Braking System and Performance for Freight Trains

Synopsis
This Standard defines the performance requirements of the braking systems of freight trains together with the principal features that shall be incorporated to enable safe operation and interworking to take place.

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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# Railways Group Standard

## GM/RT2043

### Issue Two

**Date:** June 2011

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RSSB 1
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Part A

Issue record
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<td>- Include new clause 5.3.0, new Appendix D and Appendix E</td>
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<td>- Amend all clauses that previously referenced GM/TT0168 to reference GM/RT2045.</td>
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Authorisation
The content of this document was approved by Rolling Stock Standards Committee on 18 March 2011.

This document was authorised by RSSB on 03 May 2011.

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

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Part B

1 Purpose
To define the performance requirements and principles of operation of the braking systems of freight vehicles, to enable safe operation and interworking to take place.

2 Scope
The requirements of this standard apply to all freight vehicles and on-track machines when in train formation, with a maximum operating speed of up to 75 mile/h (120 km/h) whilst running on Railtrack controlled infrastructure, except for vehicles registered for and working in international traffic under RIV regulations. Vehicles with an operating speed above 75 mile/h (120 km/h) will be covered by a later edition of this standard.

3 Definitions
The following definitions are included in Railway Group Standard GM/RT2045:

- Brake Force
- Brake Force Build Up Time
- Brake System
- Brake System Couplings
- Compatible Brake Systems
- Drag Braking
- Emergency Brake Application
- New Vehicle
- Full Service Brake Application

Brake Van
A vehicle designed to provide accommodation for the guard on freight trains.

Fade
See GM/RT2042 for this definition.

Freight Vehicles
Vehicles that are not passenger nor non-passenger carrying trailer coaching stock, nor part of passenger carrying multiple units.

Infrastructure manager
Elsewhere in this document, the term ‘infrastructure controller’ is used. The term ‘infrastructure controller’ should be interpreted as meaning an infrastructure manager responsible for infrastructure other than a station.

Multiple Unit
See GM/RT2044 for this definition.

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

Non-passenger Carrying Coaching Stock (NPCCS)
See GM/RT2041 for this definition.

Slip Coupling Test
A test to determine the stopping distance of an individual vehicle, by releasing the drawgear between the vehicle and the test train and initiating
Braking System and Performance for Freight Trains

an Emergency brake application only on the vehicle under test, so that it is brought to a standstill by the power brake of that vehicle.

Trailer Coaching Stock
See GM/RT2041 for this definition.

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

4 Brake system - general

5 Performance 5.1 Introduction

5.1.1 The principal requirement defined in this Standard for the braking performance of freight vehicles is that the maximum permissible stopping distance of trains containing freight vehicles shall not exceed the distances defined in the Standard.

5.1.2 However, because the Engineering Acceptance of freight vehicles is normally based on the results obtained from a prototype vehicle, this Standard defines the maximum permissible stopping distances for individual vehicles. This Standard also defines the maximum permitted length of trains composed of vehicles that meet these distances. See Paragraph 5.2.3.

5.1.3 This Standard also draws attention to the extension of stopping distance that results from the increase in train length. It defines the required shorter stopping distances for new individual vehicles that will ensure that very long trains composed of those vehicles will meet the stopping distance requirements defined in this Standard. The justification is given in Appendix C.

5.1.4 There are particular problems associated with the braking of the short formations of multiple units and because of this the freight trains that are formed by multiple units are required to meet the performance requirements defined in GM/RT2044.

5.1.5 In summary this Standard covers the following braking performance requirements:

a) it defines the maximum permissible stopping distance requirements for trains containing freight vehicles;

b) it defines the maximum permissible stopping distances for individual vehicles that will enable them to achieve Engineering Acceptance (see GM/RT2000);

c) it defines the maximum permitted length of trains composed of vehicles that meet the stopping distances referred to in b) above;

d) it defines the shorter stopping distances required to be met by individual vehicles that are to be operated in long trains with brakes in passenger timing;
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e) it requires freight trains formed by multiple units to meet certain requirements defined in GM/RT2044.

5.1.6 As stated in Paragraph 5.1.5 b) & d), information is given on the maximum permissible stopping distances of individual vehicles. However, it is emphasised that the principal requirement contained in this Standard is that given for the stopping distance of trains containing freight vehicles. The responsibility for ensuring that trains containing freight vehicles and especially long trains can meet this requirement, rests with the Train Operator.

5.2 Braking performance - trains that are not multiple units

5.2.1 The braking performance defined in this Standard shall be achieved by trains which include freight vehicles when operating at permissible line speed on level track with normal levels of adhesion available. See GM/RT2045 for an explanation of normal levels of adhesion.

5.2.2 The stopping distances of trains containing freight vehicles that are required to operate over routes signalled in accordance with Appendix 1 of GK/RT0034 shall not exceed those defined by Curve V of Figure 1. The stopping distances shall be achieved with a Full Service brake application.

5.2.3 Trains that consist entirely of vehicles that meet the stopping distance defined in Paragraph 5.3.1 are permitted to be operated up to the following lengths and speeds:

750 m and operating up to 60 mile/h (96 km/h) with brakes in goods timing;
690 m and operating up to 75 mile/h (120 km/h) with brakes in passenger timing.

Trains longer than 690m with brakes in passenger timing can be operated if it can be demonstrated that the train meets the stopping distances defined in Paragraph 5.2.2.

5.3 Braking performance - individual vehicles not part of multiple units

5.3.0 The validation of the braking performance of an individual vehicle shall be by one of the following methods:

a) a slip coupling test.
b) calculated stopping distances based on brake performance tests carried out in freight train formations with the hauling locomotive unbraked. The requirements associated with this method are set out in Appendix D.
c) calculated stopping distances based on brake performance tests carried out in freight train formations with the hauling locomotive braked. The requirements associated with this method are set out in Appendix E.

5.3.1 To enable the Engineering Acceptance of vehicles to be undertaken, the stopping distance derived from a slip coupling test of an individual vehicle 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 not exceed 951 metres.
Braking System and Performance for Freight Trains

5.3.2 For new freight vehicles that are to be operated at 75 mile/h (120 km/h) in trains from 690m up to 750m in length with brakes in passenger timing, the stopping distance derived from the slip coupling test shall not exceed 890m.

See Appendix C for the justification of the shorter stopping distance to be achieved by new wagons that are to be operated up to 75 mile/h (120 km/h) in trains that are between 690m and 750m in length and have brakes in passenger timing.

5.4 Braking performance - trains that are multiple units
Freight trains formed by multiple units shall comply with the performance requirements defined in Paragraphs 5.1.1 to 5.1.4 of GM/RT2044.

5.5 Conditions relevant to performance requirements
The performance defined in Paragraphs 5.2.2, 5.3.1 and 5.3.2 shall be:

a) in the case of Paragraphs 5.3.1 and 5.3.2, the stopping distance achieved by an individual vehicle during a slip coupling test, which therefore represents an Emergency Application;

b) inclusive of any brake force build up time, which itself shall be appropriate for the maximum speed of the vehicle and compatible with any vehicles to which it is intended to couple to and be designed to limit the generation of longitudinal shocks in the train during braking. See Appendix C of GM/RT2045;

c) achieved in the tare and any loading condition up to and including the maximum permitted for the vehicle. See also Paragraphs 7.1.1 and 11.2;

d) inclusive of appropriate allowances for:

- any fade associated with the increase in temperature of a friction material that may arise during any brake application, including drag braking;
- tolerances on equipment settings;
- any degradation in braking performance between maintenance.

5.6 A guide to the interpretation of Figure 1 is given in Appendix ‘B’.

5.7 A brake force, that enables the braking performance of all vehicles to be compared on the same basis, shall be calculated for inclusion in the Rolling Stock Library, in accordance with GM/RT2040.

6 Brake system energy
The brake system energy shall comply with the requirements of GM/RT2045.

7 Control system
7.1 The brake control system shall comply with the requirements of GM/RT2045, together with the following additional features:

7.1.1 If it is necessary to fit a device that has only two values of brake force for the tare and loaded conditions respectively, to satisfy the requirements of Paragraph 5.5.c) by varying the brake force, and the vehicle is designed to carry varying loads, the stopping distances shall be checked in accordance with Paragraph 11.2.
7.1.2 Vehicles that have an operating speed above 60 mile/h (96 km/h) shall be fitted with a device that enables the brake force application and release timing to be changed. See Appendix C in GM/RT2045.

7.1.3 Vehicles that normally only run in fixed train formations composed of vehicles of all the same type need not comply with the requirements of Paragraph 7.1.2.

7.1.4 For vehicles that are part of a multiple unit the control system shall also comply with the requirements of Paragraphs 7.1.2 to 7.1.6 of GM/RT2044.

8 Brake force application system

The brake force application system shall comply with the requirements of GM/RT2045.

9 Braking system coupling between vehicles

The coupling system shall comply with the requirements of GM/RT2045.

10 Parking brake

10.1 Except for vehicles that are semi-permanently coupled by couplings that are not normally released by operating staff, each vehicle shall be fitted with a parking brake. In the case of semi-permanently coupled vehicles, sufficient parking brakes shall be fitted to enable the coupled vehicles to comply with the requirements of paragraph 10.2. Each parking brake that is fitted shall be able to be applied and released from either side of the outside of the vehicle.

10.1.1 On brake vans, the parking brake control may be situated inside the vehicle.

10.2 The performance of the parking brake shall be such that it is capable of holding a fully laden vehicle stationary on a gradient of 1 in 40, when a level of wheel/rail adhesion of 0.1 is available. In the case of the semi-permanently coupled vehicles referred to in paragraph 10.1, the vehicle(s) with the handbrake shall be capable of holding stationary all the vehicles that are semi-permanently coupled together.

10.3 On new vehicles there shall be an indicator to show whether the parking brake is applied or released.

11 Acceptance tests

11.1 Acceptance tests shall be undertaken as defined by the requirements of section 11 of GM/RT2045 together with the following:

11.2 Vehicles that are defined in Paragraph 7.1.1, shall have their stopping distances checked at the maximum condition of load that still retains the brake force for the tare condition, to check that the stopping distance requirements are met in this particular loaded condition.
Figure 1 Stopping Distance Curve - Maximum Speed 75 mile/h (120 km/h). Braking performance for trains required to operate over routes signalled in accordance with Appendix 1 of GK/RT0034.

<table>
<thead>
<tr>
<th>INITIAL SPEED (mile/h)</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
<th>55</th>
<th>60</th>
<th>65</th>
<th>70</th>
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<tr>
<td>DISTANCE (metres) (Curve V)</td>
<td>195</td>
<td>281</td>
<td>401</td>
<td>532</td>
<td>669</td>
<td>829</td>
<td>916</td>
<td>990</td>
<td>1058</td>
<td>1116</td>
<td>1218</td>
<td>1258</td>
</tr>
<tr>
<td>DISTANCE (metres) (Curve B)</td>
<td>77</td>
<td>110</td>
<td>155</td>
<td>208</td>
<td>262</td>
<td>324</td>
<td>358</td>
<td>387</td>
<td>413</td>
<td>436</td>
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The Curve 'V' is defined by the signal spacing distances given for level track in Appendix 1 of GK/RT0034. The stopping distances on level track of Curve 'B' are derived from the signal spacing distance of Curve 'V' as follows:

\[ Curve\ 'B' = \frac{V}{2.56} \]

See Appendix A for the derivation of the factor used above.
Appendix A

Recommended minimum braking distances in Figure 1

It is recommended that in order to reduce the possibility of wheelslide that the minimum stopping distance of individual vehicles should not be less than that defined by Curve 'B' of Figure 1.

The factor of 2.56 used to derive Curve ‘B’ results in a stopping distance that represents the maximum retardation which it is considered desirable not to exceed, in order to reduce the possibility of wheelslide.
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Appendix B

Interpretation of Figure 1 For braking performance

B.1 The performance curve of Figure 1 defines the maximum permissible stopping distances for freight trains required to run at maximum line speed on lines that have the minimum signal spacing distances defined in Appendix 1 of the signal spacing standard, GK/RT0034. Trains that do not meet the stopping distances defined in Figure 1 may still run on routes signalled in accordance with the signal spacing distances of Appendix 1 if:

1) The maximum speed is reduced to a value that gives a stopping distance that complies with the requirements of Paragraph 5.2 or 5.4.

or

2) Examination shows that the signal spacing distance is greater than the permitted minimum. The actual maximum speed will depend on the actual signal spacing distance.

If freight trains are required to operate on routes that are signalled in accordance with Appendices of GK/RT0034 other than Appendix 1, the permissible differential train speed shall be determined from the signal spacing available on that route.

B.2 If trains exceed the braking performance required for the maximum line speed and signal spacing distance on a route, it may be possible for these trains to run at a higher speed on that route, in so far as braking performance is concerned, where permitted by the infrastructure controller.

B.3 When checking the performance of vehicles it is important that due consideration is taken of the aspects defined in paragraphs 5.5 b) and d) and where appropriate the values are measured.

B.4 A vehicle which is in an optimum state in terms of the condition of the brake equipment and tolerances on equipment settings but only just meets the required stopping distances, may not meet these requirements when changes take place.

Factors that need to be taken into account are a general deterioration of the brake equipment, or settings that drift to a less favourable value in the tolerance range or the bedding in of discs/pads.

Such a vehicle may need further assessment by the train operator, according to the intended operating conditions, to ensure that the vehicle still meets the stopping distance requirements, with the brake equipment in its changed condition. A note to this effect should be included on any Certificate of Conformance issued.
Appendix C

Guidance on the derivation of the stopping distance of new individual vehicles in long trains

C.1 For trains with an automatic air brake, the brake application is proportional to the reduction in air pressure in the brake pipe. As train length increases it takes an increasing time for the pressure in the entire length of the brake pipe to fall to the required value.

C.2 The time taken for the reduction in pressure to propagate completely down a train fitted with the automatic air brake can have the effect of extending the stopping distance of the train formation beyond that of the stopping distance of an individual vehicle. The increase in the stopping distance will depend on a number of factors such as train length and brake force build up time. In general, the longer the train and shorter the brake force build up time, the more marked will be the effect of train length on stopping distance.

C.3 To compensate for the delay in the application of the brake down the train, more powerful brakes are required on those vehicles that have brakes with short brake application times and are to be operated in long trains. Because of the delay in the application of the brake, it has a shorter time and distance over which to stop the train. A higher retardation and therefore brake force is required and hence results in a shorter stopping distance of the individual vehicle.

C.4 Investigations have been undertaken using equipment that replicates the pneumatic system of a train to determine the effect of train length on braking distance. To ensure that freight trains operating at 75 mile/h (120 km/h) and up to 750m in length with brakes in passenger timing will meet the stopping distance requirements defined in Paragraph 5.2.2, the stopping distances of an individual vehicle needs to be that defined in Paragraph 5.3.2.
Determination of the braking performance of new vehicles using an unbraked locomotive

D.1 Slip coupling tests have traditionally been used to determine the braking performance of individual freight vehicles. Whilst this approach is appropriate for simple vehicles, it is considered to be less suitable for the testing of more complex freight vehicles for example on-track machines that are locomotive hauled between worksites.

D.2 The alternative permissible strategy set out in this Appendix involves undertaking brake performance testing of the vehicle(s) (the ‘consist’) to be assessed within a freight train formation with the hauling locomotive attached. This method is derived from that described in UIC 544-1 to assess simple freight wagons when they are coupled to form a rake of identical wagons. The consist under assessment shall be at least twice the mass of the locomotive to ensure that the testing method is valid.

D.3 The locomotive used for the testing shall be equipped with both an automatic air brake and an independent brake, as set out in GM/RT2045 Appendix C. During the brake tests the automatic air brake on the locomotive shall be isolated. In the event of an emergency, the driver shall still be able to use the independent brake to apply the brakes on the locomotive.

D.4 Stopping distance brake tests shall be carried out with the consist being assessed on its own or in the train formations that are intended to be used on the network. Level track stopping distance brake tests shall be undertaken from a range of operating speeds from 20 mile/h (32 km/h) up to the maximum service speed of the formation using full service brake applications with the air brake distributor on the locomotive isolated.

D.5 Vehicles that operate in different loading conditions shall have the brake tests carried out in both tare and laden conditions. On those vehicles not fitted with load compensating brake equipment, the tare tests shall be at the maximum load before changing from tare to laden.

D.6 The braking performance shall be assessed on the basis of a mean level track stopping distance curve derived from the individual brake stopping distances. The mean level track stopping distance curve shall be determined as set out in GM/RT2045 clause 11.6.

D.7 If the consist under assessment only operates in the formations used for the brake tests, then compliance with the brake performance requirements is demonstrated by the level track stopping distances for the test train. The level track stopping distances for the consist under assessment and the unbraked locomotive shall not exceed those set out by Curve V in Figure 1.

D.8 Where the requirements of D.7 are not demonstrated or if the consist under assessment operates in different freight train formations, then the consist’s contribution to the overall brake performance shall be determined. This shall be demonstrated by calculating the equivalent stopping distance for the consist if it were operating on its own.
D.9 For the purpose of determining the brake performance of the consist under assessment, the level track stopping distance measured during the brake tests shall be expressed as:

\[ S_{DT} = D_{FR} + B_{DT} \]

Where:
- \( D_{FR} \) = Free run distance
- \( B_{DT} \) = Braking distance
- \( S_{DT} \) = Level track stopping distance from brake entry speed \( V \) (m/s)
- \( D_{FR} = \frac{1}{2} V \times \) average brake cylinder fill time of the consist

\[ B_{DT} = \frac{V^2}{2A_T} \]

Where:
- \( V \) = Brake entry speed (m/s)
- \( A_T \) = Test train deceleration

\[ B_{DT} = S_{DT} - D_{FR} \]

The test train deceleration shall be expressed as:

\[ A_T = \frac{F_T}{M_T} \]

If the consist is operating without the unbraked locomotive, the deceleration of the consist \( (A_C) \) shall be increased by the ratio:

\[ A_C = \frac{A_T \times M_T}{M_C} \]

Where:
- \( F_T \) = Test train brake retarding force
- \( M_T \) = Mass of test train
- \( M_C \) = Mass of test consist

Note: The mass of test train \( (M_T) \) is the mass of test consist \( (M_C) \) plus the mass of the unbraked locomotive.

The braking distance of the consist under test without the unbraked locomotive is shorter and shall be calculated as:

\[ B_{DC} = \frac{M_C}{M_T} \times B_{DT} \]

Thus the equivalent level track stopping distance for the consist under test \( (S_{DC}) \) on its own shall be calculated as:

\[ S_{DC} = D_{FR} + B_{DC} \]

Where:
- \( D_{FR} \) = Free run distance
- \( B_{DC} \) = Braking distance

\[ S_{DC} = D_{FR} + \left( \frac{M_C}{M_T} \times B_{DT} \right) \]

Substituting for \( B_{DT} \) gives:

\[ S_{DC} = D_{FR} + \left( \frac{M_C}{M_T} \times (S_{DT} - D_{FR}) \right) \]
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D.10 The calculated level track stopping distance for the consist on its own shall include determining the stopping distance from 60 mile/h (96 km/h) in goods timings and from 75 mile/h (120 km/h) in passenger timings for those consists capable of operating at the higher speed. The calculated level track stopping distance shall be used to demonstrate compliance against the performance requirements set out in 5.3.1 and 5.3.2.

D.11 The test method set out in this Appendix shall be used to demonstrate the overall braking performance of the consist for the freight train formation with the hauling locomotive attached. Where consists have different vehicles, for example on-track machines, the brake force values required for the Rolling Stock Library for the individual vehicles shall be determined by calculation. The requirements for the calculation of the brake force values are set out in GM/RT2040.
Appendix E

Determination of the braking performance of new vehicles using a braked locomotive

E.1 Slip coupling tests have traditionally been used to determine the braking performance of individual freight vehicles. Whilst this approach is appropriate for simple vehicles it is considered to be less suitable for the testing of more complex freight vehicles for example on-track machines that are locomotive hauled between worksites.

E.2 The alternative permissible strategy set out in this Appendix involves undertaking brake performance testing of the vehicle(s) to be assessed as a freight train with the hauling locomotive attached. This method is different from that described in Appendix D in that during the testing the locomotive brakes remain operational. The vehicles (the 'consist') under assessment shall be at least 25% of the train mass (including the locomotive and any support vehicles) to ensure that the testing method is valid.

E.3 Two sets of testing shall be carried out to produce level track stopping distance data to determine the brake performance of the consist under assessment. The test train formations shall be:

- The test locomotive, any support vehicles and the consist under assessment.
- The same test locomotive and support vehicles without the consist under assessment.

E.4 Level track stopping distance brake tests shall be undertaken for the two test train formations from a range of operating speeds from 20 mile/h (32 km/h) up to the maximum service speed of the consist under assessment. The tests shall be carried out using full service brake applications with the brakes operational on all the vehicles and the distributors set to passenger timings.

E.5 Where the vehicles in the consist under assessment operate in different loading conditions the brake tests shall be carried out in both tare and laden conditions. On those vehicles not fitted with load compensating brake equipment the tare tests shall be at the maximum load before changing from tare to laden.

E.6 The braking performance shall be assessed on the basis of a mean level track stopping distance curve derived from the individual brake stopping distances. The mean level track stopping distance curve shall be determined as set out in GMRT2045O clause 11.6.

E.7 Using a suitable mathematical process (the 'Trendline' polynomial function in Microsoft Excel being one such process), a best fit equation shall be determined for each test train formation which then enables the level track stopping distance to be calculated for any given speed. For a series of nominal braking entry speeds (as a minimum 20 mile/h (32 km/h), 40 mile/h (64 km/h), 60 mile/h (96 km/h) and 75 mile/h (120 km/h)), up to the maximum service speed of the consist under assessment, the corresponding level track stopping distances shall be determined for each the two test train formations.
Braking System and Performance for Freight Trains

E.8 For the purpose of determining the brake performance of the consist under assessment, the level track stopping distance measured during the brake tests with the test train of locomotive, support vehicles and consist stopping distance and braking distance shall be expressed as:

\[ SD_T = DF_{RT} + BD_T \]
\[ BD_T = SD_T - DF_{RT} \]

Where:
- \( SD_T \) = Level track stopping distance from brake entry speed \( V \) (m/s)
- \( DF_{RT} \) = Free run distance
- \( BD_T \) = Braking distance

\[ DF_{RT} = \frac{1}{2} V \times \text{average test train brake cylinder fill time} \]

\[ BD_T = \frac{V^2}{2A_T} \]

rearranging gives \( A_T = \frac{V^2}{2 BD_T} \)
Also \( A_T = \frac{F_T}{M_T} \)

Similarly the level track stopping distance measured during the brake tests with the locomotive and support vehicles shall be expressed as:

\[ SD_L = DF_{RL} + BD_L \]
\[ BD_L = SD_L - DF_{RL} \]

Where:
- \( SD_L \) = Level track stopping distance from brake entry speed \( V \) (m/s)
- \( DF_{RL} \) = Free run distance
- \( BD_L \) = Braking distance

Loco and \( L \) includes any support vehicles

\[ DF_{RL} = \frac{1}{2} V \times \text{loco brake cylinder fill time} \]

\[ BD_L = \frac{V^2}{2A_L} \]

rearranging gives \( A_L = \frac{V^2}{2 BD_L} \)
Also \( A_L = \frac{F_L}{M_L} \)

Where:
- \( F_L \) = Locomotive brake retarding force
- \( M_L \) = Mass of locomotive

Assuming the brake forces generated by the vehicles are independent of train formation, then for any brake entry speed the brake retarding force for the consist \( (F_C) \) shall be expressed as:

\[ F_C = F_T - F_L \]
\[ F_C = MC \times AC = (MT \times AT) - (ML \times AL) \]

Where:
- \( MC \) = Mass of test consist
- \( AC \) = Consist deceleration
Substituting for $A_L$ and $A_T$:

$$F_C = M_C \times A_C = \left( \frac{M_T V^2}{2 BD_T} \right) \times \frac{M_L V^2}{2 BD_L}$$

Rearranging gives:

$$A_C = \frac{V^2}{2 M_C} \times \left( \frac{M_T}{BD_T} \cdot \frac{M_L}{BD_L} \right)$$

The braking distance of the consist if operating alone shall be expressed as:

$$BD_C = \frac{V^2}{2 A_C}$$

Substituting for $A_C$ gives:

$$BD_C = \left( \frac{M_C}{M_T BD_T - M_L BD_L} \right)$$

$$BD_C = \left( \frac{M_C}{SD_T - D_{FRT}} \cdot \frac{M_L}{SD_L - D_{FRL}} \right)$$

**E.9** The equivalent level track stopping distance for the consist under assessment ($SD_C$) if operating alone shall be expressed as:

$$SD_C = D_{FRC} + BD_C$$

Where:

$D_{FRC}$ = Free run distance

$BD_C$ = Braking distance

$D_{FRC} = \frac{1}{2} V \times$ average consist brake cylinder fill time

Substituting the measured data for $BD_C$ the equivalent level track stopping distance for the Consist under assessment ($SD_C$) if operating alone from brake entry speed $V$ (m/s) shall be expressed as:

$$SD_C = D_{FRC} + \left( \frac{M_C}{SD_T - D_{FRT}} \cdot \frac{M_L}{SD_L - D_{FRL}} \right)$$

**E.10** The calculated level track stopping distance for the consist on its own shall include determining the stopping distance from 60 mile/h (96 km/h) in goods timings and from 75 mile/h (120 km/h) in passenger timings for those consists capable of operating at the higher speed. The calculated level track stopping distance shall be used to demonstrate compliance against the performance requirements set out in 5.3.1 and 5.3.2.

**E.11** The test method set out in this Appendix shall be used to demonstrate the overall braking performance of the consist. Where consists have different vehicles, for example on-track machines, the brake force values required for the Rolling Stock Library for the individual vehicles shall be determined by calculation. The requirements for the calculation of the brake force values are set out in GM/RT2040.
References

RGSC 01 The Railway Group Standards Code

GM/RT2045 Braking Principles for Rail Vehicles

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

GM/RT2042 Braking System Requirements and Performance for Traction Units.

GM/RT2044 Braking System Requirements and Performance for Multiple Units.

GM/RT2040 Calculation of Brake Force Data For Rolling Stock Library.

GK/RT0034 Lineside Signal Spacing (Supersedes Standard Signalling Principle SSP34).

Related reference

UIC 544-1 Brakes – Braking power, 4th edition, October 2004