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Railway applications — Braking systems of high speed trains

Part 1: Requirements and definitions

National foreword

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Foreword

This document (EN 15734-1:2010) 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of an identical text or by endorsement, at the latest by May 2011, and conflicting national standards shall be withdrawn at the latest by May 2011.

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 the EU Directive, see informative Annex ZA, which is an integral part of this document.

EN 15734, *Railway applications — Brake systems of high speed trains*, consists of the following parts:

— *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, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard describes the functionality, constraints, performance and operation of a brake system for use in high speed trains as described in the TSI High Speed Rolling Stock, operating on routes of the European railways and their infrastructure systems.

The brake system requirements specified in this European Standard apply to trains that may operate at a maximum speed of up to 350 km/h on lines specifically built for high speed and define graduated values for deceleration related to four speed ranges (see Clause 6).

This European Standard covers:

— all new vehicle designs of high speed trains;

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

This European Standard does not cover locomotive hauled trains, which are specified by EN 14198.

NOTE This document applies the functional subdivision into subsystems as specified in the TSI High speed. The braking system is part of the function: “Accelerate, maintain speed, brake and stop”.

2 Normative references

The following referenced documents are indispensable for the application of this document. 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 13749:2005, *Railway applications — Wheelsets and bogies — Methods of specifying 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 14531-6, *Railway applications — Methods for calculation of stopping and slowing distances and immobilisation braking — Part 6: Step by step calculations for train sets or single vehicles*

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

EN 14601, *Railway applications — Straight and angled end cocks for brake pipe and main reservoir pipe*

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*

prEN 15328, *Railway applications — Braking — Brake pads*

prEN 15329, *Railway applications — Braking — Brake block holder and brake shoe key for rail vehicles*

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 15734-2, *Railway applications — Braking systems of high speed trains — Part 2: Test methods*

CEN/TS 45545 (all parts), *Railway applications — Fire protection on railway vehicles*

EN 50121-3 (all subparts), *Railway applications — Electromagnetic compatibility*

EN 50125-1:1999, *Railway applications — Environmental conditions for equipment — Part 1: Equipment on board rolling stock*

EN 50126-1, *Railway applications — The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS) — Part 1: Basic requirements and generic process*

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

EN 50215, *Railway applications — Rolling stock — Testing of rolling stock on completion of construction and before entry into service*

UIC 541-03:1984, *Brakes; regulations concerning manufacture of the different brake parts; driver's brake valve*

UIC 544-1:2004, *Brakes — Braking power*

UIC 557:1998, *Diagnosis techniques for coaches*

UIC 648:2001, *Connections for electric cables and air pipes on headstocks of locomotives and driving trailers*

UIC 651:2002, *Layout of driver's cabs in locomotives, railcars, multiple unit trains and driving trailers*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 14478:2005 and the following apply.

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

NOTE It is normally the leading cab.

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

3.3
brake loop
electrical hard wire keeping brakes released when energised

3.4
brake weight percentage
brake performance according to UIC 544-1

3.5
control chamber A
is called "command reservoir" in EN 14478

3.6
direct brake
is called "straight brake" according to EN 14478

3.7
driver's vigilance device
is called "dead man's device" according to EN 14478

3.8
dynamic brake
brakes in which the brake force is produced by the movement of the vehicle or its functional elements, but not involving friction

3.9
parking brake
is called "immobilization braking" in the revised TSI

3.10
Ep assist
electrically commanded assist system to vent and feed the brake pipe

3.11
holding brake
service brake application to stop a slowly moving train to standstill and/or prevent a train from moving for a limited time

3.12
independent brake unit
set of equipment, constituting an independent unit, whose function is to generate a retarding force on a vehicle or a part of a vehicle in response to a train brake signal

3.13
local control unit
control unit acting upon a vehicle related system or sub-system

3.14
normal service brake
2/3 of full service brake, which corresponds with venting the brake pipe by 1 bar

3.15
overbraking
brake application exceeding the available wheel/rail adhesion

3.16
overcharging
pressurising the brake pipe above the level of the nominal release pressure

3.17
passenger communication alarm
functional part of the passenger alarm system providing information from and to the passenger

3.18
pilot pressure circuit
pressure circuit using components of reduced dimensions in order to control a limited flow rate which is subsequently amplified

3.19
power brake
means by which the service and emergency brakes are applied

3.20
reference speed
signal generated and used by the WSP system as an approximation of the train speed used for comparison with the instantaneous wheel set speed as part of the control set algorithm

3.21
regenerative (mode of electro-dynamic braking)
converting the braking energy into electrical energy and generating an energy flow into the main energy supply

3.22
rheostatic (mode of electro-dynamic braking)
converting the braking energy into electrical energy and dissipating the electrical energy in a resistor

4 Symbols, units and abbreviations

For the purpose of this document, the following symbols, units and abbreviations apply.

BP Air brake pipe

EBL Emergency brake loop

ECB Eddy current brake

EP Electro-pneumatic brake

MRP Main reservoir pipe

WSP Wheel slide protection

H Hydrodynamic brake

MMI Man-machine interface

s_B Braking distance

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:

a) the braking performances defined in Clause 6;

b) the design principles listed in the document below;

c) the design principles listed in relevant standards on brake systems;

d) the requirements for the operator using and maintaining the brake system in the intended manner;

e) keeping within the required limits, in order to reduce the 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:

f) the brake force applied is greater than the level of brake demanded:

1) impact on standing passengers;

NOTE No limits are so far defined to secure passengers, only reference could be made to the TSI requirement considering longitudinal forces which corresponds to 2,5 m/s².

2) excessive jerk;

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

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

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

2) emergency brake performance not achieved;

3) parking brake: performance not achieved;

4) holding brake for brake test not achieved;

h) there is no brake force, when demanded:

1) emergency brake not activated 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;

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

1) undue local brake application;

2) locked axle not detected;

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

The hazards in this list shall be assessed in accordance with EN 50126-1.

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, whilst 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 conform to the following requirements:

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

l) in the case of a loss of service brake efficiency and:

1) if detected by the driver there shall be a means available for the driver to immediately apply the emergency brake by using the same lever which is used for service braking;

2) if the driver fails to detect a loss of efficiency then the train protection system (technical intervention system) shall have access to an emergency brake application;

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

n) provide service brake effort at the level requested.

High-speed trains incorporate a speed control system functioning with different deceleration levels. The prescribed performance levels defining the minimum braking power for trains suitable for running on all high-speed lines are given in Clause 6. The compliance of these performance levels and the safety of the braking system shall be fully demonstrated as specified in EN 15734-2.

Accepted benchmark safety level for a brake system is the UIC-architecture as described in EN 14198. It is characterized by the following items:

o) a continuous, automatic and inexhaustible brake system;

p) the medium is compressed air with its favourable properties;

q) an energized (pressurized to release) brake pipe;

r) decentralized brake actuators, developing the brake force;

s) proven design components.

The components used shall withstand during their period in service any normal or exceptional stresses that have been specified. The safety implication of any failures shall be limited by appropriate means; as described in this standard.

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

t) functions at train level (in the sense used in EN 14198) shall be designed low active;

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

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

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

The acceptance criteria is defined by a reduced deceleration level as specified under degraded mode conditions “B” in the TSI as well as in Clause 6 in this document. Further reductions in the deceleration level are only tolerable when the probability of its occurrence is sufficiently low. At least, a qualitative examination shall be carried out.

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 toxic fumes. This shall be achieved by selecting appropriate materials, by an appropriate system architecture and installation arrangement.

The braking system shall, in a manner, be consistent with the train fire protection requirements according to CEN/TS 45545-1 to CEN/TS 45545-7 or according to the TSI HS RST. A fire on board the train shall not cause the brakes to automatically apply within the following times:

a) The brakes shall not automatically apply to bring the train to a halt as a result of system failure caused by a fire assuming the fire is in a technical compartment or cabinet, sealed or unsealed, containing electrical supply line and/or traction circuit equipment or a technical area with a combustion engine.

b) The time which is required to continue train operation with a fire declared to be on board is:

   1) 4 min for category A trains according to TSI SRT;

   2) 15 min for category B trains according to TSI SRT.

c) In order to prevent fire, materials with low flammability shall be used and electrical installations shall meet appropriate European Standards.

5.1.3 Reliability and availability

To comply with the essential requirements of the Directive 2008/57/EC and the requirement of the TSI 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 conditions as specified in EN 50125-1:1999. They shall function properly in those climatic zones for which they have been designed and where they will be operated.

NOTE For certain lines the operator of the infrastructure and/or the rail authorities may specify further requirements, e.g. for the Nordic countries.

5.1.5 Train configuration

Interoperable high speed trains can be configured as:

- multiple units with distributed traction equipment applied to any of the intermediate coaches or as trains with power cars (at least one) and intermediate coaches without traction equipment;
- a fixed formation train set consisting of single coaches or articulated coaches;
- trains with or without tilting equipment;
- single deck or double deck trains.

Trains of the same type may be coupled together however they shall behave in the same way as a single unit as far as braking is concerned.

Without other particular specifications the functionality and the performances of the brake system shall be fulfilled when formed up to a maximum train length of 400 m.

5.1.6 Maximum speed and line parameters

The brake system requirements specified in this standard apply to trains that may operate at a maximum speed of up to 350 km/h on lines specifically built for high speed and define graduated values for deceleration related to four speed ranges (see Clause 6).

Where trains are permitted to travel at greater speeds the brake requirements shall be specified as a result of a cooperation between the operator and the relevant transport authority [1)].

The Interoperable European high speed network also includes lines specifically upgraded for high speed and lines specifically upgraded for high speed but with special features subjected to national rules determined by the topographic conditions, the track parameters, the signalling equipment, etc. Those line conditions shall be specified for trains which shall be designed for and operated on those specific lines.

5.1.7 Coupling compatibility/capability

Interoperable European high speed trains shall:

a) couple automatically and therefore shall be equipped with a coupler at each end of a unit according to TSI High Speed:

   1) if trains of the same type are coupled then the pneumatic, electrical and electronic connections or others necessary for control shall be coupled and they shall provide full functionality;

   2) if trains of a different type are coupled then the pneumatic connection shall provide sufficient functionality of the brake system to allow hauling a damaged unit by another interoperable unit without adapter. Relying upon the pneumatic brake solely in that case operation restrictions may apply;

b) for rescue purpose a coupling with a conventional traction unit with UIC train hook according to EN 15566 by using a special adapter according to EN 15020 shall be provided. The auxiliary coupling device shall be compatible with the pneumatic pipes according to UIC 648.

If the brake demand is communicated using the brake pipe (in accordance with EN 14198) then the trainset being rescued shall respond in the form of a proportional brake force. For the rescued trainset equipped with

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1) Transport authority means ERA and/or national representative.

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 unconventional brakes and not cooperating with the UIC brake pipe an equivalent response as if equipped with UIC brake pipe shall be provided. The recommended minimum rescuing speed is 100 km/h according to EN 15020.

NOTE The method used for communicating the braking performances of a train which requires rescuing services is left to the national railways. For rescue operation restrictions, it is necessary to clearly specify restriction conditions in the onboard documentation.

If a special procedure is not specified the conventional UIC procedure using the brake weight percentage in accordance with UIC 544-1 will be applied.

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 (all subparts) with regard to EMC when applicable.

CE marking is not required.

5.1.10 Operation in very long tunnels

The brake design shall take into account the particular safety conditions in very long tunnels.

5.2 Applicable brakes

5.2.1 Basic architecture for high speed braking

Interoperable European high speed trains shall 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 sufficiently powered electro-dynamic brakes.

The safety and reliability aspects of the brake system is considered to be satisfied by a system architecture in accordance with EN 14198. This is also a benchmark for alternative brake systems, if they are applied in emergency cases.

5.2.2 Dynamic brakes

Applicable dynamic brakes are:

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

   1) develops a retarding force at the wheel/rail interface;

   2) returns the braking energy to the main power supply;

   3) alternatively, only if the electro-dynamic brake is independent from the main power supply, the braking energy shall be dissipated in the form of heat by sufficiently dimensioned brake resistors;

NOTE 1 The preferred method for dissipating the braking energy from an electro-dynamic brake is to return the energy to the main power supply.

NOTE 2 The member state may allow an exception from this restriction.

4) 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;

5) other dynamic brakes utilizing the wheel/rail adhesion.

b) The (linear) eddy current brake which is characterised by non contacting electromagnetic forces in the magnetic shoe/rail interface.

5.2.3 Friction brakes

Applicable friction brakes are:

- disc brakes, designed as wheel mounted, axle mounted, or transmission mounted discs;
- block brakes − if used, there shall be an appropriate limitation of energy input to the wheel;
- 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 in national infrastructure with conventional signalling and fixed distances interoperable high speed trains (with reference to a limited adhesion coefficient) may be equipped with additional magnetic track brakes. They will only be applied in emergency cases (TSI: below 280 km/h) or separately activated by the driver. It is permissible to include the contribution made by electromagnetic brakes independently from wheel rail adhesion for emergency braking on all lines as a means of maintaining the envisaged braking performance. When magnetic track brakes are used, these shall either be:

- 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.

5.2.5 Non conventional brakes

Non conventional brake systems (e.g. electromechanical, hydro-dynamic) 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 General aspect

Interoperable European high speed trains with electrical traction are typically supplied with a voltage of 15 kV AC (16,7 Hz) or 25 kV AC (50 Hz) [2)] and in certain cases 3 kV DC. The corresponding networks are generally or 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.

Interoperable European high speed trains shall return the electrical energy which is gained from electro-dynamic braking according to the braking force versus speed diagram to the main power supply.

2) Nominal values.

In this mode the electro-dynamic brake works in the regenerative mode and depends on the energy flow into the main power supply. As it works free from wear and regains a considerable part of the energy to be spent for traction power this mode is the most economical way for braking. Rheostatic braking shall be applied, if the regenerative mode is not available and should be used before other types of braking.

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.

The electro-dynamic brakes of the high speed rolling stock therefore shall be designed in a manner that will facilitate the dissipation of the electrical energy generated during braking. This may be achieved via a brake resistor. This is electro-dynamic braking in the rheostatic mode.

Furthermore, it is necessary that all of the auxiliary devices used for the conversion of the energy shall fully function without being dependent on electrical energy from the main power supply (e.g. conditioning of the converters, for excitation and ventilation of the traction motors, conditioning of the transformers and the brake resistors, etc.).

In the rheostatic mode working on brake resistors the electro-dynamic brake again works free from wear and does not depend upon the main power supply.

Maximum use should be made of the power/capacity available within the traction system for electro-dynamic braking whilst respecting the effects of adhesion between wheel and rail during braking.

In both the regenerative and rheostatic modes the vehicle shall be capable of generating the braking power without time restriction.

If lines of DC networks are to be operated by interoperable high speed trains 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.

The maximum brake force of the electro-dynamic brake for each wheel set 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 electric brake of this damaged unit is unavailable.

In the case of emergency braking this loss shall be compensated by the application of the pneumatic brake up to its performance limit.

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 pneumatic brake.

As an alternative to using the rheostatic brake an eddy current brake may be used if suitably rated for such duties and its use is permitted by the infrastructure manager.

5.3.2 Electro-dynamic brake (depending on the catenary in function)

A reliable contribution to the retardation can only be considered, if the electro-dynamic brake is independent from the main power supply, i.e. the braking energy shall be dissipated in the form of heat by sufficiently dimensioned brake resistors.

NOTE The member state may allow an exception from this restriction.

Rolling stock equipped with a regenerative braking system able to return energy to the catenary shall, under all circumstances, not cause the voltage to exceed the limits given in the TSI and as defined in EN 50163.

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.

5.3.3 Rheostatic brake

The electro-dynamic brake working in the rheostatic mode is independent of the presence of voltage in the catenary. It neither depends on the return of energy into the network nor receiving electrical energy from the network.

It is included in emergency braking according to the braking force versus speed diagram.

It is included in the calculation of braking performances provided the control-command can be considered to be sufficiently reliable and safe.

At least a qualitative examination shall be carried out.

5.3.4 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 seven levels of braking between “OFF” and “MAXIMUM”.

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. 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:

— MMI (separate or combined brake handle, push button);

— an automatic train control system (e.g. cruise control);

— an automatic train protection system.

The rate of change of the electro-dynamic brake force shall be the same as that achieved of by the friction brake.

In emergency cases and when the electro-dynamic brake fails the friction brake is set into operation automatically and immediately.

The availability of the electro-dynamic brake shall 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 visual warning shall be provided to the driver in the event of an electro-dynamic brake unit failure.

NOTE When the deficiency of brake force is caused by no other reasons than the WSP system in action then the electro-dynamic brake should not be deactivated within a certain time limit.

5.3.5 Brake resistors

Thermal endurance:

The brake resistors shall 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 brakings at maximum speed at the rate of 100 % electro-dynamic power.

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

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 even if this means a degradation of the electro-dynamic brake equipment concerned.

5.3.6 Hydrodynamic brake

Hydrodynamic brakes may be used providing they achieve the functionality and performance specified for the electro-dynamic brake.

5.4 Friction brake

5.4.1 General

In general the friction brake is added to the electro-dynamic brake in the case of emergency braking as well as in the case of service braking. At a very low speed down to standstill (e.g. while approaching the end of track or for shunting purposes) it is applied exclusively and ensures the precise positioning of the train.

In the event that there is contribution by the electro-dynamic brakes the other brakes shall be designed such that they are capable of taking over the full load of an emergency braking of the train systems.

Special care shall be taken when designing the material of the friction partners. Braking from maximum speed and regarding the nominal and exceptional conditions is always a high end stress of material and shall be verified by calculation and test. For more information see EN 14535-1 and prEN 14535-2 for discs and prEN 15328 for pads.

The means to control and feed the friction brake is usually compressed air for the trains of the European interoperable high speed network. 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 brake shall provide inexhaustibility according to EN 15355.

The energy necessary for braking shall be provided without any interruption.

5.4.2 Control command

The control command system of the power brake shall:

— arrange the control units per vehicle or per bogie;

— respect further requirements from EN 14198.

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.

If the control command is communicated via the brake pipe vehicles shall be equipped with a distributor valves according to EN 15355 and relay valves according to EN 15611.

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 European Standards may be considered. At least the following requirements shall be met:

— 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 ± 0,05) 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 1 min;

— 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 brake shall be capable of being isolated;

— five steps to eight steps of brake force shall be available by variation of the BP pressure;

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

It is not necessary to have the quick service function according to EN 15355, if there is an equivalent system available (e.g. ep-control).

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 control chamber A, either by a central command raising the brake pipe pressure to a defined value and subsequently followed by slow reduction of both, the brake pipe pressure and the control chamber pressure, to the nominal value according to UIC 541-03 or by a local command with manually operated devices on both sides of the train reducing the control chamber pressure 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, providing the same level of reliability as the conventional solutions is achieved.

If the central command is applied the reduction phase of the brake pipe pressure shall not start later than 20 s after the initiation.

If the reduction phase 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) and a continuous main reservoir pipe (MRP) than the inside diameter of both shall be at least 25 mm according to EN 15179.

The air pipes shall be installed in such a way that they are free of water traps and with generous bending radii (minimum dimension for bending radius $5 \times D_a$ = outside diameter). Components that may reduce the cross-section of the BP or may obstruct the brake pipe (e.g. filters) shall not be fitted. According to EN 15179 low points in the pipe work are permissible providing that they do not constitute a water trap and providing that an easily accessible drainage device is fitted.

The metal pipes used shall meet the requirements of EN 10220, EN 10305-4 and EN 10305-6. The number of pipe connections shall be as low as possible. Any necessary pipe connections shall be accessible without having to disassemble other equipment. Sections of pipes shall be selected so that it is possible to dismantle them. Threads cut into the pipes are not permitted according to EN 15179.

The number of flexible connections shall be minimised; 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 shall not occur.

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 relative to each other shall be 20 mm. In case this distance cannot be realized a 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. The requirements for air tightness are specified in EN 50215 and in EN 15734-2.

5.4.5 Mechanical components/bogie equipment

5.4.5.1 General

The friction brake used shall be a disc brake. In special cases a block brake may be used in place of or in combination with a disc brake on certain vehicles of a train set (e.g. in the power cars due to space limitations), providing the control command systems appropriately limits the energy jointly dissipated related to wheel and block.

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 pad 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 design of the brake discs shall comply with EN 14535.

The brake force application system shall be designed to:

a) have sufficient thermal capacity and/or cooling to prevent the occurrence of unacceptably high temperatures that could adversely affect braking or the structural integrity of the braking components. This shall take into account any planned braking duty cycle, including drag braking (braking to control the speed) and two rapid successive operations from maximum speed at maximum weight on the level with fully functional brake installation without the effect of any adhesion value independent brakes;

b) accept the loads that will arise from the braking forces and from the dynamic environment associated with its particular location on the vehicle according to EN 13749:2005, Annex C and Annex D;

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 design includes the wheel mounted type as well as the axle mounted type.

Provision of each wheel set with a brake force application system is mandatory.

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

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

The properties of the brake pads shall comply with the principals set out in prEN 15328.

They shall use materials that prevent the generation and emission of any products that are hazardous to health.

They shall be consistent with the maintenance policy for the train throughout its full service life (of the pad), e.g. the method of attachment between the brake pads and the brake holders shall be compliant with prEN 15328.

The conditions required in this standard shall be maintained over the whole useful thickness of the brake pads.

The coefficient of friction shall be as independent as possible of the initial braking speed, the worn profile of the friction couple, the grinding condition surface pressure and temperature in the contact area and weathering effects.

Requirements for the friction material are specified in prEN 15328, but speeds above 300 km/h are not covered by this standard.

5.4.5.5 Cylinders, callipers

The friction radius and force application point of the callipers shall be aligned with each other so that uneven wear of the pads (2 mm for sinter) is avoided so that it is possible to use fully the wear reserves. Suspension movements shall be considered.

The brake cylinders and calipers shall accept the loads that will arise from the braking forces and from the dynamic environment associated with its particular location on the vehicle according to EN 13749:2005, Annex C and Annex D.

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 block holders

Brake blocks should comply with the requirements of the future EN on the subject, and block holders shall comply with prEN 15329.

NOTE An EN on brake blocks is being prepared by WG 24 as WI 00256239.

5.5 Eddy current brake

The eddy current brake is an additional brake system and is comparable with the magnetic track brake. It is a track brake of the non-contacting type and therefore free of wear and has fully adjustable performances. It is independent of the adhesion between the wheel and rail and contributes significant brake forces, even at high speeds.

Depending on the amount of braking power dedicated to the eddy current brake the total power shall be split into several units operating completely independent from one another. A failure in one unit is not allowed to cause a subsequent failure in another unit.

The degree of distribution of power over more than one unit depends on the failure effect analysis and shall be considered in the brake calculation.

If the eddy current brake is considered in the brake calculation the electrical energy shall be provided independent from the catenary supply. One recognized method is to use the regenerative capacity of the traction system.

Complete or partial isolation of any braking units either voluntarily or automatically shall immediately and permanently be displayed to the driver.

The eddy current brake shall not adversely influence any train equipment like balises or sensors or track circuits and shall respect the requirements for EMC according to 5.1.9 of this standard.

As specified in the High-Speed Infrastructure TSI, the use of this type of brake, on the lines (to be built, upgraded or connecting) of the Trans-European high-speed network is permissible as follows:

— for emergency braking on all lines except specific connecting lines listed in the infrastructure register;

— for full or normal service braking on the sections of lines where the infrastructure manager permits it. In this case the conditions of use shall be published in the infrastructure register.

If trains with eddy current brakes are operated on lines which do not permit their use it shall be possible to deactivate and reactivate the eddy current brake without stopping the train. The safety of this switching functionality shall be demonstrated in accordance with EN 50126-1.

The following features are related to the linear type of an eddy current brake, which is in use on certain high speed trains operating on the interoperable European high speed network.

If the non contacting type makes it necessary that the vertical part of the reacting forces is supported by the axle bearings or the bogie frame, then the running stability of the train shall not be adversely effected by the support and the operation of the eddy current-brake.

In case of an unsprung support by the axle bearings the eddy current brake counts as unsprung mass. In any case the axle load will increase by the amount of vertical forces developed by the eddy current brake.

In order to maintain the specified performance during the service life the gap between the eddy current brake and the rail surface shall be capable of being checked and adjusted.

It is to be avoided that the eddy current brakes come into contact with the rails during normal operation and when encountering all track geometries.

NOTE 1 Current experience shows that lifting the eddy current brake to a running (non braking) position not in contact with the axle boxes helps to reduce the unsprung mass. This approach will also help to achieve adequate eddy current brake/rail clearances.

Checking and adjustment of the gap shall be easily possible in the workshop by simple tools.

The brake forces shall be transmitted into the bogie frame considering the relevant loads.

Sensitive parts like the electrical wires of the energy supply of the eddy current coils shall be protected against flying ballast, etc.

The design of the eddy current brake and that of the infrastructure shall be compatible. Compatibility shall be demonstrated using an accepted verification procedure according to EN 15734-2. If the brake forces of the eddy current brake are to be considered in the brake calculation, the energy supply shall be independent from the main energy supply.

If the eddy current brake is used during emergency braking, then it shall have sufficient thermal capacity to achieve an emergency brake application from the maximum train speed. This thermal capacity shall be in addition to the capacity required to achieve the specified service braking duties.

The eddy current brake shall be monitored in such a way that any reduction in capacity below that required for an emergency brake application shall result in an automatic train speed limitation and/or other operational limitations or if suitable in an information for the driver.

The eddy current brake is a further service brake on board and shall be as well controllable as the conventional brakes.

The control command is recommended to be computer aided.

NOTE 2 The eddy current brake could be managed in the same way as the electro-dynamic brake either in a separate way or through the automatic brake control.

Lowering and energizing the eddy current brake shall be covered by the routine test of the brake system.

If the eddy current brake is used during emergency braking then the application of the eddy current brake shall be commanded by venting the brake pipe or by interrupting the emergency brake loop (de-energize to apply). The emergency brake force shall not be dependent upon communication via the train bus. The safety of the system shall be demonstrated in accordance with EN 50126-1.

If an eddy current brake is used it shall comply with the following requirements:

a) performances according to TSI;

b) in the worst case, that is to say with the trainsets working in multiple to their maximum permitted train length, the maximum longitudinal braking force applied to the track by the eddy current train brake shall be:

    1) 105 kN for brake applications with a force lower than 2/3 of full service braking;

    2) linear between 105 kN and 180 kN for brake applications between 2/3 and full service braking;

    3) 180 kN for full service braking;

4) 360 kN in emergency braking;

c) the widths of the magnets shall remain within the envelope defined by EN 15273-2;

d) it shall not be allowed for one magnet to function without the opposite one in the same bogie to function as well. The eddy current brake being in function is not allowed to effect any lateral forces to the bogie.

If air pressure is necessary to move the magnets into the working position or into the resting position:

e) the availability of the compressed air shall continuously be monitored the compressed air shall be stored in a dedicated reservoir and its availability shall be continuously monitored;

f) a failure in the availability of an independent unit shall be indicated to the driver;

g) three applications cycles shall be possible even if the reservoir is not replenished from the main air supply.

5.6 Magnetic track brake

If trains are equipped with a magnetic track brake they shall comply with the following requirements:

The design requirements should comply with the future EN on this subject.

NOTE A European Standard on electro-magnetic track brakes is being prepared by WG 22 as WI 00256376.

They shall use two articulated track brakes per bogie (running gear), parked in the upper position above rail when not in operation.

Sensitive parts like the electrical wires of the energy supply of the magnetic track coils shall be protected against flying ballast, etc.

The correct operation of the track brake when applied shall be monitored (has left the upper position and current is on).

5.7 Non conventional brakes

Non conventional brake systems (e.g. electromechanical, hydro-dynamic) may be used providing that they function and perform in a manner comparable to that of a conventional brake systems 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

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 decentralised on board systems.

If a UIC type brake is used the brake pipe shall be vented down to a value of less than 2,5 bar so that the brakes will achieve the response time considered in the brake calculations.

All brakes shall develop their maximum brake force; if more than one brake influences the same wheelset, adequate precaution shall be taken to prevent overbraking.

The traction shall be cut off automatically and immediately. It cannot be reactivated before the brake demand is released completely and without a conscious action of the driver.

In case of emergency braking the specified stopping distances shall be achieved over all the speed range.

An emergency brake applied by the driver shall be releasable at any time.

5.8.2 General architecture

The structure of the system architecture shall comprise the following:

- brake demand level;
- level of brake command distribution;
- brake force generation.

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

The components generating the brake forces shall be fitted in form of multiple decentralised units in order to limit the lack 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.

The local brake command units themselves and the command chain below may be designed without redundancy if a single point failure will be limited in its degradation by a sufficient number of brake force generators not influenced by the considered failure.

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.

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

5.8.3 Demand phase

5.8.3.1 General

If the emergency brake is applied by venting the brake pipe by an electrical command, it shall principally be designed such that venting the brake pipe is achieved with the magnetic valves not excited (de-energise to apply). If it is found necessary to do it the other way round the same safety level shall be proven.

5.8.3.2 Application by the driver

5.8.3.2.1 General

The emergency brake shall be 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.

An emergency brake which has been applied by the driver can be released by them any time they want to.

If the primary device is defective a secondary device shall be available to apply the brake either by venting the brake pipe or by de-energising the emergency brake loop.

5.8.3.2.2 Brake lever in the driver’s desk

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

The majority of train operators are accustomed to find the emergency brake position moving the lever in the direction to the driver. In this position the brake pipe shall be vented without any further control mechanism and via the full cross section according to UIC 541-03.

NOTE Trains in the UK that do not cross international borders are permitted to choose the direction of brake application.

For venting the 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.

If further brake systems are commanded in emergency cases beside the pneumatic brake they shall be applied either by venting the brake pipe or by de-energizing the emergency brake loop.

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

5.8.3.2.3 Push button or comparable device

In the case of failure of the regular operator’s device provision shall be made for at least one additional device. This application shall result in the same braking performance as achieved by means of the regular emergency brake application as well as in an automatic traction cut off.

In cases of an architecture consisting of an indirect control of the brake the push button shall vent the brake pipe directly and open the emergency brake loop.

The operating devices shall be designed as a red coloured push button in a shape that does not allow any misinterpretation of its function or as a valve in a handle design (emergency brake valve). Other devices dedicated to any emergency applications, which may also appear in a push button design shall deviate clearly either in colour or shape or shall be placed outside the optimized easy access area.

5.8.3.2.4 Arrangement of devices for emergency brake application

These devices shall be accessible from the regular seated position of the driver and shall be placed in a position complying with the future recommendations of CEN/TC 256/WG 37 "Driver's cab".

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

5.8.3.3 Automatic brake application

5.8.3.3.1 General

The automatic train protection system used on the European interoperable High Speed network shall provide the following functions:

a) application of an emergency brake, featured by:

1) commanding the maximum brake force;

2) venting the brake pipe completely and via the maximum cross section;

3) commanding the electro-pneumatic brake;

4) de-energising the emergency brake loop;

b) traction cut off;

c) cut off feeding the brake pipe;

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

Provision shall be made to test the function of the train protection systems after starting a test run. Each path dedicated to assure the overall functionality shall be tested exclusively.

In cases of irregularities the protection systems shall be 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.

5.8.3.3.2 Automatic brake application caused by the LZB/ETCS/ASFA-train protection systems

The train safety systems shall be able to apply the emergency brake with the same reliability as if applied by the driver. This can be achieved by:

— a separate and direct access to vent the brake pipe; or

— breaking the brake loop.

5.8.3.3.3 Automatic brake application by the driver's vigilance device

For high speed traffic the driver's vigilance device shall command a full service brake (see 5.9.2.2) but may command an emergency brake application.

5.8.3.3.4 Automatic brake application caused by the passenger alarm system

For high speed traffic it is not found adequate to apply the emergency brake commanded by the passengers' alarm system. The function shall be in accordance with 5.9.2.3 of this standard.

5.8.3.3.5 Automatic brake application caused by a central train wide diagnosis system

5.8.3.3.5.1 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.

The integration of such a decentralised brake application device shall comply with EN 14198.

For pure diagnosis messages see 5.13 in this document.

An automatic brake application by a decentralised brake application device according to EN 14198 is permitted.

5.8.3.3.5.2 Train cut/Loss of train integrity

The loss of the train integrity (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 integrity shall be indicated to the driver.

5.8.4 Collecting and distributing brake command signals

5.8.4.1 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.

5.8.4.2 Collecting brake command signals

Suitable command collectors are the following:

- the brake pipe following the UIC architecture;
- a hard wired circuit following a safety loop design (e.g. the emergency brake loop).

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

5.8.4.3 Distribution of brake command signals

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

An adequate command distribution line can be realized by:

a) 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;

b) the emergency brake loop via electrical command devices reacting on the non energized status of the emergency brake loop such as to apply the applicable brakes;

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

The brake command distribution shall act train wide regardless any automatic couplers in the command 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 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 wheel set.

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.

From 0 up to the maximum brake force the subordinate brake systems shall be activated, each 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 and permitted to be used by the relevant transport authority;

— 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 interoperable high speed trains 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 adhesion conditions the driver should be enabled to select a different brake management, where all the wheelsets shall contribute such an amount of braking force that an identical deceleration is obtained by each of them. If more than one brake system is in action in the same running gear, the free of wear type shall be preferred.

A further mode shall be provided if found necessary due to climatic conditions.

— The driver shall be capable of applying the friction only brake system (for example to remove ice from the surface of the discs in winter conditions by inducing friction energy in the form of a short-term application above 50 km/h).

— The driver shall be capable of applying the friction only brake application to avoid possible malfunction of brake blending procedure at a speed of less than 50 km/h.

NOTE 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.

Under continuous signalling systems which are mandatory for High Speed services the required performances are specified in Clause 6 of this document in accordance with the TSI. The values of deceleration required by a full service brake decline with increasing speed ranges. It is recommended the brake system in normal condition will be capable to perform these values by applying those brakes which are free of wear without using the friction brake.

The brake management shall limit the maximum brake forces resulting from a full service brake command to those values required.

Preference shall be given to brakes belonging to the free of wear type before using the friction brakes.

The brake control shall allow an add on of about 0,1 m/s² to 0,2 m/s² on the operationally required deceleration. This allows the driver to adjust the deceleration level to the required value if driving manually. In failure conditions the friction brake may contribute to the required deceleration if the thermal constraints are respected.

The braking force 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 one or two levers shall be accessible from the regular seated position of the driver and shall be placed in a position complying with the future recommendations of CEN/TC 256/WG 37 "Driver's cab".

5.9.2.1.2 Brake handle in the drivers desk

The brake handle commanding the subordinate brake system via a brake management shall work such as the driver’s brake valve specified in UIC 541-03 as far as its arrangement and its functionality is concerned.

NOTE 1 Trains in the UK that do not cross international borders are permitted to choose the direction of brake application.

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 when another active vehicle is ahead.

NOTE 2 This function is not necessarily provided by the lever itself.

5.9.2.1.3 Combined traction- and brake control lever

The additional brake lever for the electro dynamic brakes may be combined with the traction lever. If so, the control range for traction is away from the driver, the control range for braking is towards the driver.

NOTE Trains in the UK that do not cross international borders are permitted to choose the direction of traction and brake application.

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 Application of an automatic service brake

The following components are to apply an automatic service brake:

— Driver’s vigilance device:

Any lack of driver’s vigilance shall be detected within 30 s to 60 s and shall be acoustically and/or optically indicated and shall lead in the absence of the driver’s reaction to, as a minimum, an automatic full service brake application on the train;

— holding brake (optional):

The system (brake management), if this option has been agreed shall be designed such that the train can start in a slope of 35 ‰ under maximum load and without rolling backwards except for less than 1 m;

— automatic train traction- and brake control systems;

— failure indicated by the diagnostic systems.

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 braking caused by the vigilance device respectively the passenger alarm system respectively the diagnosis systems.

The design shall allow to test the efficiency of those automatic brake applications for each signalling path during standstill and after starting a test run.

In the case of irregularities or failures the design shall allow the isolation of 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

Passenger alarm systems should comply with the future recommendations of CEN/TC256/WG 36 "Emergency and Alarm systems". Until these are published the requirements that have some impact upon an integrated brake and passenger alarm system are set out in informative Annex A.

If an emergency brake is already applied, it shall override any release command from PAS.

5.9.3 Signal processing

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

The safety and reliability aspects of the brake system is considered to be satisfied by a pneumatic system architecture in accordance with EN 14198.

Alternative solutions may be used provided they achieve an equivalent level of availability. Examples are as follows.

A centrally and train wide commanded brake level may be transmitted to a computer port via:

— electrical hard wires;

— databus (e.g. CAN, LON, MVB).

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):

a) precaution shall be taken that 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;

d) it distributes the brake forces 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 command sources, mostly as a maximum value selection;

f) receives feedback.

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

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

— controllers (distributor valves) for the pneumatic brakes;

— control units for the magnetic track brakes;

— control units for the eddy current brakes.

The command chain may comprise the following:

— data bus;

— hard wired electrical cables;

— brake pipe.

5.9.4 ATC Automatic train control system (optional)

For service braking an automatic (microprocessor based) brake command system should 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 is prior to that of the automatic command system. The signal from the automatic system is 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 is cut off and can only be reactivated by a voluntary action of the driver.

All train protection systems 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 shall be limited to the following values:

— max. da/dt = 0,6 m/ s³;

— 1,2 m/s^2 within 3 s.

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

— max. da/dt = 1,0 m/s³;

— 1,8 m/s^2 within 3 s.

In the blending process of the pneumatic brake and the dynamic brake there shall not be a gap in the brake force or an increase of more than 20 %.

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 brakes 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 of the trains.

5.10 Wheel slide protection and locked wheel detection

5.10.1 General

High speed trains shall be equipped with a wheel slide protection system combined with an independent wheel rotating monitoring system in accordance with EN 15595.

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 calculate 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:

— in all brake modes;

— during brake blending;

— when using adhesion independent brakes;

— at all levels of brake force;

— regarding all wheel diameters;

— at all levels of wheel-/rail adhesion;

— 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 in a coordinated manner.

The wheel slide protection system shall prioritize the use of the electro dynamic brake if acting upon the same wheel set together with the friction brake (if applicable).

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 comprehensive 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 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 shall be isolated by the train staff and the train operated accordingly, e.g. at reduced speed.

5.10.3 Locked wheel monitoring system

A locked wheel(set) is a critical risk in high speed traffic which may cause derailment.

Therefore locked wheelsets shall be detected by two independent systems. The installation may consist of:

— the regular wheel slide protection system;

— an additional independent locked wheel detection system.

A failure in one system shall not impair the function of the other system.

Both systems shall indicate a locked wheelset to the driver.

If either system fails the other system continuously monitors the rotation of the wheelset; nevertheless the train shall be repaired when arriving at its destination.

If both systems fail the brakes related to the wheelset concerned shall be isolated. The train is allowed to continue its mission respecting a maximum speed of 200 km/h.

5.11 Parking brake

It shall be possible for the train to be kept stationary for an indefinite period on the maximum gradient on the line concerned. When the parking brake alone is not sufficient it shall be supplemented by extra on-board facilities, e.g. scotches.

Parking brakes may be applied as a result of:

a) a driver's command; or

b) automatically substituting the pneumatic brake in case of the air pressure dropping down.

The parking brake shall be designed according to the "energize to release principle", alternatively as a hand brake.

The design calculation shall take into account:

— a gradient of 35 ‰ according to the TSI Infrastructure unless otherwise specified in the infrasructure register when those lines shall be operated by the interoperable trains;

— the normal load condition according to EN 15663;

— minimum friction coefficent between braking elements;

— maximum adhesion coefficient in accordance with 6.5;

— minimum efficiency of the mechanism;

— minimum spring forces;

— a single point failure in the parking brake mechanics.

The developed brake force shall be equal to or greater than the required brake force as a result of the calculation specified above.

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 power brake can occur the brake system equipment shall tolerate this without detriment.

If there is an unintended application of the parking brake that is not prevented by a control or equipment design feature, then the service or emergency brake shall automatically apply if the friction brake design will not tolerate the additional loadings imposed and any wear and tear resulting from these additional loadings would not be detected during normal train maintenance procedures. If required, the risk of an unacceptable level of wear and tear going unnoticed 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.

An unintended application of the parking brake shall be indicated to the driver.

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 shall be accessible, so that it can be manually released, and this should be from both sides of the train.

In the case of a manually operated spring applied brake the status of the actuator (applied = red, released = green, indication not valid) shall be indicated in accordance with EN 15220-1 outside the vehicle on both sides in a clear and concise manner and without using electrical energy.

The thermal capacity of the friction elements and the mechanical strength in case of rupture of the spring release pipe shall be verified by means of calculations, bench tests or on-track tests.

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 power brake and the parking brake.

If the parking brake is designed as a hand brake it shall comply with the holding performances specified for the spring applied brake.

The following requirements shall apply:

— force, not greater than 300 kN;

— accessibility, without a special key if located in a cabinet;

— indicators on both sides;

— the brake is applied when the hand wheel is turned in clockwise direction;

— not more than ten turns;

— provision for at least 50 % of the wheelsets and at least one disc per wheelset;

— as a minimum the first and the last vehicles in the train formation shall each incorporate parking brakes.

5.12 Location of the control devices

5.12.1 Driver's cab

5.12.1.1 General

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

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

— enabling and isolating equipment;

— 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 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;

— parking brake application command (if applicable).

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 brake control being used for the regular braking functions, i.e. service braking and emergency braking; depending on the design concept it is in the form of a conventional driver's brake valve or an electronic device according to 5.8, 5.9;

— control device for the sanding system;

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

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

— the lever for the direct brake (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 (extended access area according to UIC 651):

— 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 and within arms length and in the form of a point to point connection. 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 may 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:

- overcharging;
- isolation of the brake pipe control;
- starting the brake test;
- enable and disable the compressors;
- quit fault messages.

5.12.2 Operating devices others than in the cab

5.12.2.1 Service panel inside the coach

The service panels inside the coaches 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 on plane line under the related unfavourable conditions including stopping all trains on the back track on a high speed line:

- gauge to indicate the brake cylinder pressure;
- remote controlled isolation of the pneumatic brake, with an indication included;
- if available a remote controlled isolation of track brakes.

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

5.12.2.2 Passenger area

Passengers shall only get access to the passenger alarm system, for details see 5.9.2.3.

5.12.2.3 Isolating devices

Control 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;
- entrance areas;

— cabinets inside the vehicle.

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

The vehicle ends shall be equipped with couplers and cocks according to EN 14601.

5.13 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 on – Brake off" indicator panels on each side of the car in accordance with EN 15220-1. These panels shall have a red "Brake on" display field and a green "Brake off" display field;

— internal pressure gauges.

Provision of the indicators or gauges is required when the diagnosis system is not available or for rescuing modes.

It is not allowed to fix any other devices between the brake cylinders and the indicators than the WSP valves.

In case when the brakes are controlled by the brake pipe 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.

— In cars with several distributors, a separate indicator shall be provided for each distributor.

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

In the driver's desk the following gauges are mandatory:

— main reservoir pipe pressure;

— brake pipe pressure;

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

For the gauges the following shall apply:

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

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

— diameter brake cylinder pressure: 60 mm.

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

5.14 Fault monitoring and diagnostics

The diagnostic data shall distinguish between:

— driver related and operational related data;

— maintenance related data.

All the failures which may occur in the brake system and which:

— 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;

NOTE A system response resulting in an automatic brake application may even be justified under the aspects of the TSI SRT. A case by case consideration between manufacturer, operator and railway authority should determine the design until a reliable standard has been elaborated describing a hierarchy of emergency brake and release commands which up to now is still under consideration.

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

The failures shall be classified according to UIC 557.

Each train set 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 train sets the failure information shall be preserved in that train set only upon which the failure occurred.

Any failure messages shall include the location in the train.

Optional:

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 in case of:

   1) broken hose of the spring brake, if resulting in an undemanded brake application;

   2) application of the passenger alarm system (automatic action according to 5.9.2.3);

   3) input from other train safety system, e.g. detection of derailment;

   4) major equipment failure (e.g. cardanshaft);

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

b) an audible and/or visual (upon request) 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;

   5) undemanded brake application or release;

   6) failure of the brake rate change over function;

   7) hot axle box.

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

c) Less urgent message which provides 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) an information about an unusual status of the brake system addressed to the maintenance staff only, for example in the case of 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;

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

When the train has returned to normal functionality all messages shall only be deleted by authorised staff.

Each coach 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.

A maintenance software shall be delivered.

This software 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 maintenance software shall provide the relevant languages of the countries through which the trains operate and where the train can be maintained.

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

5.15 Driver's brake test

5.15.1 General

The brake test shall to the extent possible in static conditions:

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

— verify the continuity of the brake, using the brake pipe and 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;

— confirm the correct function of the entire command chain.

5.15.2 Regular basic brake test

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

A regular basic brake test shall be performed:

— after the train 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 a trainset (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:

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

b) verify the continuity of the brake, using the brake pipe and any other form of continuous element of the brake system where fitted.

This includes for example:

1) the ep assist where fitted;

2) the passenger communication alarm.

c) Check the isolation of the other non active driver’s brake valves.

Optional requirements:

d) calculate the brake weight percentage.

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.

5.15.3 Full brake test

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

- the test of all redundant functions in the command chain of the emergency brake application;
- the brake application and release in each vehicle of the train set.

Brakes shall be fully tested:

- regularly;
- as often as required by the architecture of the brake system and as required by the RAMS calculation.

According to the present rules introduced in the majority of the railway operators an acceptable sequence of full brake test is:

- once per day (covering 24 h);
- after train preparation;
- after repair activity that could have influenced the integrity of the brake system.

The full brake test shall as a minimum:

- test the tightness of the brake pipe;
- test the continuity of the main reservoir pipe and the availability of the air supply;
- check additional hard wired lines applying the emergency brake (if equipped);
- check the track brakes (if equipped);
- check the application and release function of the parking brake;
- check the dynamic brakes (if equipped) as far as possible in static conditions and dynamically at the first opportunity after entering service.

The contents of the brake tests described above are in accordance with the UIC compressed-air brake system. When using other control concepts the test contents shall be adapted according to the brake architecture.

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

5.15.4 Realisation of brake tests

Test the brakes shall 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-automatically, i.e. manual 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 be impossible to carry out the semi-automatic brake test unless:

- initiated from an active cab; and
- the train is stationary.

Suitable precautions shall be taken to ensure the safety of the train during the execution of the semi-automatic (e.g. to prevent train movement).

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

5.16 Power supply

5.16.1 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.

A loss of air in the main supply system that jeopardizes the full effectiveness of the brake device shall be monitored as a type b-failure according to 5.14. In case of a direct electro pneumatic brake the system response shall additionally result in an automatic application of the brakes as well as in an inhibition of the brake release function.

5.16.2 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. function beats protection of components.

The electrical energy supply for the wheel slide protection system on each vehicle shall be maintained for not less than 24 h in the event of loss of main electrical power supply for the train. This shall be considered in the battery consumption calculation.

5.17 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.

This system may also be used as an aid to reducing wheel spin in traction mode – however, its use in traction mode shall be limited in such a way that its availability for use during emergency braking is assured at all times.

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 allowed amount of sand per sanding device within 30 s is:

— for speed < 140 km/h: 400 g + 100 g;

— for speed > 140 km/h: 650 g + 150 g.

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

The CCS TSI shall specify the quantity of sand laid on the track per meter for train detection purposes and not the delivery quantity which is a RST parameter.

The number of acting sanding devices shall not exceed the following:

— for multiple units with distributed sanding devices first and last car and intermediate cars with a minimum of seven intermediate axles between two sanding devices that are not sanded. It is permissible to couple such multiple units and to operate all sanding devices at the coupled ends;

— in all other cases: a maximum of four sanding devices per rail.

The device shall only be relocated to serve the trailing wheelset if there is no space to do otherwise.

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.

The driver shall be provided with a manual control for use at the driver's discretion that when operated shall result in the substance used for compensating insufficient levels of wheel-rail adhesion being deposited continuously until the train has reached a standstill.

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 that the 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.

During low temperatures lower than 5 °C the sanding pipes, the control valves and the sanding material shall be heated to prevent freezing. The heating device shall be cut off:

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

— the heating is not demanded in cases of maintenance.

On the other hand 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 used for compensating low levels of wheel/rail adhesion both locally at all storage positions on the train and remotely from the active drivers cab. The driver should be provided with both an audible and visual warning in the event that the quantity falls below the minimum level prescribed for normal train operation.

5.18 Maintenance

Each vehicle shall be provided with a diagnosis interface respectively 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, severeness 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.

Optionally: A software for maintenance purposes shall be provided.

Easy access shall be provided to the diagnosis data in each vehicle.

All brake system components requiring access by operational staff shall be designed and located such that they can be easily accessed even 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 Brake performance

6.1 General

The brake performance of the interoperable high speed trains is mainly specified under degraded mode conditions. The degraded mode conditions are not associated with any restrictions regarding speed. The degraded mode B defines the starting point from which onwards failures affect the train performance and cause a reduction of speed or an adjustment of the brake application point if detected.

The degraded mode “B” is an accumulation of train failures as well as of unfavourable track conditions.

Compliance is achieved if the number of independent units is such that the effect of a failure is limited to the requirements specified in the TSI.

Degraded mode “A” is related to the technical architecture of the train and specifies the brake performance resulting from a technical malfunction in the electro dynamic brake system, which shall nearly achieve those performances of a train with all equipment active.

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

Service brake performance shall satisfy the operational and economic requirements.

6.2 Emergency braking

6.2.1 General

The braking requirements are specified in terms of decelerations. Regarding the physical circumstances the deceleration level decreases with increasing speed and is divided into four sections. If the equivalent stopping distances are required for design and safety studies they shall be calculated according to the formula given in the TSI HS RST.

The requirements of the TSI High Speed Rolling Stock shall be respected. Compliance is achieved if the resulting stopping distances are respected and if the corresponding calculated (mean) decelerations are respected which allow the instantaneous deceleration to deviate from the mean deceleration levels in the TSI.

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

In general the braking decelerations are specified such that they can be obtained without the assistance of any adhesion independent brakes.

In the speed range is > 30 km/h, the braking system of the unit dependent of adhesion conditions shall not assume instantaneous deceleration higher than 1,5 m/s².

The emergency braking distance shall not be longer than the full service braking distance. The braking distance shall not increase if an emergency braking is activated during full service brake application. The emergency braking performance applicable to operation shall only be related to a maximum adhesion coefficient μ in 6.5, a), 1) or 6.5, a), 2).

If adhesion independent brakes are used, the effort generated by these brakes shall be in addition to the effort generated by the adhesion dependent brakes.

The braking distances shall be obtained without the assistance of those brakes depending on the presence of voltage in the catenary.

The compliance with the specification shall be calculated in accordance with EN 14531-6 and demonstrated in accordance with EN 15734-2

6.3 Service braking

The requirements of the TSI High Speed Rolling Stock shall be respected. They should be achieved with electro dynamic brakes solely.

If adhesion independent brakes are to take over braking capacity from those using the wheel/rail contact they shall respect the constraints of the infrastructure.

6.4 Thermal requirements

The thermal brake performance shall allow a train to run on a maximum gradient set out in the High Speed Infrastructure TSI at a speed of at least equivalent to 90 % of the maximum train operating speed. This thermal performance shall be used for calculating the limiting gradient where maximum train speed can be operated.

The same conditions for train loading, means of braking and rail condition apply as for emergency braking case A as defined in 4.2.4.1, c) and e) in the TSI HS RS.

Following these conditions two consecutive emergency stops shall be considered taking into account the time to accelerate the train in between the consecutive brakings.

Compliance to this requirement shall be proven by calculation.

6.5 Adhesion values

The brake system (including the electro-dynamic brake systems) of the unit shall not assume wheel/rail adhesion that lead to the sliding of the wheel sets or the wheels during a brake application on dry rails for all load cases defined in EN 15663. The vehicle braking system shall be verified by a physical test on dry rails as defined in EN 15734-2.

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

   1) 0,15 in general except for vehicles and units that correspond to cases a), 2) and a), 3);

   2) 0,13 for self-propelling trains having seven axles or less;

   3) 0,17 for units assessed in defined or pre-defined formation (s) to be intended for high speed operation and having 20 axles or more if the train is not equipped with an automatic load device. In case of having less than 20 axles the specified safety level shall be demonstrated.

   For speeds greater than 200 km/h the wheel rail adhesion coefficient maximum demand shall be assumed to decline linearly from 0,15 to 0,1, 0,13 to 0,08 and 0,17 to 0,12 at 350 km/h.

b) During service brake application in the speed range > 30 km/h, the wheel sets or wheels of the unit equipped with:

   1) non electro-dynamic brakes (especially the friction brakes) shall not assume wheel/rail adhesion higher than the following values: same criteria as in paragraph a) above;

   2) electro-dynamic brakes shall not assume wheel/rail adhesion higher than 0,20.

c) During direct braking in the speed range > 30 km/h, the wheel sets or wheels of the unit shall not assume wheel/rail adhesion higher than 0,13.

d) During dynamic braking in the speed range > 30 km/h, if the dynamic braking is not controlled by an independent lever dedicated to the dynamic braking, the wheel sets or wheels of the unit shall not assume wheel/rail adhesion higher than 0,20. No limit value applies for the dynamic braking controlled by an independent and dedicated controller (e.g. traction/dynamic brake controller).

Wheel sets or wheels of the unit equipped with an electro-dynamic brake that assume a wheel/rail adhesion higher than 0,15 shall fulfil the following conditions:

— If the WSP is no longer able to manage the electro-dynamic brake force above 0,15, then the electro-dynamic brake systems shall be inhibited or its maximum brake force reduced to obtain a wheel/rail adhesion below 0,15.

For all adhesion conditions according to EN 15595, during service and emergency brake applications the braking distance increased of the unit shall not be longer than the maximum value admitted by EN 15595.

These limits of wheel rail adhesion demand shall be verified by calculation in accordance with EN 14531-6 for each wheel sets or wheels with the smallest wheel diameter, and with the three load cases considered.

All values shall be rounded to the second digit.

Annex A
(informative)

Passenger alarm system

To enable the train to be brought to a stop in a position of safety to permit external support or rescue the passenger alarm system shall have the following features:

— an emergency alarm initiated by a passenger shall lead to an alarm message for the driver;

— in case of a passenger alarm it shall be ensured that the train will not be stopped untimely and that the train driver will be in a position to determine the nearest accessible safe place in order to stop the train there;

— the signal received from the passenger alarm system shall initiate automatic brake application if the train driver does not acknowledge the passenger alarm signal within an acceptable time limit;

— if the driver has acknowledged the alarm then further operations of the passenger alarm shall not lead to an automatic brake application;

— the passenger shall receive a recognisable feedback following actuation of the emergency alarm;

— a voice communication link to the train crew (driver and /or on-board staff) shall also be established;

— the train shall be stopped by immediate brake actuation in case of an emergency alarm when leaving the platform and following the entry at exit of passengers;

— in case of a failure of the passenger alarm override system or if the system is switched off by the driver, an application of the emergency handle shall lead to immediate brake application.

The signal transmission between actuator and electronic brake control unit shall be technically monitored and ensured by means of a transmission system suitable for safety-relevant tasks.

It shall be permanently available and shall transmit the following signals independently from each other:

— signal “passenger alarm has been applied”:

  This is a safety-relevant transmission and it shall therefore be permanently monitored by suitable technical measures up to the rear of the train.

In case of a multiple-purpose use of a system, the transmission of the above signals has top-priority and may not be influenced by other train systems.

— command "emergency brake override":

  The demand chain is safety-relevant and shall therefore be monitored.

The emergency handles shall be designed and located according to EN 15327-1.

The application of the brake handle shall be monitored locally and the indicators shall be alight until the brake has been reset in order to give a feed back to that person who has applied the brake and to guide the train staff to the place where it has been applied.

If the brake is applied, the brake shall only be released after the reset of the brake handle has been activated.

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 New Approach Directive 2008/57/EC [3)].

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 Table ZA.1 for High speed Rolling Stock and Table ZA.2 for Safety in Railway Tunnels, confers, within the limits of the scope of this standard, 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 HS RST TSI published in the OJEU dated 26 March 2008 and Directive 2008/57/EC

Clause/subclauses of this European Standard	Chapter/§ of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
The whole standard applies.	4. Characterisation of the subsystem 4.2 Functional and technical specification of the subsystem 4.2.4 Braking 4.2.7 System protection 4.2.7.2 Fire safety 4.2.7.2.4 Additional measures to improve 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	

3) This Directive 2008/57/EC adopted on 17 June 2008 is a recast of the previous Directives 96/48/EC "Interoperability of the trans-European high-speed rail system" and 2001/16/EC "Interoperability of the trans-European conventional rail system" and revisions thereof by 2004/50/EC "Corrigendum to Directive 2004/50/EC of the European Parliament and of the Council of 29 April 2004 amending Council Directive 96/48/EC on the interoperability of the trans-European high-speed rail system and Directive 2001/16/EC of the European Parliament and of the Council on the interoperability of the trans-European conventional rail system".

Table ZA.2 — Correspondence between this European Standard, the TSI Safety in Railway tunnels published in the Official Journal on 8 March 2008 and Directive 2008/57/EC

Clause/subclauses of this European Standard	Chapter/§ of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
The whole standard applies.	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 to improve running capability 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	

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

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EN 15327-1, *Railway applications — Passenger alarm subsystem — Part 1: General requirements and passenger interface of the passenger emergency brake system*

Directive 2008/57/EC of the European Parliament and of the Council of 17 June 2008 on the interoperability of the rail system within the Community (Recast)

4) In preparation.

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