle and is used to generate the brake force.

Traction Unit
A vehicle with its own source of traction, that is designed to haul other railway vehicles, that has one or more driving positions and is able to control the braking of the vehicles coupled to it.

Wheelslide Prevention Equipment (WSP)
A system designed to make the best use of available adhesion by a controlled reduction of the brake force to prevent wheelsets from locking and sliding.

4 Brake System - general

4.1
Brake systems in use shall be those that have proved to be safe and reliable in operation on either Railtrack controlled infrastructure or another major railway network having equivalent operating conditions and speeds to Railtrack controlled infrastructure. For information the principles of operation of the current friction braking systems in use on Railtrack controlled infrastructure are listed in Appendix C.

4.2
If a brake system not covered by section 4.1 is proposed, it may be introduced, providing that the system and / or any novel component part thereof complies with the requirements of this document and has been proved to be satisfactory by the processes defined in section 11.

4.3
All vehicles shall be equipped with a power brake, except existing vehicles that are not so fitted.

4.4
Continuous and automatic operation of the power brake and its control shall result where vehicles are required to run coupled to others in a train formation to provide a system of emergency braking that defaults to brakes applied (see also section 9).

4.5
Any type of braking system may be combined with any other type of braking system but where more than one system of braking is used there shall be a smooth transition between the systems of braking, without any degradation of braking performance.

4.6
The brake system of new vehicles shall be designed to operate correctly within the temperature range -20°C to 35°C, and the following weather conditions:

- relative humidity of 100% up to temperatures of 19°C;
- any reasonably foreseeable meteorological conditions.

4.7
For all vehicles the train operator shall be satisfied that the brake systems of the trains it operates function safely in all the ambient weather conditions in which the vehicles operate. In the case of existing vehicles at least in the temperature range -15°C to 35°C.

4.8
Where full compliance with the requirements of sections 4.6 and 4.7 cannot be achieved, or the train is subjected to ambient conditions beyond those specified, the train operator shall introduce suitable control measures, such as operating restrictions or special maintenance, that will ensure safety. See also section 7.4.5.

4.9
An existing vehicle that has a modification to the brake system shall comply with the requirements defined for new vehicles in this document and those documents defined in section 5 when it is reasonably practicable to do so.

5 Performance

5.1
The key performance parameter is characterised by the stopping distance / initial speed relationship, which is defined in the following documents for specific groups of vehicles:

GM/RT2041 - Braking System Requirements and Performance for Trailer Coaching Stock
GM/RT2042 - Braking System Requirements and Performance for Traction Units
GM/RT2043 - Braking System and Performance for Freight Trains
GM/RT2044 - Braking System Requirements and Performance for Multiple Units
GM/RT2046 - Braking System Requirements and Performance for Trains which operate above 125 mile/h
GM/RT2400 - Design of On-Track Machines

5.2
The braking performance defined in these documents relies on the normal level of adhesion being available that is necessary to sustain the brake retarding force demanded. It is accepted that in conditions of low wheel / rail adhesion the friction force that can be maintained at the wheel / rail interface is reduced and other measures to achieve the required stopping distance are necessary, such as a reduction in speed, railhead surface conditioning or a means of braking that does not rely on the wheel / rail adhesion.

5.3
Compliance with the performance requirements defined in the documents listed in section 5.1, will ensure that trains whose braking systems are functioning correctly, are able to stop within the appropriate signal spacing distance or within the appropriate in cab train control system requirements, when normal levels of adhesion are available.

6 Brake System energy

6.1
The energy used directly to provide the brake force for the emergency brake shall be stored on the vehicle and there shall be:

a) safe methods that do not endanger the staff or public for the following:

- storing the energy;
- discharging the energy during any operation to apply or release the brake or vent the system;

b) as a minimum, sufficient energy dedicated for use by the brake system, stored on a vehicle to make at least one full service brake application capable of stopping the vehicle from its maximum speed and maximum loaded condition, without the addition of any further energy;

c) on new vehicles in normal operating conditions, sufficient energy dedicated for use by the brake system, stored on the vehicle to enable an emergency brake application (enhanced emergency where fitted) to be made that shall be capable of stopping the vehicle from its maximum speed and maximum loaded condition without the addition of any further energy. In a pneumatic system "normal operating conditions" shall represent the minimum pressure to which the brake supply reservoir can fall as permitted by the tolerances in the system components, whilst all the system is operating normally. See also section 7.2.6.

6.2
If the energy used to provide the brake force is generated on the train, there shall be sufficient capacity to supply all the train formations and all combinations of brake applications, including the effect of WSP operation, (where fitted). In some train formations the effect of WSP activity will significantly influence the amount of energy required on the train.

See section 11.7 and Appendix D for guidance on the amount of energy required to be available.

6.3
If the same medium that is used for providing the brake force, is also used to transmit the signal that a brake application is required (either normal or automatic) there shall be a means of preventing the signal "brake application required" being suppressed. If for example, there is a division of a train with an automatic air brake, it shall be impossible for sufficient air to be supplied to the brake pipe to overcome the drop in brake pipe pressure caused by the open pipe at the division.

6.4
If a vehicle has its own source of brake energy for use when operating independently, it shall be impossible for this to interfere with the operation of the automatic power brake when the vehicle is in a train.

6.5
The brake system shall be protected from the effects of any auxiliary systems that derive their energy from that used for braking, so that these auxiliary systems cannot in any circumstance impair the efficiency of the brake system.

7 Control system

7.1 General

7.1.1

The control system shall enable the graduated application of the brakes and the release of the brakes on a vehicle to be made from the operative driving position on that vehicle or another vehicle with a compatible brake system coupled to it in a train formation. On new vehicles the control system shall enable a graduated release of the brakes to be made.

7.1.2

There shall be sufficient devices and redundancy incorporated into the braking control and energy storage systems, to reduce the effect that a failure of one part of the system has on the braking of the minimum train formation. This is particularly important where a stored energy system is used to produce the brake force.

There shall be no single point failure which can result in a lower than demanded brake retarding force being achieved on more than one vehicle (or alternatively a local brake control system affecting no more than two bogies on adjacent vehicles) in the train simultaneously. A particular example of this is that the brake retardation rate change required, where the brake force is reduced when operating at speeds exceeding 125 mile/h, is to be initiated individually on each vehicle and not solely through a train wire.

7.1.3

If several types of brake system are to work in conjunction with one another, there shall be provision for all types to be controlled by the same brake controller. On all new vehicles, there shall be an automatic return to the type of brake that provides the emergency braking, in the event of a failure of any other type of braking.

7.1.4

Where the control system permits tolerances in the level of energy to apply and release the brake that could result in it being impossible to fully release the power brake after changing the source of the control, a control system shall be provided that will enable the brakes to be fully released on the train. The overcharge facility on automatic air brake systems is an example of this.

7.1.5

Driving Positions shall be provided with devices to enable the driver to:

- monitor the brake control system, where continuity is not self-proving as defined in section 7.2.4;
- monitor the energy supply used for the automatic braking system;
- monitor the level of the brake application being achieved on the vehicle with the operative driving position as follows:
  - ◊ the emergency brake system;
  - ◊ on new vehicles each braking system or the overall braking performance (retardation).

7.1.6

It shall be possible for a train to be parked with a full brake application that either results automatically from the action of the driver shutting down the operative cab or under manual control of the driver.

7.1.7

Except in the case of hydraulic type parking brakes, a means shall be provided by which any type of brake application can be released manually if there is a failure of the normal method of release. These devices shall comply with the requirements of sections 6.1a) and 7.5.1.

7.2 Continuous and Automatic Features

7.2.1

The control system shall be designed so that an emergency brake application, which shall bring the train to a stand, shall result if:

a) there is a failure of the medium providing the method of control for the automatic brake system;

b) on new vehicles there is a failure of the primary source of the energy that is then supplied to the train to provide the brake force. It shall be impossible to override this part of the system using the normal operating controls, except on trains that also operate through the Channel Tunnel;

c) there is a loss of the continuity in the control system caused by an accidental division of the train;

d) either:

- the stored energy on the vehicle falls below that defined in section 6.1b;
or
- there is a failure of the method of replenishing the stored energy on the vehicle, if the method is not the same as that which provides the continuity as required by section (c) above.

Neither of the requirements of section (d) apply to existing locomotives when being hauled dead.

7.2.2

It shall be impossible for the control system (excluding WSP) to release the brakes if the system is in such a condition that there would be insufficient energy remaining to make a brake application, as required by section 6.1.

7.2.3

The control system shall be capable of initialising a brake application with a retardation equivalent at least to a full service brake application as a result of an input from safety and emergency systems such as passenger communication alarm, AWS, TPWS, DSD, Vigilance. In the case of new vehicles it shall be possible for the driver to override the signal from the passenger communication alarm so that the train can be braked to a stop at a suitable location. In the absence of a positive acknowledgement by the driver, the passenger communication alarm shall result in the initiation of a full service brake application.

7.2.4

Where continuity is not self-proving as part of the control system design, vehicles shall be provided with a means by which a brake continuity test can be undertaken in order to prove the continuity of the automatic brake when in a train formation.

7.2.5

Either a full service or emergency brake application shall automatically inhibit or interrupt traction power. It shall however be possible to apply traction power with a partial brake application in order to assist the starting of trains on gradients.

7.2.6
Except on existing vehicles not so fitted and trains that also operate through the Channel Tunnel, there shall be a system of interlocks between the traction control system and the brake control system that prevents traction power being applied:

- until sufficient energy for the automatic brake system has been proved to be available to provide at least an emergency brake application;
- until, on new vehicles, sufficient energy for the automatic brake system has been proved to be available to provide an enhanced emergency brake application if this facility is fitted.

In the case of trains that also operate through the Channel Tunnel, there shall be a system to monitor the brake system energy as an alternative to the traction interlock.

7.3 Service Brake Control

7.3.1
Drivers' brake controllers shall be provided at driving positions in accordance with GM/RT2161 and have the following features:

a) They shall enable graduated brake applications to be made between the fully released and fully applied conditions, with intermediate levels of braking available as are appropriate to the operating duty of the vehicle.

b) The normal convention adopted for vehicles operating on Railtrack controlled infrastructure is that the brake controller shall be arranged to apply the brake when the handle is moved forwards / away from the driver and release the brake when the handle is moved backwards / towards the driver.

c) Where it is preferred that the brake controller apply and release directions comply with the UIC standard directions (apply when moved backwards / towards the driver and release when moved forwards / away from the driver), the train operator shall undertake a study to identify the implications for safety of train operation which could result from the introduction of vehicles with such brake controllers. The study shall consider factors such as:

  - whether drivers will be required to work totally on vehicles of one particular type or are required to interwork with other fleets;
  - the ability to retrain existing drivers from the standard direction of control;
  - the proposed duty of the train.

7.3.2
Where there is no additional safety risk, it shall be permissible to adopt the UIC standard directions. However, where the adoption of the UIC standard directions poses an increased risk to train operation, additional safeguards shall be adopted to counteract the risk.

7.3.3
Service brake applications and releases shall only be possible from that driving position which the driver has designated as the operative driving position.

7.4 Emergency Brake Control

7.4.1
The method of control shall have a separate arrangement for demanding an emergency brake application from that for demanding a full service application. The system for the emergency application shall be as direct as possible, to eliminate as far as practicable any possible failure of this arrangement.

The stopping distance given by the emergency braking shall be equal to or less than that produced by the full service braking.

7.4.2
Normally the emergency brake control arrangement shall be operable at all times from any of the positions at which it is provided, unless there is a special arrangement by which it can be by-passed from all except that at the driving position.

7.4.3
The driver's brake controller shall be provided with an emergency brake application position beyond the full service position, where the control system enables this to be incorporated. A separate control shall be provided:

- on existing vehicles where it is not possible to incorporate an emergency brake application position as part of the service brake control;
- on new vehicles, in addition to the provision of any emergency brake application position on the brake controller.

Except for on-track machines on new vehicles the separate emergency brake control shall take the form of a plunger type control(s) as follows:

a) An emergency brake application shall be initiated by depressing the control, which shall be coloured red and remain latched in the application position until manually released.

b) It shall be possible to visually determine when the control is in the applied or released position.

In the case of on-track machines an alternative type of separate emergency brake control is permitted.

7.4.4
Where the emergency and full service brake applications rely on the venting of energy, consideration shall be given to protection from blockage of the exhaust outlets, particularly by ice or frozen snow (see Appendix E). On new vehicles the emergency and full service exhaust outlets shall be kept separate.

7.4.5
On existing vehicles with driving positions, consideration shall be given to the fitting of a separate device to enable an emergency brake application to be made. This device shall not be adversely affected by freezing weather conditions.

7.5 Isolation Devices and Drain Cocks

7.5.1
Devices incorporated into the brake system to enable particular parts to be isolated or drained shall:

a) be accessible and visible to authorised users and, in the case of isolation devices, clearly and indelibly labelled to indicate their function;

b) be located and protected to prevent, as far as is reasonably practicable, inadvertent or malicious operation;

c) in the case of pneumatic or hydraulic systems, be arranged to be open when the operating handle is in line with the pipe in which they are connected. If this is not possible there shall be a label to indicate the functional state. (Except for those drain cocks where the handle is in line with the pipe when closed);

d) where drain cocks that are in an exposed position, either be protected as required by section b) above, or have the axis of the handle arranged to be in line with the direction travel of the vehicle, so that when operated the handle is moved across the vehicle. This will reduce the risk of the handle being moved by debris during vehicle operation. In the case of new vehicles, those drain cocks on reservoirs that provide energy for the brake system shall be protected to prevent them being damaged.

7.5.2
If a dynamic brake is provided it shall be possible for this to be isolated, in a manner that does not in any way impede the operation of the emergency brake.

8 Brake Force application system

8.1
The brake force application system shall be designed to:

a) have sufficient thermal capacity and / or cooling to prevent the occurrence of unacceptably high temperatures that could adversely affect braking or the structural integrity of the braking components, taking into account any planned braking duty cycle, including drag braking;

b) accept the loads that will arise from the braking forces and from the dynamic environment associated with its particular location on the vehicle;

c) use materials that prevent the generation and emission of any products that are hazardous to health;

d) in the case of disc brakes, minimise the build up of ice by incorporating an automatic slack adjuster mechanism that maintains an appropriate clearance between the braking surface on the disc and the friction material.

8.2
For information, specifications previously used for disc brake pads and brake blocks are shown in the related documents section of this document.

9 Brake System Coupling between vehicles

9.1
Brake system couplings to provide the required continuity can be automatically or manually connected. They shall be designed to prevent inadvertent disconnection while vehicles remain connected by the normal drawgear but shall disconnect easily if vehicles separate due to the failure of the drawgear and thereby ensure that an emergency brake application results.

9.2
If the brake system couplings contain stored energy and can be manually disconnected, except on vehicles that are coupled by semi-permanent couplings, there shall be a method adjacent to the coupling of isolating the coupling from the stored energy supply. On new vehicles there shall be a means of dissipating any energy trapped in the coupling, before disconnecting.

9.3
If it is the intention to connect the end of a new vehicle directly to existing vehicles during their normal operation, and the brake system has been designed and proven to be compatible with the characteristics of the existing vehicle brake system, the inter-vehicle brake system coupling at that end shall be compatible with that of the existing vehicle.

9.4
It shall not be possible to connect the brake system couplings of vehicles whose brake systems are not compatible. It is acceptable for these vehicles to be mechanically coupled together via auto-couplers but if the brake control systems are incompatible there shall be measures to prevent their connection via the auto-coupler.

10 Parking Brake

Parking brake requirements are defined in the documents listed in section 5.1.

11 Acceptance requirements

11.1
Static and stopping distance tests, designed to prove that the vehicle or train meets the stopping distance requirements specified in the appropriate Railway Group Standard for that particular group of vehicles, shall be undertaken on the following:

- all new vehicle designs;
- existing vehicle designs that are modified such that the braking performance could be affected.

11.2
Stopping distance tests are not required in the following circumstances:

a) Each individual vehicle of a particular design does not have to be tested but there shall be sufficient tests to establish that the new design of vehicle or modified vehicle design meets the specified requirements.

b) If the brake system and brake forces of a new vehicle are very similar to an existing design and the vehicle operating weight is similar and records exist of satisfactory stopping distance tests.

c) If for modified vehicles with friction braking there is sufficient data available from stopping distance tests with other vehicles that meet the conditions listed below, to enable a calculation to be made to verify that the modified vehicle will meet the required stopping distances:

   - the same brake forces and friction materials (friction couple) were used;
   - the specific pressure at the friction couple is similar to that used on the previous vehicles;
   - the vehicle weights are similar;
   - the maximum vehicle speeds are the same.

If the maximum speed or weight of the modified vehicle is greater than the value of the existing test data, limited testing at the speeds and or weight for which there is no data shall be undertaken.

11.3
Before any operation on Railtrack controlled infrastructure, there shall be appropriate scrutiny of the design of new systems and components. In addition appropriate integrity and reliability tests shall be undertaken to ensure that any new major components, sub-assemblies or friction materials that affect braking performance will operate reliably and safely. These tests shall be undertaken on those components, sub-assemblies and friction materials (see Appendix B) that have not previously demonstrated satisfactory service experience in brake systems. The tests can be undertaken on a test rig, provided that all the forces and conditions, including climatic, that could reasonably be expected to be met in service are covered.

11.4
Before they are put into fleet-wide service all new major components or sub-assemblies that employ new principles of operation, new friction materials or complete brake systems that do not comply with section 4.1 shall be subject to and satisfactorily complete, a service trial. The trial shall normally be of 12 months duration, and shall cover representative climatic conditions and duty cycles on a sufficient number of vehicles.

11.5
If a service trial of 12 months is not considered necessary, a risk analysis shall be undertaken to determine the minimum length of the trial. A risk analysis shall also be undertaken to determine whether a component should be the subject of the procedures defined in sections 11.3 and 11.4.

11.6
The results of the stopping distance tests shall be assessed on the basis of a mean stopping distance curve derived from the individual stopping distances. The following requirements shall be met:

a) There shall be sufficient test speeds to generate a stopping distance curve, unless limited testing is being carried out as permitted by section 11.2.

b) There shall be at least two stopping distance tests at each nominal test speed.

c) The mean stopping distance curve shall normally be derived from a suitable mathematical process.

d) The mean stopping distance curve shall be less than or equal to the target stopping distance.

e) Except for test results from freight trains, it is permissible for a certain amount of the scatter in the stopping distances to exceed the maximum braking distance by a maximum of 5% of the target braking distance.

f) The total amount of scatter in the stopping distances at any speed shall not exceed ±15% of the mean stopping distance curve.

g) Stopping distances are based on the signal spacings set out in GK/RT0075. Note that in GK/RT0075 Appendices B and C signal spacings now include speeds below 40 mile/h. When assessing trains against these two Appendices, tests shall be conducted at speeds of 30, 20 and 10 mile/h to check the braking performance. For new friction couples, these low speed tests shall be used to confirm that the retardation has not significantly degraded.

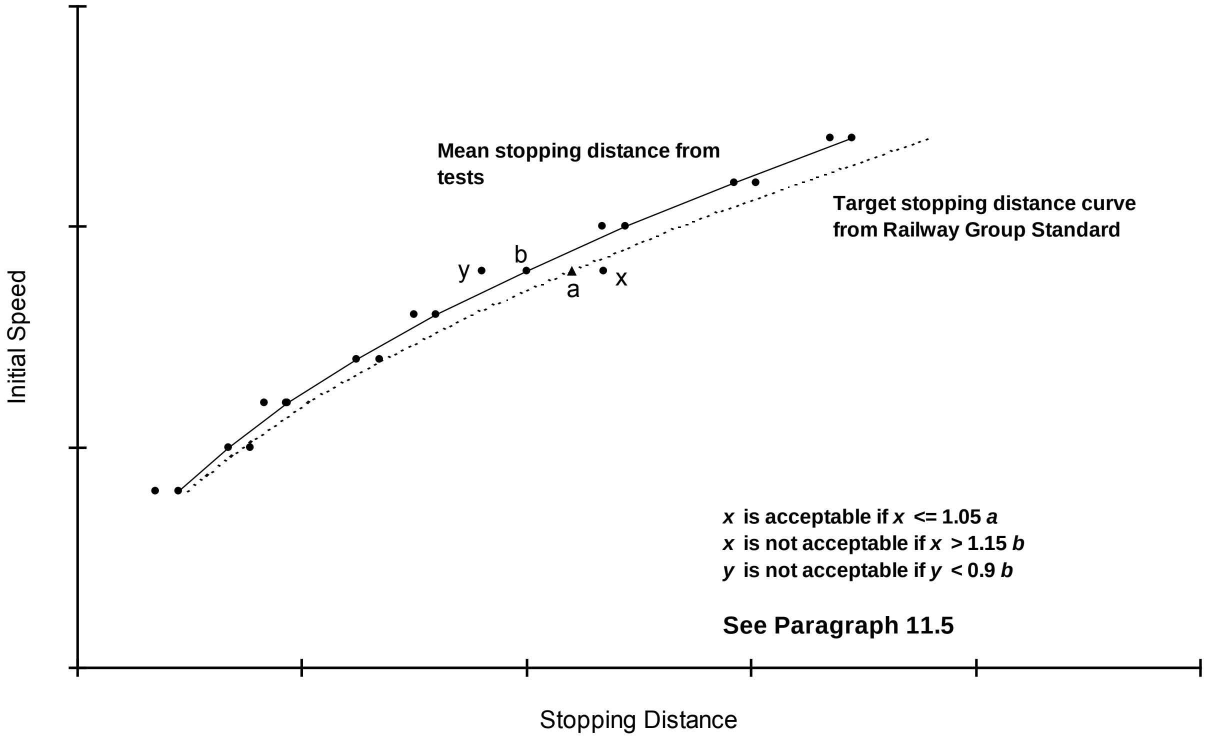
See Appendix ‘A’ for an illustration of test results.

11.7
On new trains that have WSP equipment and use compressed air for the brake system energy, a test shall be undertaken to simulate WSP activity by creating a large air flow rate in the brake system. Appendix D gives guidance on the air flow rate to be achieved and the duration of the test. At the end of the test the pressure in the brake supply reservoir shall be sufficient to provide a full service brake application. Consideration of requirements for sufficient brake system energy shall also be undertaken when alternative energy systems are used within the brake system.

Appendix A

This Appendix is for information only

Assessment of stopping distance test results



Note: acceptability of a, b, x and y comparisons are to be performed using distance and not speed measurements.

Appendix B

This Appendix is for information only

Dynamometer testing of friction materials

B.1
To meet the requirements of section 11.2, dynamometer tests should be carried out using a full scale dynamometer and a friction face equivalent to that which the friction material will act upon. The following minimum requirements should be included:

B.2
The dynamometer should simulate the axleload to be used in service up to and including the maximum. The axleload shall be proportioned to that shared by the friction material position subject to test.

B.3
The braking force on the friction material should be equivalent to that obtained in full service braking and within 10% of the calculated value for the appropriate axleload. The area of the friction material should be the same as that used the application on the vehicle.

B.4
Dynamometer tests should be carried out simulating brake stops from a range of speeds up to and including the maximum vehicle speed. The tests should simulate the tare and fully laden conditions of the vehicle or braking duties.

B.5
The following measurements should be recorded:

- *Initial speed;*
- *Force on friction material;*
- *Stopping distance;*
- *Stopping time;*
- *Initial friction face temperature;*
- *Maximum friction face temperature achieved during braking;*
- *Average friction coefficient;*
- *Instantaneous friction coefficient as a function of speed.*

B.6
A brake fade sequence should be carried out which will include 4 stops from the maximum speed axleload and full service braking force.

B.7
A drag brake sequence should be carried out at 47 mile/h for 20 minutes against 20kW for friction materials to be used for passenger applications or 40kW for freight applications. If the braking cycle is predicted to be worse than these values an alternative figure appropriate to the new cycle should be used.

B.8
A wet test should be carried out simulating the minimum and maximum braking forces at the equivalent axleloads. This should use a water spray delivering at least 25 litres / hour on to the friction surface for disc pad tests and 14 litres / hour for tests of brake blocks.

B.9
The designation of the friction material tested should be recorded and the design, method of manufacture and principal constituents should not be changed without changing the designation of the material. In this case the new material should be subject to retesting.

B.10
The result of the dynamometer tests should be assessed to ensure the friction material meets the requirements of section 8.1 of the document.

Appendix C

This Appendix is for information only

Principles of operation of current friction Brake Systems in use on Railtrack controlled infrastructure

1 Automatic air-brake (single or two pipe)

C.1.1
Each vehicle has a distributor or triple valve (existing fleets only), air operated brake cylinders and an auxiliary reservoir (AR) and is connected by an automatic air-brake pipe (ABP) charged to 5 bar, which is continuous throughout the train. The distributor is connected to the ABP and responds to variations in brake pipe pressure to pass compressed air from the AR to the brake cylinders or vent the air from the brake cylinders. A second pipe, the main reservoir pipe (MRP), normally charged to 7 bar, can be used to charge the AR directly but not when a triple valve is used, to form the two pipe system. Failure of the MRP does not affect the automatic air-brake pipe and the system reverts to single pipe operation.

C.1.2
An initial reduction of the pressure in the ABP sensed by the distributor is necessary to generate an application of the brake on each vehicle. The amount of application is proportional to the reduction in the ABP pressure and the brake is released by recharging the ABP pressure. A reduction of 1.5 bar in the ABP pressure is required to produce a full service brake application and the ABP pressure reduction occurs in 5-8 seconds. In an emergency brake application the ABP pressure falls to zero.

C.1.3
The reduction or increase in the ABP pressure can be achieved by means of an air-brake valve at the driving position or by a control at the driving position which is connected electrically or pneumatically to devices remote from the driving position which regulate ABP pressure in response to the electrical signals.

C.1.4
The continuous and automatic element is given by the inter-vehicle connections of the automatic air-brake pipe. If these are broken, the loss of air pressure results in an automatic brake Application on both parts of the train. The coupling heads comply with the following:

Pipe	*Colour*	*Bore*	*Specification*
ABP	*Red*	*25.4 mm*	*BS 3710 Fig 5 Type b not fitted with valve or UIC Leaflet 541-1 Appendix 4.*
MRP	*Yellow*	*19 mm*	*BS 3710 Fig 4 Type a, 19 mm fitted with valve to suit 28.5 mm hose.*

C.1.5
Brake Force Build Up and Release Times Currently in Use
To take account of the different coupling characteristics and operating speeds of freight and passenger trains, different brake force application and release times are used. For the automatic air-brake system, the following times have been adopted for an individual vehicle. These times are related to an emergency brake application, with its very rapid reduction in ABP pressure in order that they are not influenced by the rate of fall of the air-brake pipe pressure in a full service brake application:

Brake Timing Type	*Application Time for Brake Cylinder Pressure to Reach 95% of Maximum (Seconds)*		*Release Time for Brake Cylinder Pressure to Fall from Maximum to 0.4 bar (Seconds)*	
	Single Pipe System	*Two Pipe System*	*Single Pipe System*	*Two Pipe System*
PASSENGER	*3 – 5*	*2 – 3*	*15 - 20 ***	*15 - 20 **
GOODS	*18 – 30 **	*9 - 15 **	*30 - 45*	*30 - 45*

Note that for traction units:
** these times are 20 - 28 seconds, ** these times are 9 - 12 seconds.*

2 Automatic air-brake with electro-pneumatic (EP) assist

C.2.1
The arrangement is as for section 1.1 but in addition to the continuous ABP, there are train wires connecting EP valves on each vehicle. When the driver operates the air-brake controller, the train wires are arranged to carry an electrical signal to the EP valves which locally vary the brake pipe pressure simultaneously on each vehicle, on the basis of either an energise to apply or release principle.

C.2.2
The continuous and automatic element is given by the inter-vehicle connections of the automatic air-brake pipe.

The brake force build up time is 4 - 5 secs and release time is 5 - 6 secs.

3 Automatic air-brake and electro-pneumatic (EP) control

C.3.1
As for section 1.1 with regard to the vehicle mounted compressed air-brake equipment but there is an additional EP system with train wires that carry an electrical signal to EP valves on each vehicle, which control the application of the brakes by admitting air from the main reservoir pipe to the brake cylinders, on the basis of energise to apply. The release of the brakes is obtained by venting the brake cylinders. Under normal operation, the brake pipe is not used to control the brake but can be used if the EP control fails.

C3.2
As the EP system in 3.1 is not fail-safe, the continuous and automatic element is given by the inter-vehicle connections of the air-brake pipe.

The brake force build up time is 4 - 6 secs.

4 Air-brake with electro-pneumatic (EP) control

C.4.1
Each vehicle has air operated brake cylinders, together with a reservoir for the storage of compressed air and is connected by a main reservoir pipe (MRP) that supplies compressed air to each vehicle. A train wire is arranged to carry the electrical supply to the drivers brake controller from the rear of the train, thereby ensuring electrical continuity throughout the train is proven. Electrical signals from the drivers brake controller are then carried down train wires to the EP valves on each vehicle that control the release and application of the brakes, on the basis of the energise to release principle.

C.4.2
The continuous and automatic element is given by the inter-vehicle connections of the train wires. If the continuity in the train wires is interrupted and therefore the electrical supply to the brake controller and thus to the EP valves is lost, the brakes automatically apply.

The brake force build up time is 2 - 3 secs and release time is 3 - 6 secs.

5 Direct air-brake

C.5.1
Provides an additional brake, independent of the automatic train brake on traction units, using compressed air controlled separately from the automatic brake system, that is fed directly to the air-brake cylinders on the vehicle.

C.5.2
This brake is not fail-safe (because when running as a single vehicle there is no requirement for a continuous or automatic element) but the control system shall be as direct as possible.

C.5.3
Direct Air-Brake, brake force Build Up and Release Times Currently in Use

Application Time for Brake Cylinder Pressure to Reach 95% of Maximum (Seconds)	*Release Time for Brake Cylinder Pressure to Fall from Maximum to 0.4 bar (Seconds)*
2.5 – 4	*7*

6 Automatic vacuum brake (for existing fleets only)

C.6.1
A vacuum brake pipe, continuous throughout the train, connects all the vehicles that have vacuum brake cylinders. The vacuum regime releases the brake and also creates vacuum on both sides of the piston in the cylinder, one side acting as a reservoir and providing brake power when vacuum is reduced in the brake pipe. A brake valve is provided to control the admission of atmospheric air to the vacuum brake pipe and the underside of the piston in the vacuum cylinder. The extent to which the level of the vacuum is reduced determines the level of the brake application.

C.6.2
The transmission of the signal down the vacuum train pipe can be improved by means of a direct admission (DA) valve or accelerated freight inshot valve (AFI) at each brake cylinder.

C.6.3
The continuous and automatic element is provided by the vacuum brake pipe as admission of atmospheric air automatically results in a brake application.

Appendix D

This Appendix is for information only

Guidance on the Brake System energy requirements to take account of WSP activity

D.1
WSP activity will increase the energy used by the brake system although the amount of additional energy will depend on the value and extent of the low adhesion and the effectiveness of the WSP system.

D.2
In the case of a compressed air system, the ability of the system to provide sufficient air will depend on:

- *the compressor delivery capacity and reservoir volume;*
- *the ability of the system pipework and valves to deliver the required flow rates to all the vehicles;*
- *the effectiveness of the WSP system.*

D.3
Experience indicates that a flow rate of approximately 600 litres / min / vehicle is required. This air consumption needs to be sustained for the length of time that would be required to stop the vehicle in low adhesion conditions. This will depend on the vehicle maximum speed and adhesion available.

D.4
Based on adhesion surveys, a reasonable value likely to be present over the entire duration of a stop would be one that gave a mean retardation of 4.5%g. Using the vehicle maximum speed and this retardation, it is possible to calculate the time taken for the stop and therefore the time over which the air should be delivered. For vehicles with a maximum speed of 100 mile/h this equates to 100 secs.

D.5
Air delivery less than 600 litres / min can be accepted if it can be demonstrated that the WSP system on the train is such that the air consumption requirements of the WSP under low adhesion conditions is less than this value.

D.6
The following test will enable a check to be made on the ability of the brake system to provide sufficient energy. To create the air flow defined in section D5, the air pipes to sufficient brake cylinders should be disconnected on each vehicle and a full service brake application made which will then result in high air consumption. By monitoring the time that the compressor runs and its rated delivery capacity the air consumption can be established. The air pressure on which the delivery rate of the compressor is established should be the mid point between the governor settings.

D.7
At the end of the period of time calculated by the method described in section D4, the pressure in the reservoir on each vehicle should be sufficient to provide a full service brake application.

Appendix E

This Appendix is for information only

Factors to be taken into account when considering the protection of driver's brake valve exhaust outlets

E.1
If there has been an incident on a vehicle when ice and / or snow blocked the vent pipes that exhaust compressed air from the driver's brake valve and prevented a brake application being made.

E.2
For particular vehicles the following should also be considered:

a) Is the current location of the vent pipe vulnerable to the build up of ice and snow?

b) Is the vehicle likely to be involved in snowploughing which could increase the possibility of ice and snow build up round the vent pipe orifice?

c) Does the vehicle operate in areas where there is experience of heavy snowfalls combined with periods of low temperatures (less than -15°C)?

d) Has there been any experience of vent pipes being blocked on the vehicle concerned in the current area of operation of the vehicle?

E.3
If the result of the above analysis reveals that there is an unacceptable risk of the vent pipe being blocked by the build up of ice or snow, arrangements should be made to protect the vent pipes from being blocked.

References

Railway Group Standards

RGSC 01 The Railway Group Standards Code
RGSC 02 The Standards Manual

GK/RT0075 Lineside Signal Spacing and Speed Signage

GM/RT2041 Braking System Requirements and Performance for Trailer Coaching Stock

GM/RT2042 Braking System Requirements and Performance for Traction Units

GM/RT2043 Braking System and Performance for Freight Trains

GM/RT2044 Braking System Requirements and Performance for Multiple Units

GM/RT2046 Braking System Requirements and Performance for Trains Which Operate Above125 mile/h

GM/RT2161 Requirements for Driving Cabs of Railway Vehicles

GM/RT2400 Design of On-Track Machines

GE/RT8000 Rule Book

The Catalogue of Railway Group Standards and the Railway Group Standards DVD give the current issue number and status of documents published by RSSB. This information is also available from www.rgsonline.co.uk.

Related Documents

BR Specification 569 and UIC Leaflet 541-3 define acceptance requirements for disc brake composition brake pads.

For tread brakes, the following specifications define the requirements for brake blocks

TL/TS0150 Cast iron brake blocks (supersedes BR 142);
BR 567 High friction composition 'K' blocks;
BR 574 Low friction 'L' composition blocks;
UIC 541-1 Regulations concerning the construction of various brake components.
Railway Safety (Miscellaneous Provisions) Regulations 1997 (see Regulation 6)