BS EN 16185-1:2014

BSI Standards Publication

Railway applications — Braking systems of multiple unit trains

Part 1: Requirements and definitions

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National foreword

This British Standard is the UK implementation of EN 16185-1:2014.

The UK committee draws users' attention to the distinction between normative and informative elements, as defined in Clause 3 of the CEN/CENELEC Internal Regulations, Part 3.

Normative: Requirements conveying criteria to be fulfilled if compliance with the document is to be claimed and from which no deviation is permitted.

Informative: Information intended to assist the understanding or use of the document. Informative annexes do not contain requirements, except as optional requirements, and are not mandatory. For example, a test method may contain requirements, but there is no need to comply with these requirements to claim compliance with the standard.

The UK committee would like to emphasize that requirements contained in this standard need to be read in conjunction with the UK notified national technical rules for rail vehicles. In particular:

• The movement direction of the brake control lever set out in sub clauses 5.8.2.1.2 and 5.9.2.1.2 is not mandatory for UK domestic applications. It is permitted to increase the brake application by moving the brake control lever away from the driver and for the emergency brake position to be furthest from the driver.

When rounded values require unit conversion for use in the UK, users are advised to use equivalent values rounded to the nearest whole number. The use of absolute values for converted units should be avoided in these cases. For the values used in this standard:

INS, RST and ENE speed conversions	
km/h	**mph**
2	1
3	1
5	3
10	5
15	10
20	10
30	20
40	25
50	30
60	40
80	50
100	60
120	75
140	90
150	95
160	100
170	105
180	110
190	120

INS, RST and ENE speed conversions	
km/h	**mph**
200	125
220	135
225	140
230	145
250	155
280	175
300	190
320	200
350	220
360	225

The UK participation in its preparation was entrusted by Technical Committee RAE/4, Railway Applications - Rolling stock, to Subcommittee RAE/4/-/1, Railway applications - Braking.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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This European Standard was approved by CEN on 13 October 2014.

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Foreword

This document (EN 16185-1:2014) has been prepared by Technical Committee CEN/TC 256 “Railway Applications”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2015, and conflicting national standards shall be withdrawn at the latest by June 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2008/57/EC.

For relationship with EU Directive 2008/57/EC, see informative Annex ZA which is an integral part of this document.

This series of European Standards *Railway applications — Braking systems of multiple unit trains* consists of:

— *Part 1: Requirements and definitions;*

— *Part 2: Test methods.*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard describes the functionality, constraints, performance and operation of a brake system for use in self propelling thermal and electric trains operating on routes of the European conventional rail system network.

This European Standard covers:

— all new vehicle designs of self-propelling thermal and electric trains being operated at a maximum speed up to 200 km/h, in the following text simply called EMU/DMU;

— all major overhauls of the above-mentioned vehicles if they involve redesigning or extensive alteration to the brake system of the vehicle concerned.

This standard does not cover:

— locomotive hauled trains which are specified by EN 14198;

— mass transit rolling stock which is specified by EN 13452-1;

— high speed trains being operated at speeds greater than 200 km/h which are specified by EN 15734-1.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 837-1:1996, *Pressure gauges — Part 1: Bourdon tube pressure gauges — Dimensions, metrology, requirements and testing*

EN 854, *Rubber hoses and hose assemblies — Textile reinforced hydraulic type — Specification*

EN 10220, *Seamless and welded steel tubes — Dimensions and masses per unit length*

EN 10305-4, *Steel tubes for precision applications — Technical delivery conditions — Part 4: Seamless cold drawn tubes for hydraulic and pneumatic power systems*

EN 10305-6, *Steel tubes for precision applications — Technical delivery conditions — Part 6: Welded cold drawn tubes for hydraulic and pneumatic power systems*

EN 13749, *Railway applications — Wheelsets and bogies — Method of specifying the structural requirements of bogie frames*

EN 14198, *Railway applications — Braking — Requirements for the brake system of trains hauled by a locomotive*

EN 14478:2005, *Railway applications — Braking — Generic vocabulary*

EN 14535-1, *Railway applications — Brake discs for railway rolling stock — Part 1: Brake discs pressed or shrunk onto the axle or drive shaft, dimensions and quality requirements*

EN 14535-2, *Railway applications — Brake discs for railway rolling stock — Part 2: Brake discs mounted onto the wheel, dimensions and quality requirements*

EN 15020, *Railway applications — Rescue coupler — Performance requirements, specific interface geometry and test methods*

EN 15179, *Railway applications — Braking — Requirements for the brake system of coaches*

EN 15220-1, *Railway applications — Brake indicators — Part 1: Pneumatically operated brake indicators*

EN 15273-2, *Railway applications — Gauges — Part 2: Rolling stock gauge*

EN 15355, *Railway applications — Braking — Distributor valves and distributor-isolating devices*

EN 15566, *Railway applications — Railway rolling stock — Draw gear and screw coupling*

EN 15595, *Railway applications — Braking — Wheel slide protection*

EN 15611, *Railway applications — Braking — Relay valves*

EN 15663, *Railway applications — Definition of vehicle reference masses*

EN 15734-1:2010[1)], *Railway applications — Braking systems of high speed trains — Part 1: Requirements and definitions*

EN 16185-2, *Railway applications — Braking systems of multiple unit trains — Part 2: Test methods*

EN 16207, *Railway applications — Braking — Functional and performance criteria of Magnetic Track Brake systems for use in railway rolling stock*

EN 16334, *Railway applications — Passenger Alarm System — System requirements*

EN 45545 (all parts), *Railway applications — Fire protection on railway vehicles*

EN 50121-3-1, *Railway applications — Electromagnetic compatibility — Part 3-1: Rolling stock — Train and complete vehicle*

EN 50121-3-2, *Railway applications — Electromagnetic compatibility — Part 3-2: Rolling stock — Apparatus*

EN 50125-1, *Railway applications — Environmental conditions for equipment — Part 1: Rolling stock and on-board equipment*

EN 50126 (all parts), *Railway applications — The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)*

EN 50163, *Railway applications — Supply voltages of traction systems*

EN 50553, *Railway applications — Requirements for running capability in case of fire on board of rolling stock*

UIC 541-1, *Brakes — Regulations concerning the design of brake components*

UIC 541-3, *Brakes — Disc brakes and their application — General conditions for the approval of brake pads*

UIC 541-4, *Brakes — Brakes with composite brake blocks — General conditions for certification of composite brake blocks*

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1) This document is currently impacted by the corrigendum EN 15734-1:2010/AC:2013.

UIC 544-1, *Brakes — Braking power*

UIC 557, *Diagnosis on passenger rolling stock*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 14478 and the following apply.

3.1
active cab
single cab in a train consist which is used to control traction and service braking and which is normally the leading cab

3.2
brake blending
controlled merging of brake forces resulting from different brake force generating systems

3.3
brake weight percentage
brake performance in accordance with UIC 544-1

3.4
driver's vigilance device
dead man device
brake control interface through which a human driver is caused positively/voluntarily to communicate his vigilance

[SOURCE: EN 14478:2005, 4.9.3.1]

3.5
dynamic brake
brakes in which the brake force is produced by the movement of the vehicle or its functional elements, but not involving friction

3.6
emergency brake loop
EBL
dedicated safety loop used to initiate an emergency brake application

3.7
Ep assist
electrically commanded assist system to locally vent and feed the brake pipe

3.8
direct ep-brake
continuous brake system using electrical command signals to directly apply and release the brakes

3.9
holding brake
service brake application to prevent a train from moving for a limited time

3.10
local control unit
control unit acting on a system at a level lower than the multiple unit (for example on a bogie or vehicle basis)

3.11
pilot pressure circuit
pressure circuit using components of reduced dimensions in order to control a limited flow rate which is subsequently amplified

3.12
reference speed
signal generated and generally used by the WSP system as an indication of the train speed used for comparison with the instantaneous wheel set speed as part of the control set algorithm

3.13
regenerative (mode of electro-dynamic braking)
converting the braking energy into electrical energy and generating an energy flow into the main energy supply

3.14
rheostatic (mode of electro-dynamic braking)
converting the braking energy into electrical energy and dissipating the electrical energy in a resistor

3.15
safety loop
hardwired electrical loop following the energize to release principle

Note 1 to entry: A safety loop may be used on vehicle level as well as train level. This European Standard assumes a train wide functionality. Examples of safety loops are:

— emergency brake loop;

— passenger alarm;

— door status traction interlock.

3.16
maximum braking load
load condition lower or equal to “design mass under exceptional payload” as defined in EN 15663

Note 1 to entry: When a load condition lower to “design mass under exceptional payload” is considered it needs justification and declaration in the vehicle documentation.

The maximum braking load is based on the maximum expected density of standing passengers on board in addition to the normal load and is specified for each project. For this purpose the following categories should be considered:

1) 0 kg/m^2 in the standing area for trains with restricted seat reservation system which means no standing passengers at all;

2) 160 kg/m^2 in the standing area for long distance trains;

3) 300 kg/m^2 in the standing area for trains that are worked intensely with a medium volume of passengers (for example as found in regional trains);

4) 500 kg/m^2 in the standing area for trains that are worked intensely with high volumes of passengers (for example such as found in inner cities and suburbs for example Paris RER, Berlin DC-network, London).

All other conditions (seats occupied, luggage areas, etc.) are in line with the definition for the design mass under exceptional payload in accordance with EN 15663.

4 Symbols and abbreviations

For the purposes of this document, the following symbols, units and abbreviations apply:

BP	Brake pipe
BCU	Brake control unit
C	Brake cylinder
CR	Conventional rail
DMU	Diesel multiple unit
EBL	Emergency brake loop
ECB	Eddy current brake
EMC	Electromagnetic compatibility
EMU	Electrical multiple unit
ETCS	European train control system
CCS	Control, command and signalling
H	Hydrodynamic/Hydrostatic brake
IM	Infrastructure Manager
MMI	Man-machine interface
MRP	Main reservoir pipe
MTB	Magnetic track brake
RST	Rolling stock
RU	Railway undertaking (train operator)
SRT	Safety in Railway Tunnels
TEN	Trans European Conventional rail network
TSI	Technical Specification for Interoperability
WSP	Wheel slide protection
λ	Effective braking power
1 bar	$= 10^5$ N/m^2 $= 10^5$ Pa $= 10^{-1}$ MPa

5 Design principles

5.1 General requirements

5.1.1 Safety

Braking systems shall conform to the following, subject to the operator using and maintaining the system in the intended manner:

a) the braking performances defined in Clause 6;

b) the design principles in accordance with the requirements of this European Standard;

c) the design principles listed in the standards on brake systems referred to in Clause 2;

d) keeping within the specified effects on the track as specified in 5.1.9 and 5.5.

In the course of the system design the following risks shall be considered and mitigated. As a minimum, the following hazards shall be taken into account.

e) the brake force applied is greater than the maximum design level:

1) impact on standing passengers;

NOTE No limits are so far defined to secure passengers.

2) impact on track shifting forces;

3) excessive jerk;

4) significant damage to the contact surface of the wheels;

f) the brake performance is lower than the level of brake demanded:

1) keeping traction effort on the train while emergency brake is requested;

2) required emergency brake performance not achieved;

3) required parking brake performance not achieved;

g) there is no brake force when demanded:

1) no emergency brake on the whole train when requested;

2) automatic (emergency) brake not initiated in the case of an unintended train separation (loss of train integrity);

3) parking brake: loss of performance over the time;

h) there is a brake force when a brake demand has not been made:

1) undue local brake application (pneumatic or parking);

2) locked axle not detected;

i) brake component failures that could cause death or injury or damage to the train or infrastructure, e.g. derailment.

The hazards in the previous list shall be assessed in accordance with EN 50126 (all parts).

Concluding from the hazards listed above the emergency brake shall have a high level of integrity and shall always be available when the brake system is set up for operation, whereas the service brake, while it may share subsystems and components, etc. with the emergency brake, need not achieve the same level of integrity. Nevertheless, the service brake shall be designed to comply with the following requirements:

j) the service brake shall be activated on the whole train when requested;

k) independently from the service brake:

1) it shall be possible for the driver to immediately initiate the emergency brake by using the same lever which is used for service braking or by using another independent device;

2) the train protection system (technical intervention system) shall be capable of initiating the emergency brake;

l) cut off traction effort on the whole train while service brake is requested;

m) provide service brake effort as high as requested.

The required performance levels for different EMU/DMU categories are given in Clause 6 and Annex A. The compliance of these performance levels and the safety of the braking system shall be fully demonstrated as specified in EN 16185-2.

A brake system which is considered to be safe shall incorporate the following items:

n) a continuous, automatic and inexhaustible brake system;

o) an energize to release brake command line, as a minimum for the emergency brake;

p) decentralized brake actuators, developing the brake force; using locally stored energy;

q) proven design components, see Annex B.

An accepted bench mark safety level for a brake system is the UIC-architecture as described in EN 14198.

If other system architectures are selected, they shall meet the requirements n) to q) in an equivalent manner.

The components shall withstand any duties expected to occur during their period in service. The safety implication of any failures shall be limited by appropriate means; as described in this European Standard.

Single point failures shall not cause any relevant malfunctions regarding emergency brake application. That means:

r) functions at train level (in the sense used in EN 14198) shall be designed as energized to release;

s) safety relevant functions at train level shall provide redundancy or a back-up function for any electrical command chain applying the emergency brake;

t) the man machine interface shall provide at least two separate means for demanding an emergency brake application;

u) malfunctions on local level (in the sense used in EN 14198) could be tolerated if the loss of a local function is limited to an acceptable effect (for example by means of using sufficient quantity of independent units in the train).

Proper functionality of the brake system is also affected by a design of the piping and component design as specified in 5.4.4.

5.1.2 Fire protection

The braking system shall be protected against the effects of fire and shall not emit toxic fumes. This shall be achieved by selecting appropriate materials, by an appropriate system architecture and installation arrangement.

The braking system shall be consistent with the train fire protection requirements according to EN 45545 (all parts).

Running capability under fire shall be satisfied as well. This shall be achieved by being consistent with the requirements in accordance with EN 50553.

5.1.3 Reliability and availability

To comply with the essential requirements related to reliability and availability, the requirements of 5.13 and 5.17 shall be applied.

5.1.4 Environmental condition

The rolling stock and the equipment on board shall perform under the conditions as specified in EN 50125-1. They shall work properly in those climatic zones, for which they have been designed and where they will be operated.

For certain lines, further requirements may be required, e.g. for the Nordic countries.

5.1.5 Train configuration

EMU/DMU can be configured as:

— fixed formations with distributed traction equipment applied to any of the vehicles or as trains with power units (at least one) and additional vehicles without traction equipment;

— a fixed formation train set consisting of single vehicles or articulated coaches;

— single vehicle - also known as a railcar;

— trains with or without tilting equipment;

— single deck or double deck trains.

EMU/DMU with the same brake control architecture may be formed together and their functionality shall be the same as a single unit as far as braking is concerned.

The maximum train length over which the functionality and the performances of the brake system shall be specified. If not defined a train formation of at least 200 m should be considered.

5.1.6 Maximum speed and line parameters

The conventional rail network includes lines of different line characteristics which are determined by the topographic conditions, the track parameters, the signalling equipment, etc. The line conditions over which the train will be operated shall be specified.

5.1.7 Coupling compatibility/capability

EMU/DMU of the same type shall be equipped with couplers at each end of the unit to provide the pneumatic, electrical and electronic connections or others necessary for brake control and shall provide full functionality. This can be achieved by:

1) fully automatic coupler providing full functionality (preferred option);

2) combination of automatic and manual connection or;

3) fully manual connections.

If trains of a different type are coupled then the pneumatic connection may provide sufficient functionality of the brake system to allow hauling a damaged unit by another interoperable unit without adapter. In that case relying upon the pneumatic brake solely may result in operational restrictions; the railway undertaking shall specify the functionalities and the performances of the brake system.

For rescue purposes by a conventional traction unit with a train hook as defined in EN 15566 a special adapter for example in accordance with EN 15020 shall be provided.

For the trainsets equipped with the UIC brake it is not necessary to have electrical energy on board or to be provided with electrical energy by the rescuing trainset or locomotive. For trains with brake systems that are not compatible with the UIC brake pipe an equivalent response as if equipped with UIC brake pipe shall be provided and may require electrical supply on board. In both cases demand is communicating using the BP connection to the unit and the trainset being rescued shall respond in the form of a proportional brake force.

The recommended minimum rescuing speed is 100 km/h.

5.1.8 Longitudinal track forces

The maximum longitudinal force applied to the track by the brake equipment shall always be less than the force that would occur with an acceleration or deceleration of 2,5 m/s^2.

5.1.9 EMC

The brake equipment shall fulfil the requirements of EN 50121-3-1 and/or EN 50121-3-2 with regard to EMC when applicable.

CE-marking is not required.

5.1.10 Operation in very long tunnel

The brake design shall take into account the particular safety conditions in very long tunnels as set out in the SRT TSI.

This should be achieved by being consistent with the requirements in accordance with EN 50553.

5.2 Brake equipment types

5.2.1 Basic architecture for EMU/DMU braking

EMU/DMU trains should be equipped with brakes which are free of wear and these brakes should play a major part in the brake concept. This could be achieved by application of dynamic brakes.

5.2.2 Dynamic brakes

Applicable dynamic brakes are:

the electro-dynamic brake, i.e. operating the traction motors in the generator mode:

— developing a retarding force at the wheel/rail interface;

— preferably returning the braking energy to the main power supply, which is called the regenerative mode;

— developing a retarding force independent from the main power supply with the braking energy being dissipated by sufficiently dimensioned brake resistors, which is called the rheostatic mode;

— a blending between the regenerative and rheostatic mode may be considered if the reliability of the function can be demonstrated, especially if also used for emergency braking.

The following operational applications are permitted:

— applied in service brake only, not applied in emergency cases;

— applied in service brake, applied in emergency cases but not considered in the brake calculation;

— applied in service brake, applied in emergency cases and considered in the brake calculation.

If the regenerative brake is included in the emergency brake calculation, the effect of the absence of the external power supply shall be considered and mitigated.

If the rheostatic brake is included in the emergency brake calculation, the resistor shall have sufficient thermal capacity to perform an emergency brake application following the most demanding service braking duty specified and the control-command shall be considered to be sufficiently reliable and safe. The performance of such dynamic brake shall not depend on the return of energy into the network, nor does it depend on receiving electrical energy from the network.

The (linear) eddy current brake is characterized by non-contacting electromagnetic forces in the magnetic shoe/rail interface. This type of brake is presently not used in EMU/DMU, but may be considered for future applications. As it is presently used for High Speed Trains see EN 15734-1:2010, 5.5[2] for further details.

5.2.3 Friction brakes

Applicable friction brakes are:

— disc brakes, designed as wheel mounted, axle mounted, or transmission mounted discs;

— tread brakes;

— if appropriate, other types of brakes, e.g. drum brakes.

5.2.4 Magnetic track brakes

In order to keep stopping distances within specified limits on certain lines EMU/DMUs may be equipped with additional magnetic track brakes. They will only be applied in emergency cases or separately activated by the driver. It is permissible to include their contribution for emergency braking as a means of maintaining the envisaged braking performance. When magnetic track brakes are used, these shall be either:

— electromagnetically excited, battery supported track brakes, which are kept in an upper position and clearance free in the bogie frame in the released status;

— permanently magnetically excited track brakes which are kept in an upper position and clearance free in the bogie frame in the released status. It is permissible for this type of track brake to also fulfil the parking brake function, if a sufficient brake force development can be demonstrated to comply with 5.11;

— track brakes, which are constantly kept in the lower position are permitted when agreed between the RU and IM.

NOTE For further information, see EN 16207.

2) This document is currently impacted by the corrigendum EN 15734-1:2010/AC:2013.

5.2.5 Non-conventional brakes

Non-conventional brake systems (e.g. electromechanical, other energy recovery systems) may be used providing that they function and perform in a manner comparable to that of a conventional brake system as described in this standard.

5.3 Dynamic brakes

5.3.1 Electro dynamic brakes

EMU trains are supplied with a nominal voltage of 15 kV AC (16,7 Hz) or 25 kV AC (50 Hz)[3)] or 3 kV DC or 1,5 kV DC or 750 V DC. The corresponding AC-networks are generally capable and the DC networks are under certain conditions capable of dissipating the electrical energy which is returned to the main power supply during braking. This enables the distribution of electrical energy for use by other trains or consumers. The capacity (of dissipation) generally is in the same range as that of the provided traction power.

EMUs should make use of these features and should return the electrical energy which is gained from electro-dynamic braking to the main power supply.

The main power supply networks of the railways may not always be fully receptive – this is a permitted service condition and features and controls shall be incorporated into the brake system to take account of it.

If the regenerative mode is not available rheostatic braking should be applied, and should be used before other types of braking.

If lines of DC networks are to be operated by EMUs, regenerative braking is permitted, but optional. Restrictions and conditions such as those specified in EN 50163 or imposed by the infrastructure manager shall be respected.

In addition, in the event that the supply to the catenary is lost, the train shall detect this and shall suspend the regenerative brake so that it does not impede the line voltage dropping to 0 V.

The maximum brake force of the electro-dynamic brake for each wheelset should be of that value, which is implied by the maximum adhesion coefficient (see Clause 6), in order to cover a maximum range of speed without additional application of the friction brake.

In the event of a fault in a power unit, only the electro-dynamic brake of this damaged unit should be unavailable.

In the case of service braking, train wide blending should be used to compensate for the loss by using the other dynamic brakes up to their performance limit before the application of the friction brake.

If the loss of electro-dynamic brake performance can be replaced by another brake system on board the train, then the electro-dynamic brake concerned may be automatically deactivated. However, if not, the availability of the electro-dynamic brake shall be maintained in the case of an emergency braking even if this means a degradation of the electro-dynamic brake equipment concerned.

5.3.2 Control Command of the electro-dynamic brakes

It shall be possible to vary the electro-dynamic brake alone or in connection with further brake systems in a minimum of 7 levels of braking between “OFF” and “MAXIMUM”.

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3) Nominal values.

If the electro-dynamic and the friction brakes act simultaneously on the same wheelset, the total braking force shall be limited so that it does not exceed a maximum design adhesion coefficient as specified in 6.5 and a maximum design retardation as specified in 6.2. The actual available adhesion shall be considered by the control system (see also 5.10).

The electro-dynamic brake is controlled by the traction control unit. Target values can be commanded by:

— separate or combined brake handle;

— emergency push button if permitted by the brake architecture;

— an automatic train control system (e.g. cruise control); if permitted by the brake architecture;

— an automatic train protection system if permitted by the brake architecture;

— brake control system.

The rate of change of the electro-dynamic brake force and of the friction brake force shall be coordinated.

In emergency cases and when the electro-dynamic brake fails the friction brake shall be set into operation automatically and immediately. The availability of the electro-dynamic brake should be continuously monitored and displayed to the driver along with the electro-dynamic brake force achieved as a proportion of the force demanded. An audible and/or visual warning should be provided to the driver in the event of an electro-dynamic brake unit failure.

Dynamic brakes used for service and emergency brake applications shall be controlled to make best use of the available adhesion. Dynamic brakes should not be routinely inhibited when low adhesion is detected. Dynamic brake systems should incorporate a WSP-functionality in accordance with EN 15595.

5.3.3 Brake resistors

If the electro-dynamic brake is used for emergency cases then the brake resistors should be designed such that they are capable of dissipating the maximum power and the maximum current generated by the electro-dynamic brake without time restriction (100 % duty cycle).

If the capacity is less than 100 % only that reduced capacity can be regarded in the brake calculation.

If the capacity is such that time restrictions shall be observed the brake resistors shall at least dissipate two consecutive emergency brake applications at the rate of 100 % electro-dynamic power. The interval between the emergency brake application shall take into account the units own traction performance.

An automatic protection of the resistors against thermal overload or overcurrent may be incorporated into the design.

5.3.4 Hydrodynamic/hydrostatic brake

Hydrodynamic/hydrostatic brakes may be used providing they respect the functionality specified for the electro-dynamic brake. The following operational applications are permitted:

— applied in service brake only, not applied in emergency cases;

— applied in service brake, applied in emergency cases but not considered in the brake calculation;

— applied in service brake, applied in emergency cases and considered in the brake calculation.

If it is included in the calculation of braking performances no time limit is permitted on its operation and the control-command shall be considered to be sufficiently reliable and safe. The hydrodynamic braking performance shall be verified during the brake type tests.

5.4 Friction brake

5.4.1 General

In general, the friction brake is added to the dynamic brake during emergency braking and service braking.

An exclusive application of the friction brake may be required at low speeds in order to ensure the precise and smooth positioning of the train.

The friction brake shall be designed such that it is capable of taking over the full thermal duty of an emergency brake application from maximum speed. For further requirements see 6.4.

The means to apply the friction brake usually is with compressed air for the EMU/DMUs. Other forms of energy are permitted providing that equivalent safety can be demonstrated.

It is not permitted to use the compressed air from reservoirs of the braking system and the brake pipe for any purpose other than braking. In addition to supplying compressed air to the brakes, the MRP may also be used for supplying energy to other users in the vehicle (e.g. door operating, toilets, air suspension, etc.).

The energy necessary for braking shall be provided without any interruption, but it is not necessary to maintain a constant value in the supply pipe. For details see 5.15.

5.4.2 Brake control requirements

5.4.2.1 System architecture

The main functions of the system architecture shall comprise the following:

— creating brake demand level;

— distribution of the brake demand;

— brake force generation in response to the brake demand.

The control command system of the brake shall:

— rely on components and subassemblies of proven design and high availability (see also Annex B);

— arrange the control units per vehicle or per bogie.

Application of the brake in the train which is controlled from the leading vehicle via a train wide brake command shall meet the following functional and safety requirements in the various vehicles:

5.4.2.2 Requirement 1: Continuity

All brakes in the train shall be capable of being applied from a single control point, normally in the operational cab.

5.4.2.3 Requirement 2: Automatic application

Each individual brake system or combinations of them shall operate automatically, i.e. in the event of an unintentional train separation in two or several parts. The brakes on all parts of the train shall apply, bring each part to a standstill and keep it in the same position until released by other intentional operations.

Emergency brake devices in non-operational cabs should also be capable of requesting a brake application.

5.4.2.4 Requirement 3: Inexhaustibility

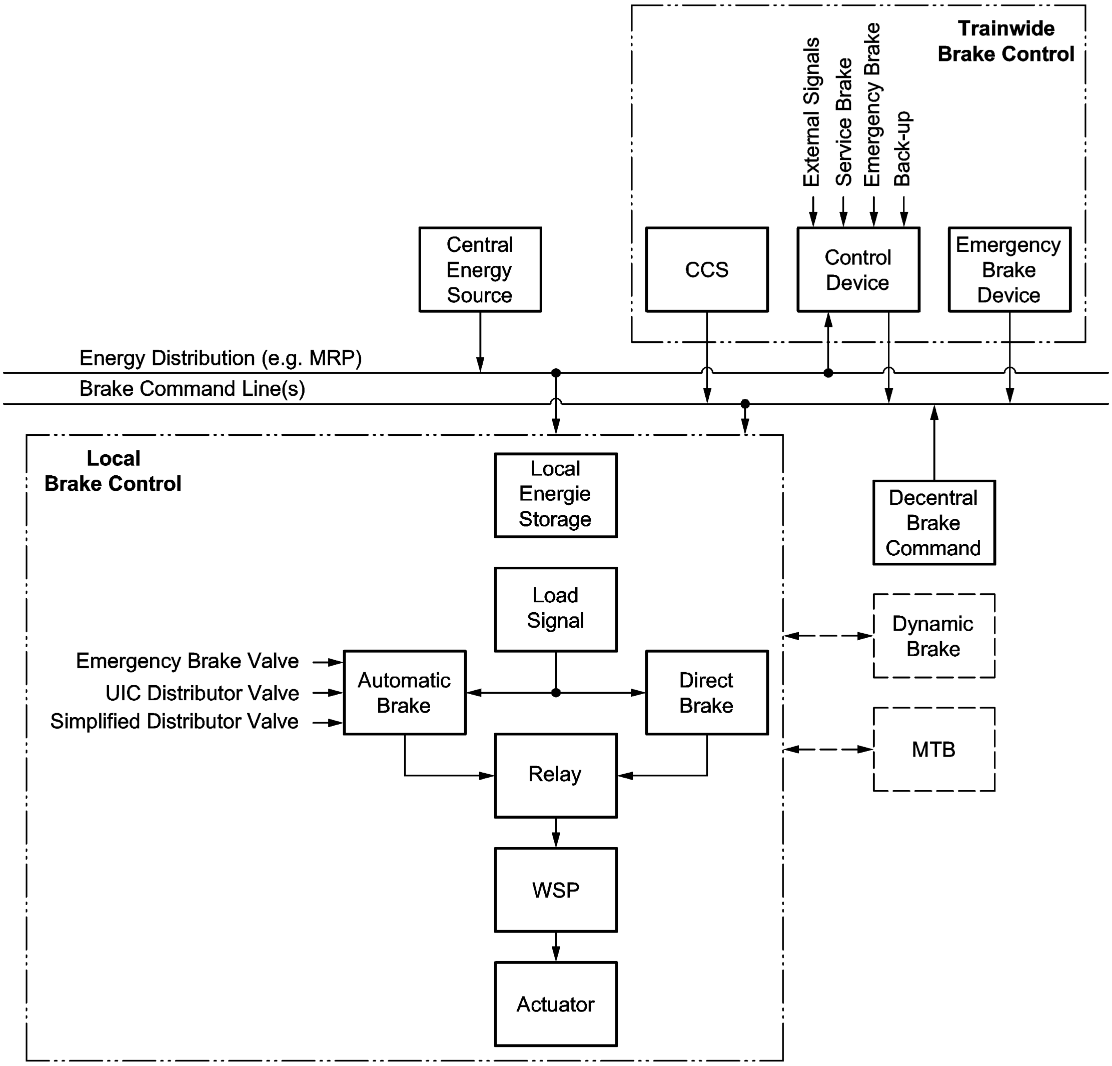
The braking power available in the active brake system of the train shall be adequate to attain full brake force:

— at all times during the train journey; and

— under all track conditions.

5.4.2.5 Requirement 4: Basic architecture

— A minimum architecture as shown in the flowchart in Figure 1 shall be considered.



Key

Actuator	brake cylinder
CCS	control, command and signalling
MTB	magnetic track brake
WSP	wheel slide protection

Figure 1 — Flowchart of basic structure of a brake system (on unit level and local level)

5.4.2.6 Structure of the brake architecture

The basic brake architecture is based on:

— a central control level;

— a distribution of a central demand and the supply of the brake energy;

— a local control level.

The local control level shall contain the automatic brake function and the service brake function.

5.4.2.7 Energy supply

The automatic/emergency brake function shall apply the emergency brake using the energy from the local energy storage when the applicable brake command line is de-energized, caused by:

— an intentional action by the driver or a CCS system;

— an unintentional train separation;

— the loss of electrical energy onboard;

— the loss of air supply. This should be a second stage event after a fault message to the driver.

The service brake function shall apply the brake using the energy from the local energy storage in response to the service brake command line. The service brake command line can operate either on an energize-to-apply or an energize-to-release basis.

The preferred solution for the service brake is the direct ep-brake operating on an energize to apply basis. The conventional indirect brake of the UIC type may be added to ensure the rescuing of a damaged train or in order to upgrade the reliability or availability of the system.

If it is intended to use the conventional UIC brake in an EMU/DMU to provide both the automatic and service brake functions then the system requirements shall be in accordance with EN 14198.

5.4.2.8 Requirements of the local control unit

As a minimum the output characteristics of the brake control unit (BCU) shall be consistent with the requirements of EN 15355 and EN 15611, such as: precision, hysteresis, minimum output pressure (inshot), proportional pressure characteristic, capability of refilling the brake cylinder after WSP activity.

The load depending function shall be subject to national safety rules:

— default to crush (= maximum braking load) (e.g. in the UK for short trains which is 20 axles or less);

— default to tare load (= design mass in working order in accordance with EN 15663) (implies provision of a warning message to the driver).

After a maximum of 5 s all the brake units shall have developed 95 % of their brake force.

The brake build up time shall be as short as possible in taking into consideration the limitation of the longitudinal forces in the train and the jerk limitations as set out in 5.1.8 and 5.9.6.

The time to release the friction brake completely shall respect a jerk limit, capable to provide suitable comfort and safety for passengers moving through the train.

The release time shall not be shorter than the brake build up time.

The local control system shall be sized to achieve the fill and release flow rates needed to achieve the brake performance and the duty including the effects of WSP operation.

5.4.2.9 Sub-function brake application

If at the local level there is more than one control channel to apply the brake then an emergency brake application shall take priority.

The emergency brake valve, which can be part of the whole system or a stand-alone component shall operate on the principle of energizing to release.

If there are two independent means to apply the emergency brake, then the brake architecture shall be configured so that the emergency brake application deriving from the control channel which is supposed to be the fastest one is not restricted by the other control channel.

If the service brake control demand is communicated via the brake pipe, the vehicle shall be equipped with a distributor valve in accordance with EN 15355 (or a device that has an equivalent behaviour) and relay valves in accordance with EN 15611.

5.4.2.10 Requirements related to the brake pipe

If the brake pipe is used only in cases of emergency braking or for rescuing a damaged train set distributor valves which are not fully compliant with these ENs may be considered. At least the following requirements shall be met for the normal predefined formation, otherwise associated operating rules shall be declared:

— reduction in brake pipe pressure required to obtain maximum brake cylinder pressure: (1,5 ± 0,1) bar. (coming from a nominal value in the BP of (5,0 ± 0,1) bar);

— the insensitivity of the brake to slow decreases in brake pipe pressure shall be such, that the brake is not activated if the normal working pressure drops by 0,3 bar in one minute;

— the sensitivity of the brake to slow decreases in brake pipe pressure shall be such, that the brake is activated within 1,2 s, if the normal working pressure drops by 0,6 bar in 6 s;

— the local control unit shall be capable of being isolated from the brake pipe;

— 5 steps to 8 steps of brake force shall be available by variation of the BP pressure;

— the status of brake (applied/released) shall be recognizable.

If a local brake control device can be overcharged provision shall be made that the pressure in the brake pipe can be adjusted to that in the command reservoir, either by:

— a central command raising the brake pipe pressure to a defined value. This subsequently shall be followed by slow reduction of both, the brake pipe pressure and the pressure in the command reservoir, to the nominal BP value or by;

— a local command with manually operated devices on both sides of the train reducing the pressure in the command reservoir to that of the brake pipe as specified in EN 15355 and EN 14198;

— local solutions as specified in EN 15355 which operate automatically after a central initiation by the train driver may be used instead.

If the overcharge is applied, the reduction phase of the brake pipe pressure shall not start later than 20 s after the overcharge pressure has reached its maximum value.

If the overcharge process is interrupted by a brake application, it shall be restarted after the brakes are released again and the process shall continue at the same pressure level in the BP as in the moment of interruption.

If the system is equipped with a brake pipe and a main reservoir pipe provision shall be made to close the pipes with a coupling cock on all vehicle ends when those vehicles can be decoupled in normal service and also between self-sufficient units of train sets.

If a power car can be operated separately from the train then it shall be equipped with an additional direct brake or alternatively a separate and independent brake per bogie of the power car.

5.4.3 Installation of the brake equipment

If the train is equipped with a continuous air brake pipe (BP) then the inside diameter shall be at least 25 mm The MRP shall be dimensioned in such way so that no restrictions will affect the function of the vehicle. A pipe with an internal diameter of at least 19 mm shall be used.

The air pipes shall be installed in such a way that they are free of water traps and with generous bending radii as set out in Annex C. Components that may reduce the cross-section of the BP or may obstruct the brake pipe (e.g. filters) shall not be fitted. Low points in the pipe work that could constitute a water trap shall be easily accessible and provided with a drainage device.

For BP and MRP metal pipes shall be used. Steel pipes shall meet the requirements of EN 10220, or EN 10305-4 or EN 10305-6. The number of pipe connections shall be as low as possible. Any pipe connections shall be accessible. Sections of pipes shall be selected so that it is possible to dismantle them. Threads cut into the pipes are not permitted in accordance with EN 15179.

The number of flexible connections shall be minimized; they shall be used only if there is a relative movement between two connecting points during operation, maintenance activities or if they are connected to equipment which is subject to vibrations.

The requirements of EN 854 shall be met. A reduction of the cross-section of a pipe shall not be caused by the use of any flexible connection.

Electric cables and flexible connections shall be installed without twisting and/or excessive bending. They shall also be fixed to withstand the mechanical stresses that may occur in railway operation. Electric cables shall be shielded or screened if required.

A minimum clearance of the brake components required under all operational conditions shall be demonstrated. Special attention shall be given to the limit values of wear of brake blocks and brake pads, etc, taking into account the maximum suspension movements, the minimum permissible wheel diameter, the moving angles and vehicle movements at ramps and in curves, etc.

In principle the minimum distance between two components that move relatively to each other should be 20 mm. In case this distance cannot be achieved, verification is required to confirm that no unacceptable hazards occur.

5.4.4 Leakage

The expected safety and high availability of the air brake requires sufficient tightness of the air equipment. Starting with the MRP charged up to the nominal pressure the maximum leakage in the MRP shall not be more than 0,2 bar in 3 minutes. The leakage in the BP shall not be more than 0,1 bar in 3 minutes starting from the nominal (5 bar) running pressure.

5.4.5 Mechanical components/bogie equipment

5.4.5.1 General

The friction brake used is preferably a disc brake. A tread brake may be used in place of or in combination with a disc brake on certain vehicles of a train set providing the system architecture appropriately limits the energy jointly dissipated related to wheel and block.

Each wheelset shall be provided with a brake force application system that shall be available for use during emergency braking.

A slack adjuster shall be provided for each brake actuator and shall be designed with sufficient capacity to compensate the wear of the friction brake components, e.g. pads, discs, blocks and wheels.

It shall be possible to visually check the conditions of the mechanical brake components without the need to remove any other items of train equipment.

5.4.5.2 Friction material

The composition of the brake friction materials shall be selected so that the best compromise is ensured between:

— the technical characteristics of the brake;

— the wear and service life of the pads and blocks;

— aggressiveness to the brake disc and the wheel rim;

— limiting the noise emission.

5.4.5.3 Brake discs

The brake disc shall comply with the following requirements:

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. This shall take into account any planned braking duty cycle, including drag braking (braking to control the speed). For further thermal requirements, see 6.4;

b) accept the loads that will arise from the braking forces and from the dynamic environment associated with its particular location on the vehicle in accordance with EN 13749.

Aspects of sufficient cooling respectively shielding aspects shall be considered for the discs as well as for the surroundings, especially if temperature is increased due to new materials like ceramics.

Accepted designs include the wheel mounted type and the axle mounted type (both in accordance with EN 14535-1 and/or EN 14535-2), and transmission mounted discs.

The dimensions of the discs and the clearance between the rails shall be in accordance with EN 15273-2.

5.4.5.4 Brake pads and brake pad holders

Brake pads and brake pad holders shall comply with UIC 541-3.

5.4.5.5 Actuator and callipers

The friction radius and force application point of the callipers shall be aligned with each other so that uneven wear of the pads is avoided so that it is possible to use fully the wear reserves. Suspension movements shall be considered. The same applies for tread brake systems as far as applicable.

The brake cylinders and callipers shall withstand the loads that will arise from the braking forces and from the dynamic environment associated with its particular location on the vehicle in accordance with EN 13749.

Suitable protection shall be provided against the compounding of the clamping forces arising from the fully applied pneumatic brake and the spring brake when applied, so as to avoid overloading of the mechanical parts and exceeding wheel/rail adhesion. If nevertheless a compounding may occur in certain service conditions, then the mechanical parts shall withstand the stresses applied.

5.4.5.6 Brake blocks and brake block holders

Brake blocks and brake block holders shall comply with UIC 541-4 and UIC 541-1 respectively.

5.5 Eddy current brake

This type of brake is presently not used in EMU/DMU but may be considered for future applications.

If an eddy current brake is considered it shall comply with the requirements set out in EN 15734-1.

5.6 Magnetic track brake

The design and test requirements shall be in accordance with EN 16207.

5.7 Non-conventional brake systems

Non-conventional brake systems (e.g. electromechanical) may be used providing that they function and perform in a manner comparable to that of a conventional brake system as described in this standard.

Non-conventional brakes are those brakes which are not mentioned in the sub-clauses above.

5.8 Emergency brake concept

5.8.1 General architecture

The emergency brake is the brake having the highest level of integrity.

The application of this function shall be possible at any time and with highest reliability for:

— the driver;

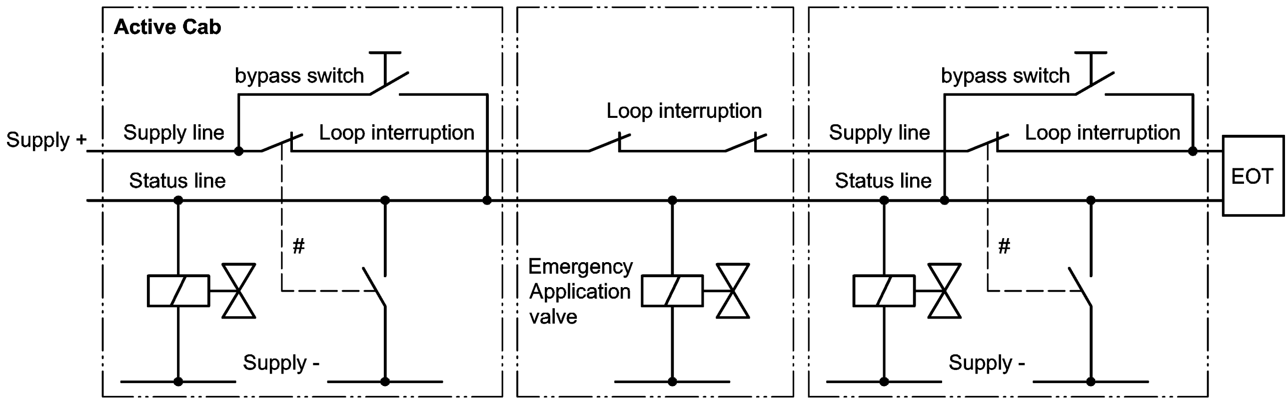
— the train safety systems, initiated by the infrastructure and signalling (ATP = automatic train protection);

— and other train safety systems, initiated by (decentralized) on board systems.

The central functions shall follow the “energize to release” principle. The central command running continuously through the train shall provide automatic brake application if the energy is cut off.

In case of a direct ep-brake there shall be an emergency brake loop (EBL) through all vehicles in the formation that shall be used to generate electrical release signals to brake units at each vehicle. If the emergency break loop is interrupted the electrical release signal for the brake units is lost and the emergency brake shall automatically apply.

Figure 2 is an example for the principal design.



Key

\# drivers brake handle/push button – showing emergency position in the active cab

EOT End of Train

Figure 2 — Flowchart of principal design for a emergency brake loop (EBL)

The emergency brake loop (EBL) shall:

— only be energized when there is an active cab;

— be designed in accordance with the principle “energize to release”;

— be routed from the head of the train (active cab) to the rear of the train (supply line) and then back to the head (status line). In the supply line all the emergency brake command devices (e.g. the brake application devices, drivers vigilance device, CCS) shall be able to interrupt the safety loop (emergency brake demand);

— be realized by dedicated lines and installed in a protected manner; a suitable voltage is for example 110 VDC ± 5 % at the generator and it is expected that the distribution system guarantees greater than 110 VDC - 30 % at all locations in the train;

— be insulated from any local energy supply;

— be used only for supplying components involved in an emergency braking;

— enable monitoring and testing of its integrity;

— enable bypass-modes for rescue purposes depending of the failure case;

If a brake system with UIC characteristic is used the brake pipe shall be vented rapidly and completely down to a value of less than 2,5 bar so that the brakes will achieve the response time considered in the brake calculations. If the emergency brake is applied by venting the brake pipe by an electrical command, it shall preferably be designed such that venting the brake pipe is achieved with the magnetic valves not excited (de-energize to apply).

If an emergency brake is applied it shall override any release command.

The traction shall be cut off automatically and the process to achieve this shall be initiated immediately. It cannot be reactivated before the brake demand is released completely and without a deliberate action of the driver.

An emergency brake applied by the driver shall be releasable at any time by the driver, except where specified by the operator or required by legal rules in force in the countries where the train set is operated.

For rescuing mode using a train fitted with a UIC brake system, a fully electrical brake control design shall also provide a connection with the brake pipe which allows it to respond to a brake command coming from the rescuing train. The multiple unit shall be capable of venting the brake pipe at the coupled end. This ensures that an emergency brake application can be initiated when being rescued.

Brake demand and distribution are central functions over the train. This is a high level reliable function, redundancies may be provided to achieve this target. In the case of single point failures the brake system shall behave as specified in 5.1.1.

The local brake command units and the components generating the brake forces shall be fitted in form of multiple decentralized units in order to limit the loss of brake force as a result of a malfunction to a tolerable value. A failure in one unit is not allowed to cause a subsequent failure in another unit.

Each mechanical or electrical or pneumatic failure of an independent unit of the brake system, which may occur locally in the train, has no more effects than the isolation of this unit.

All brakes systems capable of being used in emergency shall develop their maximum brake force (for the load state when the brake is load compensated). Where more than one brake influences the same wheelset, adequate precaution shall be taken to prevent the combined brake application exceeding the wheel/rail adhesion values given in 6.5.

5.8.2 Demand phase

5.8.2.1 Application by the driver

5.8.2.1.1 General

The emergency brake shall be capable of being applied with the same device used by the driver for service braking.

The emergency brake position on the handle shall be a notched and extreme position beyond the full service position.

The lever shall remain in the emergency position until it is removed by the driver.

If the primary device is defective a secondary device shall be available to apply the emergency brake.

5.8.2.1.2 Primary brake application device in the driver’s desk

Specific design of the brake application device should comply with the future recommendations of CEN/TC 256/WG 37 "Driver's cab".

Following the majority of train operators for safety reasons, the lever shall be moved in the direction towards the driver into the emergency brake position.

If provision is made for venting the brake pipe a pilot pressure circuit may be used as well, if a second independent path is provided in parallel and if the safety level is equivalent to a direct acting device.

If further brake systems are commanded in emergency cases beside the pneumatic brake they shall be applied by de-energizing the emergency brake loop and/or by venting the brake pipe (if fitted).

The brake pipe shall not be vented into the driver’s cab.

5.8.2.1.3 Secondary brake application device

Specific design and location of the brake application device should comply with the future recommendations of CEN/TC 256/WG 37 "Driver's cab". This is commonly achieved using a red push-button device.

This device shall de-energize the emergency brake loop and vent the brake pipe (if fitted) and it shall be capable of providing an input signal to other control systems. This application shall result in an automatic traction cut off.

The device shall remain in the “applied” position until the driver resets the device as a deliberate action.

5.8.2.2 Brake application commanded by CCS-System

5.8.2.2.1 General

The rolling stock shall respond to the CCS- system fitted to the train by providing the following functions:

a) application of an emergency brake, featured by:

   1) commanding the maximum brake force;

   2) de-energizing the emergency brake loop;

   3) venting the brake pipe completely and via the maximum cross section (if fitted);

b) traction cut off;

c) cut off feeding the brake pipe (if fitted);

d) displaying the reason for the brake application to the driver.

Provision shall be made to test the function of the CCS- systems. Each path dedicated to ensure the overall functionality shall be tested exclusively.

In cases of irregularities the CCS systems shall be capable of being isolated. The isolation of one system in cases of deficiencies shall not cause other systems to shut down. The failure of one system shall not cause a subsequent failure in another one.

NOTE It is accepted that different CCS systems act on the brake system using the same interface.

5.8.2.2.2 Automatic brake application by the driver’s vigilance device

For conventional rail traffic the driver’s vigilance device shall command a full service brake (see 5.9.2.2) or command an emergency brake application and shall initiate a traction cut-off command.

5.8.2.2.3 Automatic brake application caused by the passenger alarm system

The requirements for an automatic brake application and traction cut-off initiated by the passenger alarm system shall be in accordance with EN 16334.

5.8.2.2.4 Automatic brake application caused by a monitoring system

5.8.2.2.4.1 General

Responding to particular failures it may be found necessary to apply an automatic brake by a central command unit on the basis of the diagnosis data. Such an application shall be restricted to those incidents when immediate danger is arising and if a related warning message addressed to the driver is too slow.

For example a derailment detection system (when available) should immediately apply the brakes as well as advising the driver.

Such a decentralized brake application device shall command a full service brake (see 5.9.2.2) or command an emergency brake application and shall initiate a traction cut-off command.

For pure diagnosis messages see 5.13 in this document.

5.8.2.2.4.2 Train division/Loss of train continuity

The loss of the train continuity (e.g. caused by a train division by force or by an unintended release of the couplers) shall initiate an automatic brake in all parts of the train.

The loss of the train continuity shall be indicated to the driver.

5.8.3 Collecting and distributing brake command signals

5.8.3.1 General

The emergency brake demand can be initiated by number of different command sources. These shall be collected and distributed to the local command units.

If needed adequate redundancies shall be provided and shall be demonstrated in accordance with EN 50126 (all parts).

5.8.3.2 Collecting brake demand signals

Suitable demand collectors are the following:

— a hard wired circuit following a safety loop design (e.g. the emergency brake loop);

— the brake pipe.

The detailed design shall represent a proven safety integrity level against short circuit, wire cut off and impact of unintended voltage supply.

5.8.3.3 Distribution of brake demand signals

The transfer of a central brake demand shall be distributed train wide to the locally distributed brake demand units and shall enable them to generate braking forces from local resources.

An adequate demand distribution line can be realized by:

a) the emergency brake loop via electrical demand devices responding to the de-energized status of the emergency brake loop such as to apply the applicable brakes;

b) the pneumatic brake pipe, distributing:

    1) directly to the distributor valves of the indirect pneumatic brake;

    2) via sensors or pressure switches to assisting brake systems like electro-dynamic brakes, magnetic track brakes, eddy current brakes;

c) dedicated brake control lines or data bus as an additional parallel demand line.

The brake demand distribution shall act train wide regardless any automatic couplers in the demand chain.

In the case an emergency brake loop is designed it shall represent a proven safety level against short circuit, wire cut off and impact of unintended voltage supply.

The voltage level selected shall be appropriate for the envisaged length of train, e.g. 110 V.

The brake systems making a contribution to the required retardation according to Clause 6 shall be commanded or directly controlled via the continuous control distribution line.

5.9 Service braking

5.9.1 Brake management – brake blending

The service brake requires a brake blending as an interaction of those brakes which are designed for the use during service braking. In that case more than one brake system may act upon the same wheelset.

For the service brake, the principle of brake management is to optimize the use of those brakes which work in a regenerative manner and/or are free of wear.

Up to their maximum brake force the subordinate brake systems shall be activated in the following hierarchy:

— the regenerative electro dynamic brake in order to achieve the highest possible level of converting brake energy into electrical energy;

— rheostatic electro dynamic brake;

— further free of wear systems, if available;

— friction brake;

— optional: arrangement to command the electro dynamic/dynamic brake exclusively if required for maintaining speed.

The management of the combinations possible regarding certain preferences and failure strategies applicable in the design of the EMU/DMUs should be assisted by a computer aided system and its brake management software.

The above mentioned hierarchy defines the so-called preference mode in which the brake management system shall act under normal service conditions.

As a response to more unfavourable conditions (e.g. low adhesion) the driver should be enabled to select a different brake management, where all the braked wheelsets should contribute an amount of braking force such that there is the same adhesion demand at all wheels. If more than one brake system is in action in the same running gear, the free of wear type should be preferred.

If the brake blending is limited to simple conditions with not more than two brake systems the responsibility for the blending may be left with the driver.

The braking force of the train shall respond proportionally to the movement of the brake lever (alternatively the pulse duration of a time dependant brake handle) between the first step and the maximum brake force. It is accepted the first step can achieve at least 10 % of the maximum service brake power.

5.9.2 Brake command

5.9.2.1 Application by the driver

5.9.2.1.1 General

Service braking may be commanded by a single brake handle, if the brake management is designed to distribute the brake forces automatically.

The installation of a separate lever to exclusively command the dynamic brakes is permitted as an alternative.

These devices should comply with the future recommendations of CEN/TC 256/WG 37 "Driver's cab".

5.9.2.1.2 Primary brake application device in the drivers desk

It shall only be possible to control the service brake using the driver’s brake device located in the active cab.

It shall be possible for the driver to inhibit the service brake control in an active cab from charging the brake pipe when another active vehicle is ahead.

NOTE This function is not necessarily provided by the lever itself.

5.9.2.1.3 Combined traction- and brake control lever

This combined lever shall act in the way that the control range for traction is away from the driver, the control range for braking is towards the driver.

In that case precaution shall be taken by means of the component design that an unintended switch over from one function into the other cannot occur, e.g. by a notch in the 0-position.

5.9.2.2 Service brake application not initiated by the driver

The following systems are capable of applying a service brake:

— driver’s vigilance device;

— holding brake (optional), for further requirements, see 5.11.2;

— monitoring system following detection of a severe failure.

They shall cause the following reactions:

— application of a service braking with defined brake forces and following the defined brake management modes;

— traction cut off;

— indication of the reason for a brake application; such as vigilance device, passenger alarm system, monitoring systems.

The design shall allow to test the capability of each command source after starting a self-test routine during standstill.

In the case of irregularities or failures the design shall allow to isolate the equipment causing the service brake application request.

The isolation of one item shall not cause any restrictions to the other systems.

A failure in one item shall not cause a failure in another item.

5.9.2.3 Passenger alarm system

The requirements described in EN 16334 for automatic brake application caused by the passenger alarm system shall be applied.

5.9.3 Signal processing

The brake demand may evolve from different sources of brake demand as mentioned in 5.9.1 and 5.9.2.

A centrally and train wide commanded brake level may be transmitted by:

— a common train databus (e.g. CAN, LON, MVB, etc.) or more dedicated bus systems;

— electrical hard wires;

— a pneumatic system architecture in accordance with EN 14198.

Those signal paths may be used solely or in combination with one another.

Data shall be received and distributed throughout the train by a central brake control unit (also known as the train brake manager) taking into account the following:

a) only one train brake manager can be active in the entire train;

b) it is selected by the criteria “active cab”;

c) it provides the diagnosis data (if available);

d) it distributes the brake demands dedicated for the local control units distributed over the train, e.g.:

   1) vehicle related brake manager;

   2) segment related brake manager;

e) the selection of brake demand sources, mostly as a maximum value selection;

f) receives feedback (if available).

The recipients for the demand values on the lowest level (local brake control units) are for example:

— the traction control units for the electro-dynamic brakes;

— controllers for the pneumatic brakes;

— control units for the eddy current brakes if fitted.

5.9.4 ATC Automatic train control system

For service braking an automatic (microprocessor based) brake command system may be available besides the manual brake application.

The features regarding brake management with a priority of the free of wear brake systems shall be followed as well as in the manual mode.

The brake demand from the brake handle shall have priority over the automatic command system. The signal from the automatic system shall be valid only if the driver's brake handle is in the brake release position.

If the driver's brake handle is applied the automatic train control system shall be cut off and may only be reactivated by a voluntary action of the driver.

All train protection systems shall override the automatic command system.

5.9.5 Combined braking with two brake handles

Where it is desirable to command the dynamic brake independently of the other brake systems this can be achieved by a separate brake handle.

When combined with friction brake commands the dynamic blending strategy can either be automatic or the responsibility of the driver.

5.9.6 Jerk / ramps

In the case of service braking including full service braking with blending or without blending the jerk for speeds > 10 km/h should for reasons of passenger comfort be limited to the following values:

— max da/dt = 0,6 m/ s^3. Subject to the approval by the transport authority, this may be raised up to 1,0 m/s^3 in accordance with EN 13452-1.

In the case of emergency braking with or without blending effects as a result of failures in the system the jerk for speeds > 10 km/h should be limited to the following values:

— max da/dt = 2,0 m/s^3. Subject to the approval by the transport authority, this may be raised up to 4,0m/s^3 in accordance with EN 13452-1.

To provide the driver with confidence of the brake application, the blending process of the dynamic and the pneumatic brake shall not result in a significant change of deceleration of the train during the transition phases. A recommended value of the acceptable change is 20 % of the instantaneous deceleration.

To achieve this requirement it is permissible to ramp off the dynamic brake while the pneumatic brake is being established.

The jerk levels may be exceeded during WSP activity.

5.9.7 Coupling / Decoupling

During coupling, brakes applied to secure the standstill of the train shall not be released.

The command “uncoupling“ requires a deliberate action of the driver so that it cannot be the result of an unintentional or faulty action (e.g. from inactive driver’s cab).

The command "uncoupling" shall only be accepted when the inexhaustible brakes (parking brake) are applied in advance.

No uncoupling (whether intentional or not) shall be possible when the train is moving.

An unintended train separation shall cause an immediate and automatic brake application in each part of the train.

5.10 Wheel slide protection

5.10.1 General

EMU/DMU trains shall be equipped with a wheel slide protection system.

5.10.2 Wheel slide protection

The purpose of the wheel slide protection system is to avoid wheel flats and to optimize the use of the available adhesion while braking.

The system shall measure the speed of all wheelsets on each vehicle independently and shall be capable of calculating the reference speed without using a trainwide speed signal and it shall control the brake force in order to achieve the specified performance in accordance with EN 15595.

The wheel slide protection shall work properly under the following conditions:

a) in all brake modes;

   1) during brake blending;

   2) when using adhesion independent brakes;

b) at all levels of brake force;

c) regarding all wheel diameters;

d) at all levels of wheel-/rail adhesion;

e) rapid changes in levels of wheel-/rail adhesion.

There may be advantages in using more speed signals on a collective trainwide basis so as to increase the accuracy of the reference speed and to reduce the sensitivity against sensor failures.

Therefore, a trainwide exchange of the reference speeds between a number of wheel slide protection systems may be permitted under certain conditions; these are:

— high reliability;

— a communication system dedicated to brake command signals;

— adequate and proven safety level;

— analysis to show that there are no common mode failure mechanisms.

If more than one brake system develops the brake force on the same wheelset (or wheel), then it may be controlled either by a common wheel slide protection system or by two or more separate wheel slide protection systems.

In any case a concept for the wheel slide protection system shall be selected which reliably controls the overall brake force on the wheelset(s) concerned and it shall be able to reduce the brake force to zero (in order to prevent locking) and it shall be able to reapply the brake forces separately for each of the wheelsets except mechanically or electrically linked wheelsets.

The wheel slide protection system should prioritize the use of the dynamic brake if acting upon the same wheelset together with the friction brake.

If more than one brake system is working on the same wheelset using its own wheel slide protection, both systems shall update their reference speeds continuously.

The wheel slide protection system shall be equipped with a diagnosis system.

All speed signals shall be monitored. In the event that one or more speed signals are deemed inaccurate or unreliable then the wheel slide protection system shall automatically compensate by ignoring these speed signals.

The wheel slide protection system should provide an output signal to the TCMS indicating the presence of a locked wheel. This function may also be provided by dedicated wheel rotating monitoring system (for further details see EN 15734-1:2010, 5.10.3[4]).

The electrical energy supply for the wheel slide protection system shall be backed up by a battery. The capacity and the distribution of the batteries throughout the train shall be designed in such a manner that a loss of energy is improbable. In the event of loss of the electrical energy to the wheel slide protection systems or if any other fault disabling the WSP is detected then the brakes on the vehicles concerned should be capable of being isolated by the train staff and the train operated accordingly, e.g. at reduced speed.

The volume of the compressed air in the auxiliary reservoirs shall be such that WSP activities will not cause air consumption so that the energy for braking will be exhausted.

5.11 Brake functions to keep a train stationary

5.11.1 General

It shall be possible for the train to be kept stationary in the following conditions:

— holding brake;

— immobilization brake;

— parking brake.

5.11.2 Holding brake

The purpose of a holding brake is:

— to secure the train at standstill during a stop in a station and

— to secure the train on a gradient during a hill start.

This is achieved by the application of partial or full service brake initiated automatically or by the driver. The brake shall release either after a certain traction force has been developed or after a certain period of time or by a manual command.

The holding brake shall be capable of holding a train under the conditions of maximum braking load and a gradient of 35 ‰ if not otherwise specified.

5.11.3 Immobilization brake

The purpose of an immobilization brake is:

4) This document is currently impacted by the corrigendum EN 15734-1:2010/AC:2013.

— to hold in a stationary position the EMU/DMU with maximum braking load for at least two hours, in the event of the braking energy supply being disrupted or the power supply failing.

The immobilization brake shall be capable of holding a train on a gradient of 35 ‰ if not otherwise specified.

The immobilization brake is normally initiated by an application of the full service brake or emergency brake. The brake shall not be capable of being released if there is insufficient energy supply to achieve a further full service brake.

It is permissible to substitute the immobilization brake function by the parking brake if it automatically applies when the energy on board for the service brake is lost.

5.11.4 Parking brake

The purpose of a parking brake is:

— to keep the train stationary in shut down configuration for an indefinite period of time without energy supply.

The parking brake shall be capable of securing an EMU/DMU in the load condition design mass in working order in accordance with EN 15663 in a stabling point (depot) on a gradient of 5 ‰ if not otherwise specified.

If it is intended for the EMU/DMU to be kept stationary for an indefinite period on the maximum gradient on the line concerned the parking brake may provide sufficient performance. Alternatively if the parking brake is not sufficient it shall be supplemented by extra on-board facilities e.g. scotches.

Parking brakes may be applied as a result of:

1) a direct driver's command; or

2) a driver's command by application of the pneumatic brake (as a pre-stage) followed by an automatic substitution of the pneumatic brake in case of the air pressure dropping down; or

3) an automatic command when the cab is shut down by application of the pneumatic brake (as a pre-stage) followed by an automatic substitution of the pneumatic brake in case of the air pressure dropping down.

The parking brake shall be designed according to the "energize to release principle".

The design calculation shall at least take into account:

— static friction coefficent of the brake pads or blocks;

— maximum adhesion coefficient of 0,12 (as set out in TSI "Locomotives and passenger RST");

— proven static efficiency of the mechanism;

— minimum spring forces;

— the proven clamping force;

— a single parking brake unit not working.

The developed brake force shall be equal to or greater than the required brake force as a result of the calculation specified above. This shall also occur during the substitution phase of the service brake by the spring brake.

The force developed by the parking brake should not compound with the force developed by the air brake on the same wheelset. If a compounding of the brake forces from the parking brake with those from the service/emergency brake can occur the brake system equipment shall tolerate this without detriment.

An unintended application of the parking brake (for example the loss of release pressure) shall be indicated to the driver. In addition technical solutions may be considered to prevent the spring brake applying in the event of the failure of the release pipe.

If there is the risk of an unacceptable level of wear and tear going unnoticed, this shall be further mitigated by carrying out additional examinations, e.g. an examination of the equipment concerned either immediately after the event, or at the end of the scheduled train service, etc.

For EMU/DMU equipped with pneumatic brake control in accordance with EN 14198, an unintended release of the parking brake by filling the BP via leakages from the several air reservoirs shall be prevented. This may be achieved by a special device connected to the BP which ensures, any leakages into the BP are exhausted.

It shall be possible to release the parking brake without the use of electrical energy for the rescuing purposes. The parking brake shall reset automatically when it is next released using the normal method e.g. by filling the release pipe with compressed air.

The parking brake manual release mechanism shall be accessible without going under the vehicle and should be accessible from both sides of the train.

In the case of a manually operated pressure released spring applied brake release pressure (applied = red, released = green, indication not valid) should be indicated without using electrical energy in accordance with EN 15220-1.

The parking brake shall still be capable of manual release even when the full service brake is applied.

Friction brake wear shall be automatically compensated by a device that permits operation of the service/emergency brake and the parking brake.

5.12 Location of the control devices

5.12.1 Driver's cab

5.12.1.1 General

The location of the control devices should comply with the future recommendations of CEN/TC 256/WG 37 "Driver's cab".

Control devices shall be provided in the driver's cab for the following:

— testing of brake functionalities in accordance with 5.8, 5.9 and 5.11;

— enabling and isolation of equipment at train level;

— managing faults.

Location and design of the control devices shall respect ergonomic aspects as well as the importance of the function and the frequency of application.

When a cab respectively a driver’s desk is made active then the train brake system shall also be made active with the exception of the man-machine interfaces in all other cabs in the train, but in those cabs still providing the following functions:

— emergency brake application;

— optional: parking brake application command;

The activation of the cab shall not change the application or release status of the brake. The status may only be changed as a result of a direct action on the part of the driver.

5.12.1.2 Primary area

The following devices shall be located in the easy reach area and the access to each device shall be ergonomically optimized:

— the combined traction-/brake control device if available;

— the brake control device being used for the regular braking functions, commanding service braking and emergency braking; depending on the design concept;

— the lever for the electro-dynamic brake (if available);

— the lever for the direct brake (if available);

— control device for the sanding system (if available).

5.12.1.3 Secondary area

The following devices shall be located in the secondary area and the access to each device shall be still from the driver's normal seated position.

— emergency push button according to 5.8;

— button to control the spring applied brake, if manually operated according to 5.11.

These devices shall be accessible from the driver's normal seated position within arms length and without obstruction. It is not necessary to locate them on the driver's desk and not in the field of view of the driver when observing the signals and the track.

5.12.1.4 Tertiary area

The following devices should be located in the tertiary area:

— isolating switches;

— isolation cocks;

— MMI for ATP data.

5.12.1.5 MMI – Man Machine Interface for the driver

Certain manipulations which do not occur frequently and which are not safety related may be integrated in the MMI-displays designed as soft keys or touch screen interfaces. They are for example:

— starting the brake test;

— enable and disable the compressors;

— quit fault messages;

— overcharging (if applicable);

— isolation of the brake pipe control.

5.12.2 Operating devices other than in the cab

5.12.2.1 Service panel inside the vehicles

The service panels inside the vehicles provide local options to control certain functions which allow the train staff to remain inside the train while managing faults instead of leaving the train:

— gauge to indicate the brake cylinder pressure;

— remote controlled isolation of the pneumatic brake, with an indication included, (if applicable);

— if available a remote controlled isolation of track brakes (if applicable);

— indicator for parking brake (5.11.4) in case of manually operated spring applied brake if this indicator is not on the outside of the vehicle.

The easy access for the train staff shall be ensured. Access of unauthorized persons shall be prevented.

5.12.2.2 Passenger area

Passengers shall get access to the passenger alarm system as set out in EN 16334.

5.12.2.3 Isolating devices

Devices shall be provided to isolate a brake malfunction in order to permit operation to the next destination.

Possible locations are for example:

— panels outside the vehicle; consideration should be given for access from both sides of the vehicle;

— entrance areas;

— cabinets inside the vehicle.

The isolation of a local brake controller shall be made clearly visible for the user (i.e. the distributor valve). Isolating cocks shall be available for those devices which are connected with the brake pipe.

5.13 Fault monitoring and diagnostics

5.13.1 Brake indicators

Provision shall be made to enable the driver to check the brake command and brake response status continuously along the entire train.

Suitable means to achieve this is the provision of:

— a diagnosis system providing information into the driving cab;

— easily visible “Brake applied – Brake released” indicator panels on each side of the car in accordance with EN 15220-1. These panels shall have a red “Brake applied” display field and a green “Brake released” display field;

— internal pressure gauges.

Provision of the indicators or gauges is required when the diagnosis system is not available or for rescuing modes. These indicators shall operate completely independent from the battery and the supply with electrical energy. The same applies for the parking brake if manually operated.

It is not allowed to fix any other devices between the brake cylinders and their indicators other than the WSP valves. If the intention is to check the operation of the WSP valve then the indicator shall be downstream of the valve.

In vehicles with several local brake control units, a separate indicator shall be provided for each individual control unit.

Inside the vehicles a gauge indicating the brake cylinder pressure is mandatory if no outside indication.

In the driver's desk display of the following information is mandatory in all operational conditions:

— main reservoir pipe (MRP) pressure;

— brake pipe (BP) pressure (if applicable);

— optional equipment for the cab: the brake cylinder pressure of the related vehicle.

If gauges are used, the following shall apply:

— minimum accuracy: class 1.6 in accordance with EN 837-1:1996;

— diameter for brake pipe pressure gauge and reservoir pipe pressure gauge: greater or equal 80 mm;

— diameter brake cylinder pressure pressure gauge: greater or equal 60 mm.

The gauges shall be designed such that in the case of a broken supply pipe the leakage is limited to a tolerable amount without affecting the mission of the train.

5.13.2 Diagnosis System

The diagnostic data shall distinguish between:

— driver related and operational related data;

— maintenance related data.

All the failures of the brake system detected by the diagnostic system that:

— bring about an automatic system response shall be immediately drawn to the attention of the driver along with advice regarding the cause of the automatic action;

— require an immediate action from the driver (stopping the train or slowing down) shall be indicated clearly on the driver's desk.

The failure shall be prioritized. One strategy is set out in UIC 557.

Each EMU/DMU shall store its own set of diagnostic data. The data of the complete train shall be indicated in the active cab.

After regular decoupling of two EMU’s/DMU’s the failure information shall be preserved in that EMU/DMU on which the failure occurred.

Any failure messages shall include the localization in the train.

It could be helpful to introduce a further classification of failures regarding the phases of operation like:

— failure message immediately after detection when the train is still in motion;

— failure message when the train has come to a standstill;

— failure message during preparation of the train respectively after the brake test.

The failure of the monitoring system itself shall be indicated to the driver.

Classification of failure events:

a) immediate automatic action in form of an emergency brake or a full service brake for example in case of:

    1) broken hose of the spring brake, if resulting in an undemanded brake application that can generate an unsafe situation;

    2) application of the passenger alarm system (automatic action as set out in 5.9.2.3);

    3) input from other train safety system, if applicable:

        i) detection of derailment;

        ii) major mechanical failure (for example cardanshaft, axle box bearings);

    4) others, if urgently required by the train architecture;

b) audible and/or (upon request) visual warning provided with sufficient data/information to advise the driver of the necessary action, for example in the case of:

    1) critical reduction of compressed air pressure in the main reservoir system, in which case the driver action is to stop the train at the nearest suitable place;

    2) failure of a pneumatic brake unit;

    3) failure of an electrical brake unit;

    4) non rotating wheelset; (if applicable);

    5) undemanded brake application or release;

    6) hot axle box, if applicable.

The driver shall be provided with the means of acknowledging the warning (visual and audible) alarms. In addition all warnings shall be registered on a suitable data recorder.

c) Messages which provide operational and brake system (safety) status information to the driver and the maintenance staff, for example in the case:

    1) loss of a safety relevant redundancy;

    2) one or more isolation or override devices have been operated;

d) Information about an unusual status of the brake system addressed to the maintenance staff only, for example in the case of:

    1) failure of a WSP speed sensor.

The different types of failure events require different safety integrity levels for the message transmission:

— Type a) requires a hard wired safety loop for collecting the message data or alternatively a de-central initiation of a train wide emergency brake application;

— Type b) to type d) requires normal availability which allows collecting and transmitting the data via the data bus.

When the EMU/DMU has returned to normal functionality all messages shall only be deleted by authorized staff.

Each vehicle shall be provided with suitable interface connections of external service terminals and may also be equipped with a device to perform local tests assisted by a small display and keyboard.

Those failures which are recorded by computer aided devices shall be related to the date and time of the failure and other relevant data, e.g. speed, severity.

An intermittent failure shall be stored within the memory on the train until such time as the cause of the failure has been identified and corrected.

The diagnostic system shall enable the staff to read via an easily accessible interface:

— the operational status of the brake system;

— the failure code;

— the date and time of the failure and other relevant data;

— the values of various parameters in real time.

The diagnostic system shall provide the relevant languages of the countries through which the trains operate and where the train can be maintained.

Downloaded data should also be displayed graphically and should be capable of being exported in standard data format for use on a normal computer.

5.14 Driver's brake test

5.14.1 General

The drivers brake test shall achieve the following with the train in a static condition:

— confirm that all brake subsystems are configured correctly and that they are communicating;

— confirm that the energy supply of the brake system is available throughout the entire train;

— verify the continuity of the brake command system, using the brake pipe and/or any other form of continuous element of the brake system;

— confirm the correct function of the brakes throughout the entire train, which means the correct application and release function.

Provision shall be made that during the brake test the train shall be kept stationary.

5.14.2 Regular basic brake test

The brake system shall be designed so that the following test may be easily carried out.

A regular basic brake test shall be carried out:

— after the train has been parked and the driver has closed down the active cab and the train has been put into service again;

— after change of the direction;

— after coupling and uncoupling an EMU/DMU (to confirm continuity and the correct function of the brakes in the added or in the split portions of the train);

— before being rescued;

— after connecting a locomotive for rescuing purposes.

The regular basic brake test shall as a minimum:

— check the functions of the active driver's brake control, using the driver's cab mounted indicators;

— verify the continuity of the brake, using the brake pipe and/or any other form of continuous element of the brake system where fitted.

This includes for example:

— the ep assist where fitted;

— check the isolation of the other non active driver's brake valves.

The ep assist functions need not be tested when the ep brake force has not been included within the train brake force calculation.

It shall be possible to execute the regular basic brake test within 3 min.

5.14.3 Full brake test

A full (driver's) brake test shall comprise:

— the test of the command chain of the emergency brake application using the primary control devices;

NOTE The CCS self-test also checks the emergency brake command, but is considered as additional to this full brake test.

— the brake application and release in each vehicle of the EMU/DMU.

Brakes shall be fully tested:

— regularly;

— as often as required by the architecture of the brake system and as required by the RAMS calculation.

A typical sequence for conducting the full brake test is as follows:

— once per day (covering 24 h);

— after repair activity that could have influenced the integrity of the brake system.

The full brake test shall as a minimum:

— test the availability of the energy supply of the brake system (e.g. pressure level in the main reservoir pipe);

— check additional hard wired lines applying the emergency brake;

— check the track brakes (if equipped);

— check the application and release function of the parking brake; if applicable;

— check the dynamic brakes (if equipped) as far as possible in static conditions;

— consist of the test as described in 5.14.2 (regular basic test).

If not covered by the items above, the test contents shall be adapted according to the brake architecture.

NOTE Some features can only be checked in an automatic procedure.

5.14.4 Undertaking brake tests

The brakes can be tested as follows:

— manually, where the brake status is checked at the outside or inside of the train using the brake indicators located on each vehicle;

— semi-automatic brake test performed in the active cab using a display to provide step by step guidance and display electronic data collection;

— optionally: an automatic brake test (automatically performed by the system including target/actual comparison) with a subsequent functional check of the man-machine interfaces in the cab. (e.g. brake valve, push button).

As a minimum, the results of the last three full brake tests shall be stored within either the train or brake computer, including date and time.

For the semi-automatic and automatic brake tests the results shall be clearly displayed. The displayed location of all faults shall be performed reliably.

It shall only be possible to carry out the semi-automatic or automatic brake test when:

— initiated from an active cab and

— the train is stationary.

If required by the operator, the brake system can calculate the total brake weight percentage of the train based on the total weight of the train and the brake weight from each independent brake unit. The calculated brake weight percentage shall be displayed for the driver.

5.15 Power supply

5.15.1 Air pressure supply

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

The vehicle's brake supply reservoirs shall be dimensioned such that the air consumption of the WSP does not impair the performance of the pneumatic brake. The brake supply reservoir capacity and the minimum supply pressure shall provide two emergency brake applications at the maximum brake cylinder pressure.

A loss of air in the main supply system shall be monitored and a warning given as set out in 5.13.

Provide a permanent monitoring of the supply of brake energy with a minimum mandatory function that shall inhibit the traction and any brake release function should the level drop below a predetermined value. This value shall be sufficient to ensure the maximum brake cylinder pressure.

Monitoring at individual brake reservoir level is recommended for short EMU/DMU formations such as those units with 12 wheelsets or less.

5.15.2 Electrical energy supply

The supply of electrical energy for the brakes shall be given preference when considering the operation of any devices or system incorporated for managing the train electrical power supplies, i.e. brake function has a higher priority than protection of components.

A WSP system shall have its own protected circuit. Fuses or circuit breakers for the WSP shall be separated from others on the vehicle. The WSP shall be supplied whenever there is power available. Automatic cut-off of the supply is only permissible in the case of sleep mode (no vehicle movement) or battery protection for battery safety reasons (degraded battery situation or low voltage caused by long-term lack of supply).

5.16 Enhancement of wheel-rail adhesion

A means shall be fitted to the train to compensate for insufficient wheel-rail adhesion during braking. This shall be based upon the application of a suitable substance (standard application is sand, etc.) to the wheel-rail interface when the level of adhesion available at this interface is less than the level of adhesion demanded by the brake and it shall be available at all times during braking. In the following paragraphs the term sand is used as an alternative for any substance used for compensating insufficient levels of wheel-rail adhesion.

This system may also be used as an aid to reducing wheel spin in traction mode

The substance used shall be deposited in an effective, reliable and repeatable manner in all train operating conditions during service and emergency braking. Equipment heating and ventilating devices, etc. may be incorporated into the low adhesion compensation system if required.

The use of sanders and the amount of sand shall be subject to the agreement of the infrastructure manager.

If there is no specification from the infrastructure manager, the laid sand on the rail shall not exceed is 5 g per meter.

NOTE Higher quantities of sand delivery can be agreed between the operator and the relevant transport authority. This can be considered as a preliminary procedure until the CCS TSI is revised.

The following shall be considered when selecting the substance to be used to compensate for insufficient wheel-rail adhesion and the equipment used to deposit the substance at the wheel rail interface:

— excessive wheel wear;

— excessive rail wear;

— detrimental effects on train detection systems;

— detrimental effects on the environment (pollution).

The driver shall be provided with a manual control for use at the driver's discretion to allow sanding to be used continuously.

Automatic sanding during braking is permitted when WSP activities are detected. The infrastructure manager may place restrictions on the use of the automatic sanding (e.g. for emergency braking only).

A means shall be provided for testing the correct function of the wheel-rail adhesion compensation system during train maintenance, including a means for checking the individual rate and consistency of deposition of the substance used is within acceptable limits and that speed and other vehicle system interlocks (e.g. WSP) are active.

The system shall work at all operating temperatures. When operating below 5 °C the system components should be heated.

The heating device shall be turned off:

— if the outside temperature is more than 5 °C;

— the heating is not demanded in cases of maintenance.

However, the heating device shall be at the disposal for maintenance staff for test purposes.

It shall be possible to check the quantity of the substance required to ensure daily operation which is used for compensating low levels of wheel-rail adhesion. The driver should be provided with a warning in the event that the quantity falls below the minimum level prescribed for normal train operation.

5.17 Maintenance

The brake system shall be provided with diagnostic interfaces with a suitable connection for a mobile test computer to indicate failures in the brake system, the WSP and the related equipment (like speed sensors for example) and to provide information on the type of failure and its location.

Failures which are monitored on microprocessor based devices shall provide related information on the context of the failure (e.g. time and date, speed, severity of the failure, etc.).

The failure message shall be stored until the failure has been repaired.

Intermittent failures shall be stored until the cause of the failure has been identified and corrected.

Easy access shall be provided to the diagnosis data in each vehicle or control segment of the train.

All brake system components requiring access by operational staff shall be designed and located such that they can be easily accessed. This provision should also allow the operation when the train is positioned alongside station platforms.

Maintenance staff shall be capable of changing brake pads and blocks safely by isolating the power and parking brakes.

All enclosed devices to operate the brakes and to indicate the status of the brakes shall be given access by a standardized key, at least covering the operator's fleet.

6 Braking performance

6.1 General

The braking performance of the EMU/DMU trains shall be declared for the rolling stock register; it shall provide the following information:

— nominal performance of the train consist;

— degraded mode conditions as set out in TSI “Locomotive and passenger RST”.

The performance contribution of each (local) subsystem which can be isolated separately shall be recorded in the technical file of the EMU/DMU.

The brake performance required for safety shall be achieved by the emergency brake.

NOTE The purpose of the service brake performance is to satisfy the operational and economic requirements.

6.2 Emergency braking

6.2.1 General

The braking requirements shall be specified in terms of decelerations (recommended solution for application with ETCS, pre-programmed data on board), alternatively braking requirements can be specified in terms of Lambda-values or stopping distances.

The braking performances shall fall within one of the performance categories (P, R, R+) as set out in the diagrams of Annex A. The diagrams show a selection of suggested curves in the defined categories as an aid to the design of the brake system. Preferably one or more of the curves should be selected in the design phase to define the braking performance in order to be compatible with the infrastructure braking requirements.

If load compensating brake systems are not fitted or do not cover the exceptional load conditions then specific operational rules may be necessary.

In the speed range > 30 km/h, the braking system of the unit dependent of adhesion conditions shall not assume instantaneous deceleration higher than 1,5 m/s^2 (excluding effects of running resistance).

The emergency braking stopping distance shall not be longer than the full service braking distance. The emergency braking performance applicable to operation shall only be related to a maximum adhesion coefficient demand μ as given in 6.5, a).

If adhesion independent brakes are used (e.g. category R+ in Annex A), the effort generated by these brakes shall be in addition to the effort generated by the adhesion dependent brakes.

The compliance with the specification shall be demonstrated in accordance with EN 16185-2.

6.2.2 Particularities of the national lines

Interoperable EMU/DMU trains shall additionally respect the national particularities when they are operating on the respective national networks, e.g. use of magnetic track brakes.

The requirements shall be specified.

6.3 Service braking

The minimum braking performance (in step 1) shall provide a detectable retardation. This should be at least 0,1 m/s^2 excluding effects of running resistance. Further steps shall increase the retardation in proportion to the increasing demand.

Maximum service brake shall provide at least 75 % of the emergency brake instantaneous retardation without any adhesion independent brakes. Higher target value could be specified at the design phase to define the braking performance in order to be compatible with the operator's or infrastructure braking requirements.

During the transition period from a full service brake application to an emergency brake application a maximum reduction of deceleration of 0,2 m/s^2 for a maximum time of one second is on level track permitted.

6.4 Thermal requirements

The thermal brake capacity shall permit two consecutive emergency brake applications from maximum speed at maximum braking load on level track with fully functional brake installation. The interval between the emergency brake applications shall take into account the units own traction performance. The brake materials shall withstand the resulting temperatures and mechanical stresses. The extension on the stopping distances resulting from the second emergency brake application shall be declared. Following subsequent cooling the brake materials shall permit the rolling stock to remain in service without restrictions. The requirements for the cooling period shall be declared.

The thermal brake capacity shall permit a single emergency brake application, when applied at any point during a period of specified duty cycles. The emergency brake shall be considered to occur where the starting thermal stress is at a maximum value derived from the duty cycle defining initial temperature and entry speed. The stopping distances achieved under these conditions shall be declared. If the train is subject to degraded mode conditions operational restrictions shall be derived on the basis of equivalent thermal stresses.

Additional requirements may also be necessary for operation on routes with significant gradients steeper than 35 ‰.

Maintaining the speed on a gradient may be achieved by the dynamic brakes only.

Compliance to these thermal requirements shall be proven by calculation or by test.

6.5 Adhesion values

a) During emergency brake application in the speed range > 30 km/h, the wheelsets or wheels of the unit shall not assume wheel/rail adhesion higher than the following values:

    1) 0,15 for EMU/DMU having more than 7 axles;

    2) 0,13 for EMU/DMU having 7 axles or less.

b) During service brake application in the speed range > 30 km/h, the wheelsets or wheels of the unit shall not assume a wheel/rail adhesion demand greater than in paragraph a) except for electro-dynamic brakes, which shall not assume wheel/rail adhesion higher than 0,20.

c) If the EMU/DMU is fitted with a direct brake in the speed range > 30 km/h the wheelsets or wheels of the unit shall not assume wheel/rail adhesion as specified in paragraph a).

When testing service and emergency brake applications on all artificially generated adhesion conditions as set out in EN 15595, the braking distance increased of the unit shall not be longer than the maximum value permitted by EN 15595.

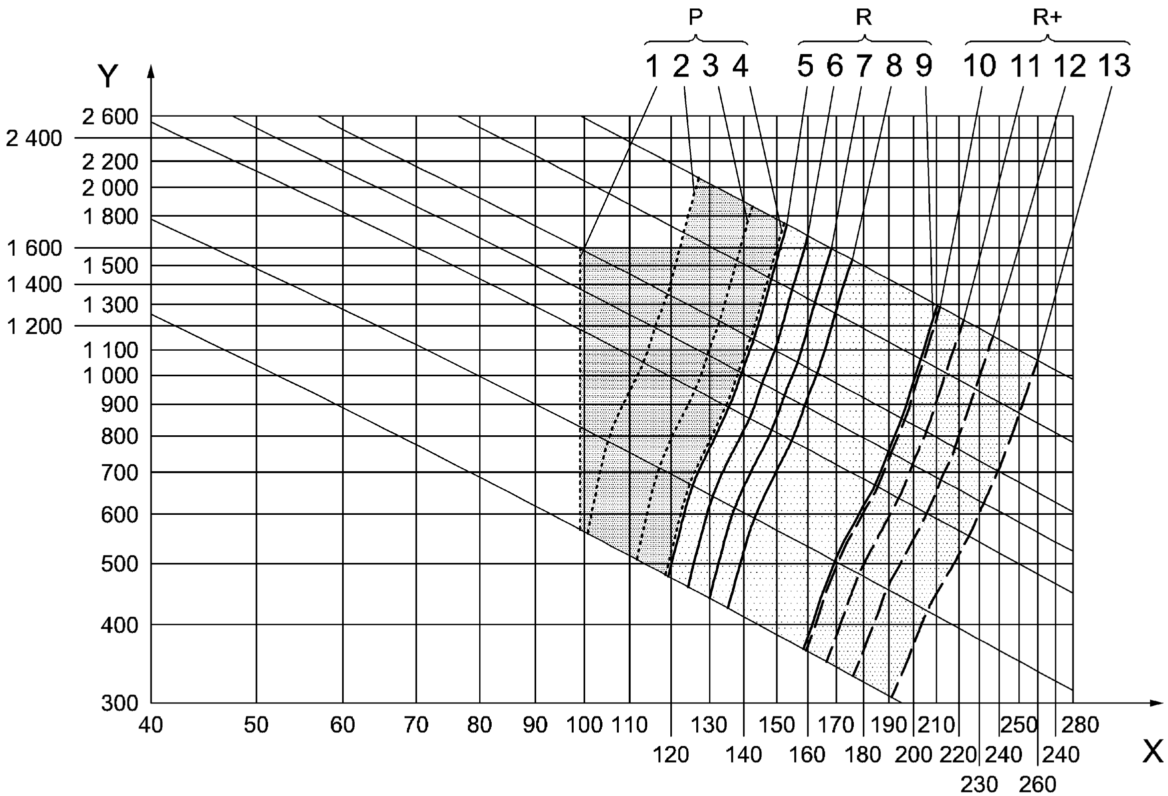
These limits of wheel rail adhesion demand shall be verified by calculation for each wheelsets or wheels with the smallest wheel diameter and in the range of the load cases considered.

All values shall be rounded to the second digit.

Annex A
(normative)

Brake performance categories

Figure A.1 shows brake performance categories, stopping distance over brake weight percentage (using the assessment sheet from UIC 544-1).



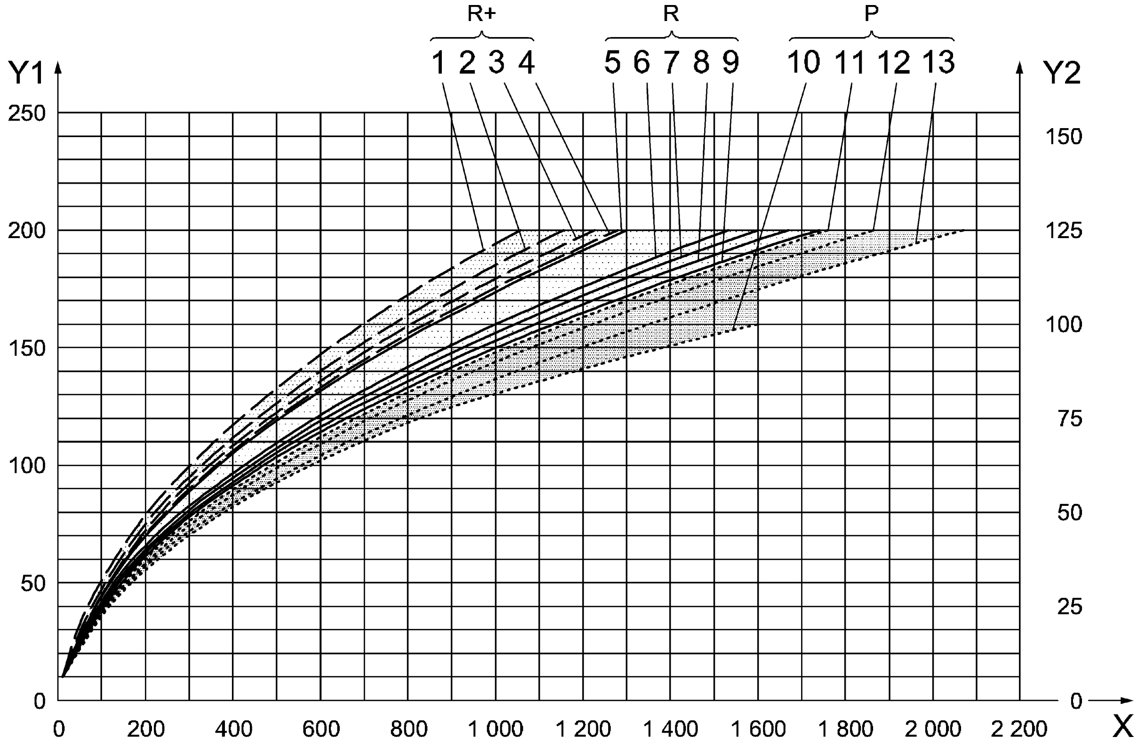
Key

Y stopping distance in m
X brake weight percentage in %
1 P1 (UK)
2 P2 (UIC)
3 P3 (France)
4 P (max)
5 R (min)
6 R1 (UK)
7 R2 (UIC)
8 R3 (Germany)
9 R (max)
10 R+Mg1 (min)
11 R+Mg2 (Germany)
12 R+Mg3
13 R+Mg (max)

NOTE All values are for level gradient.

Figure A.1 — Brake performance categories, braking stopping distance over brake weight percentage

Figure A.2 and Table A.1 show brake performance categories, speed vs braking distance.



Key

Y1 initial speed in km/h

Y2 initial speed in mph

X braking distance in m

1 R+Mg (max)

2 R+Mg3

3 R+Mg2 (Germany)

4 R+Mg1 (min)

5 R (max)

6 R3 (Germany)

7 R2 (UIC)

8 R1 (UK)

9 R (min)

10 P1 (UK)

11 P (max)

12 P3 (France)

13 P2 (UIC)

NOTE All values are for level gradient.

Figure A.2 — Brake performance categories, speed vs braking distance

Table A.1 — Brake performance categories, speed vs braking distance

Curve		**P1** UK	**P2** UIC	**P3** France	**P** max	**R** min	**R1** UK	**R2** UIC	**R3** Germany	**R** max	**R+Mg1** min	**R+Mg2** Germany	**R+Mg3**	**R+Mg** max
Evaluation speed	v km/h	100	120	120	120	120	120	120	120	120	140	140	140	140
Braked weight percentage UIC 544-1	λ %	99	105	117	125	125	131	135	143	170	184	194	206	225
Initial speed	v_0 km/h	**Braking distance** $s(v_0)$ m												
	60	200	220	200	195	190	185	180	170	155	150	145	135	135
	70	260	290	265	255	250	240	235	225	200	195	185	175	170
	80	345	370	335	325	320	305	300	285	250	245	235	225	210
	90	450	460	415	400	395	380	370	350	305	300	290	275	260
	100	565	555	505	480	475	465	445	425	365	365	345	330	310
	110	700	665	605	575	570	550	530	505	435	430	410	390	365
	120	850	785	710	675	670	650	625	590	505	505	480	455	425
	130	1 015	910	825	780	775	755	720	685	585	585	555	525	490
	140	1 190	1 050	950	895	890	870	830	785	670	665	635	600	555
	150	1 400	1 195	1 080	1 020	1 015	990	945	890	760	755	720	680	630

Annex B
(informative)

Explanation of “proven design” concept

This Annex provides further explanations for the concept of proven design.

Extract from British Railway Group Standard for demonstration of “proven design”

a) 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 that have not previously demonstrated satisfactory service experience in brake systems under corresponding conditions. 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.

b) 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 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.

c) 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 assessment procedures above.

Annex C
(normative)

Minimum values of bending radii for steel pipes

Table C.1 shows the minimum values of bending radii for steel pipes.

Table C.1 — Bending radii for steel pipes

Dimensions in millimetres

External diameter of the pipe *d*	**Bending radius** *R*	**External diameter of the pipe** *d*	**Bending radius** *R*
6 8 10; 10,2	16 20 25	44,5; 45; 48; 48,3 50; 51; 54; 56; 57; 60; 60,3 63,5; 65; 70; 76; 76,1	125 160 200
12; 13,5 14; 15; 16 17,2; 18	32,5 40 45	80; 82,5; 88,9; 90 95; 100; 101,6; 102; 108 110; 114,3	250 315 350
20; 21,3 22; 25 26,9	55 65 70	120; 212; 127 133; 139,7 152,4; 159; 165,1; 168; 168,3	400 450 500
28; 30 31,8; 32; 33,7; 35; 36; 38 40; 42; 42,4	80 100 110		

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC

This European Standard has been prepared under a mandate given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the Directive 2008/57/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Tables ZA.1 and ZA.2 for the current TSIs at the time of the publication of this standard and Tables ZA.3 and ZA.4 for the new approved TSIs, within the limits of the scope of this standard, give a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard, the CR TSI Locomotives and Passenger RST (TSI CR Loc & Pass) published on 26.05.2011 in the OJEU. and Directive 2008/57/EC

Clause/subclauses of this European Standard	Chapter/§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
The whole standard applies.	4.Characterisation of the Rolling stock subsystem 4.2 Functional and technical specifications of the subsystem 4.2.4 Braking 4.2.4.1 General 4.2.4.2 Main functional and safety requirements 4.2.4.3 Type of brake system 4.2.4.4 Brake command 4.2.4.5 Braking performance 4.2.4.6 Wheel rail adhesion profile – Wheel slide protection system 4.2.4.7 Dynamic brake – Braking system linked to traction system 4.2.4.8 Braking system independent of adhesion conditions 4.2.4.9 Brake state and fault indication 4.2.4.10 Brake requirement for rescue purpose	Annex III, Essential requirements 1 General requirements 1.1 Safety Clauses 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5 1.2 Reliability and availability 1.3 Health Clause 1.3.2 1.4 Environmental protection Clause 1.4.2 1.5 Technical compatibility 2 Requirements specific to each subsystem 2.4 Rolling stock 2.4.1 Safety §3 2.4.2 Reliability and availability 2.4.3 Technical compatibility §3	This table will be obsolete with the publication of the TSI “Loc & Pass” and superseded by Table ZA.3.

Table ZA.2 — Correspondence between this European Standard, the TSI SRT published in the OJEU dated 7 March 2008 and Directive 2008/57/EC

Clause/subclauses of this European Standard	Chapter/§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
5.1.2 Fire protection 5.1.10 Operation in very long tunnel	4.Characterisation of the subsystem 4.2 Functional and technical specifications of the subsystem 4.2.5. Subsystem rolling stock 4.2.5.5. Additional measures for running capability of passenger rolling stock with a fire on board 4.2.5.5.1 General objectives and required running capability for passenger trains 4.2.5.5.2 Requirements for brakes	Annex III, Essential requirements 1 General requirements 1.1 Safety Clauses 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5 1.2 Reliability and availability 1.3 Health Clause 1.3.2 1.4 Environmental protection Clause 1.4.2 1.5 Technical compatibility 2 Requirements specific to each subsystem 2.4 Rolling stock 2.4.1 Safety §3 2.4.2 Reliability and availability 2.4.3 Technical compatibility §3	This table will be obsolete with the publication of the revised TSI SRT and superseded by Table ZA.4.

Table ZA.3 — Correspondence between this European Standard, the TSI Locomotive and Passenger Rolling Stocks (approved by the RISC68 on 23 October 2013), and Directive 2008/57/EC

Clause/subclauses of this European Standard	Chapter/§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
The whole standard applies.	4.2 Functional and technical specification 4.2.4 Braking 4.2.4.1General 4.2.4.2Main functional and safety requirements 4.2.4.3 Type of brake system 4.2.4.4 Brake command 4.2.4.5Braking performance 4.2.4.6Wheel rail adhesion profile - Wheel slide protection system 4.2.4.7 Dynamic brake - Braking system linked to traction system 4.2.4.8 Braking system independent of adhesion conditions 4.2.4.9Brake state and fault indication 4.2.4.10 Brake requirements for rescue purposes 4.2.10 Fire safety and evacuation 4.2.10.4 Requirements related to emergencies §4.2.10.4.4 Running capability	Annex III, Essential requirements 1 General requirements 1.1 Safety Clauses 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5 1.2 Reliability and availability 1.3 Health Clause 1.3.2 1.4 Environmental protection Clause 1.4.2 1.5 Technical compatibility 2 Requirements specific to each subsystem 2.4 Rolling stock 2.4.1 Safety §3 2.4.2 Reliability and availability 2.4.3 Technical compatibility §3	

Table ZA.4 — Correspondence between this European standard, the TSI SRT (approved by the RISC68 on 23 October 2013), and Directive 2008/57/EC

Clause/subclauses of this European Standard	Chapter/§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
5.1.2 Fire protection 5.1.10 Operation in very long tunnel	4.2.Functional and technical specifications of subsystem 4.2.3 Subsystem rolling stock 4.2.3.3 Requirements related to emergencies 4.2.3.3.4 Running capability	Annex III, Essential requirements 1 General requirements 1.1 Safety Clauses 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5 1.2 Reliability and availability 1.3 Health Clause 1.3.2 1.4 Environmental protection Clause 1.4.2 1.5 Technical compatibility 2 Requirements specific to each subsystem 2.4 Rolling stock 2.4.1 Safety §3 2.4.2 Reliability and availability 2.4.3 Technical compatibility §3	This TSI refers to Requirements of the TSI “Loc & Pass” Clause 4.2.10.4.4.

Bibliography

[1] EN 13452-1, *Railway applications — Braking — Mass transit brake systems — Part 1: Performance requirements*

[2] prEN 16186-1, *Railway applications — Driver's cab — Part 1: Visibility, layout, access*

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