

BS EN 14033-1:2011



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Railway applications — Track — Railbound construction and maintenance machines

Part 1: Technical requirements for running

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee RAE/2, Railway Applications - Track.

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

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Foreword

This document (EN 14033-1:2011) 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of an identical text or by endorsement, at the latest by August 2011, and conflicting national standards shall be withdrawn at the latest by August 2011.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 supersedes EN 14033-1:2008.

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

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

This series of standards EN 14033 "*Railway applications — Track — Railbound construction and maintenance machines*" consists of the following parts:

- *Part 1: Technical requirements for running*
- *Part 2: Technical requirements for working*
- *Part 3: General safety requirements*

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 United Kingdom.

Introduction

This European Standard was prepared to meet the basic requirements of EU Directives to facilitate an open market for goods and services.

The railway specific particulars of the machines for construction and maintenance form the objective of this European Standard.

The risks which exist in all mechanical, electrical, hydraulic, pneumatic and other components of machines and which are dealt with in the relevant European Standards are not within the scope of this European Standard. Where necessary, references are made to appropriate standards of this type and the interoperability of the rail system within the Community.

1 Scope

1.1 General

This European Standard defines the specific technical railway requirements for running of machines and other vehicles used for construction, maintenance and inspection of track, structures, track formation and fixed electric traction equipment.

This European Standard applies to all railbound machines and other vehicles – referred to as machines – running exclusively on the railway (utilising adhesion between the rail and wheels) and used for construction, maintenance and inspection of track, structures, infrastructure and fixed electric traction equipment. This European Standard applies to machines that are intended to operate signalling and control systems. Other machines are dealt with in other European Standards, see Annex K.

Special requirements can apply for running on infrastructures with narrow gauge or broad gauge lines, lines of tramways, railways utilising other than adhesion between the rail and wheels, road-rail machines and underground infrastructures.

This European Standard covers the requirements for safety and access of railway traffic, railway specific requirements for running on different infrastructures in relation to necessary movements of the machine as a train and movements to reach work sites.

1.2 Validity of the European Standard

This European Standard applies to new designs taking into consideration the recommendations given in Annex L on the application of the standard (migration rule).

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 286-3, *Simple unfired pressure vessels designed to contain air or nitrogen – Part 3: Steel pressure vessels designed for air braking equipment and auxiliary pneumatic equipment for railway rolling stock*

EN 286-4, *Simple unfired pressure vessels designed to contain air or nitrogen – Part 4: Aluminium alloy pressure vessels designed for air braking equipment and auxiliary pneumatic equipment for railway rolling stock*

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 12080, *Railway applications – Axleboxes – Rolling bearings*

EN 12663-1:2010, *Railway applications – Structural requirements of railway vehicle bodies – Part 1: Locomotives and passenger rolling stock (and alternative method for freight wagons)*

EN 12663-2:2010, *Railway applications – Structural requirements of railway vehicle bodies – Part 2: Freight wagons*

EN 13103, *Railway applications – Wheelsets and bogies – Non-powered axles – Design method*

EN 13104, *Railway applications – Wheelsets and bogies – Powered axles – Design method*

EN 13260, *Railway applications – Wheelsets and bogies – Wheelsets – Product requirements*

EN 13261, *Railway applications – Wheelsets and bogies – Axles – Product requirements*

EN 13262, *Railway applications – Wheelsets and bogies – Wheels – Product requirements*

EN 13715, *Railway applications – Wheelsets and bogies – Wheels – Wheels tread*

EN 13979-1, *Railway applications – Wheelsets and bogies – Monobloc wheels – Technical approval procedure – Part 1: Forged and rolled wheels*

EN 14033-2, *Railway applications – Track – Railbound construction and maintenance machines – Part 2: Technical requirements for working*

EN 14033-3:2009, *Railway applications – Track – Railbound construction and maintenance machines – Part 3: General safety requirements*

EN 14198:2004, *Railway applications – Braking – Requirements for the brake system of trains hauled by a locomotive*

EN 14363:2005, *Railway applications – Testing for the acceptance of running characteristics of railway vehicles – Testing of running behaviour and stationary tests*

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 14535-2:2007, *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 15152, *Railway applications – Front windscreens for train cabs*

EN 15153-1, *Railway applications – External visible and audible warning devices for high speed trains – Part 1: Head, marker and tail lamps*

- EN 15153-2, *Railway applications – External visible and audible warning devices for high speed trains – Part 2: Warning horns*
- EN 15179, *Railway applications – Braking – Requirements for the brake system of coaches*
- EN 15220-1, *Railway applications – Brake indicators – Part 1: Pneumatically operated brake indicators*
- EN 15273-2, *Railway applications – Gauges – Part 2: Rolling stock gauge*
- EN 15355, *Railway applications – Braking – Distributor valves and distributor-isolating devices*
- EN 15528, *Railway applications – Line categories for managing the interface between load limits of vehicles and infrastructure*
- EN 15551, *Railway applications – Railway rolling stock – Buffers*
- EN 15566, *Railway applications – Railway rolling stock – Draw gear and screw coupling*
- EN 15611, *Railway applications – Braking – Relay valves*
- EN 15624, *Railway applications – Braking – Empty-loaded changeover devices*
- EN 15625, *Railway applications – Braking – Automatic variable load sensing devices*
- prEN 15807:2008, *Railway applications – Pneumatic half couplings*
- prEN 15839, *Railway applications – Testing for the acceptance of running characteristics of railway vehicles – Freight wagons – Testing of running safety under longitudinal compressive forces*
- prEN 15877-1:2009, *Railway applications – Marking on railway vehicles – Part 1: Freight wagons*
- EN 50121-3-1, *Railway applications – Electromagnetic compatibility – Part 3-1: Rolling stock – Train and complete vehicle*
- EN 50121-3-2, *Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus*
- EN 50153:2002, *Railway applications – Rolling stock – Protective provisions relating to electrical hazards*
- EN 50238:2003, *Railway applications – Compatibility between rolling stock and train detection systems*
- ISO 8573-1, *Compressed air – Part 1: Contaminants and purity classes*
- ISO 11112, *Earth-moving machinery – Operator's seat – Dimensions and requirements*
- NF F11-100:2005, *Railway rolling stock – Quality of compressed air for pneumatic apparatuses and circuits use*
- UIC 438-1:2004, *Identification marking for passenger rolling stock*¹⁾
- UIC 520:2003, *Wagons, coaches and vans – Draw gear – Standardisation*
- UIC 527-1:2005, *Coaches, vans and wagons – Dimensions of buffer heads – Track layout on S-curves*
- UIC 530-2:2008, *Wagons – Running safety*

¹⁾ Railway Technical Publications (ETF), 16 rue Jean Rey, F-75015 Paris

UIC 535-2:2006, *Standardisation and positioning on wagons of steps, end platforms, gangways, handrails, tow hooks, automatic coupler (AC), automatic draw-on coupling and brake valve controls on the UIC member RUs and OSJD member Rus*

UIC 541-03:1984, *Brakes – Regulations concerning manufacture of the different brake parts – Driver's brake valve*

UIC 541-4:2007, *Brakes – Brakes with composition brake blocks – General conditions for certification of composite brake blocks*

UIC 543:2007, *Brakes – Regulations governing the equipment of trailing stock*

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

UIC 545:2007, *Brakes – Inscriptions, marks and signs*

UIC 640:2003, *Motive power units – Inscriptions, marks and signs*

3 Terms and definitions

For the purposes of this document, the following terms and definitions and the terms listed in the relevant railway specific documents and in the UIC leaflets apply.

3.1

railbound machine (on-track machines, OTM)

vehicle specially designed for construction and maintenance of the track and infrastructure and used in different modes: working configuration, running configuration as a self-propelling vehicle, running configuration as a hauled vehicle, when:

- it is running on its own rail wheels,
- it is designed to have characteristics necessary for the operation of track based train detection systems

3.2

demountable machine

self propelled machine that can run and work on rail and which is not intended to operate signalling and control systems

NOTE 1 Such a machine is designed to get on and off track by its own means or with other lifting equipment. In the case of demounting by its own means these are not intended for running on the ground.

NOTE 2 Such a machine is permitted to work on the railway only under special operating conditions granted by the infrastructure manager and run under special conditions granted by the authorised body and/or the infrastructure manager.

3.3

trailer

non-self propelled machine that can be hauled on rail wheels

NOTE 1 Trailers are not designed and intended to operate signalling and control systems and are not designed to be transported between work areas on their rail wheels.

NOTE 2 This includes attachments with rail wheels.

3.4

railway infrastructure

all installations required for the running of railway vehicles

EXAMPLE Tracks, crossings, catenaries and signals.

- 3.5

type examination certificate
document issued after the checking of documents and/or testing of vehicles in which the agreement of the running of the machine in the railway infrastructure is confirmed
- 3.6

train
operational formation consisting of one or more machines/vehicles
- 3.7

portable machines
machine designed or adapted to be manually propelled along the track with wheels or rollers which is not designed to operate track signalling systems
- 3.8

trolleys
equipment for transport along the track of materials, tools and/or various equipment moving on wheels or runners and operated by human force only. It is designed so that it can be manually placed on or off the track

4 Machine categorisation

4.1 Categories

The application of all requirements of this European Standard is not possible in every case because of the differences in the design of machines.

The machines are therefore divided into seven categories as shown in Table 1.

Table 1 — Machine categories by maximum travelling speed

		Self-propelled machine travelling speed (v)		Non-self-propelled machine ^b
		≥ 100 km/h	< 100 km/h	
Can be incorporated into a train ^a with a speed of:	v ≥ 100 km/h	Category 1	Category 2	Category 3
	v < 100 km/h	---	Category 4	Category 5
Cannot be incorporated into a train		---	Category 6	Category 7
^a These machines could have restrictions for their position in a train.				
^b These types of machines are permitted to have a self propelling function in working configuration only.				

4.2 Type examination and categories

In order to use this European Standard, it is necessary to establish in which category the machine belongs. The corresponding requirements for the categories are defined in Annex A.

Machines meeting the requirements for their category, receive running approval for this category only.

5 Gauge

5.1 General rules

Machines shall meet the dimensional requirements of EN 15273-2 in all respects except where stated otherwise in special national conditions, see Annex B. The critical points near the limits of the permissible kinematic gauge shall be shown in the documentation according to Annex C.

Machines intended to run on infrastructures with more restrictive gauges shall conform to the specific rules of those infrastructures and the corresponding restrictions shall be shown in the documentation.

5.2 Stowing of moveable machine parts in transport positions

Except for pantographs all moveable parts of the machine that can encroach on the gauge defined in 5.1, including those parts that are prevented from abnormal movement by their operating mechanism safety features, shall be stowed and held by efficient red painted locks. It is not permitted to paint the machine red in the areas of the locks. The locks shall be designed so that foreign objects such as pieces of ballast cannot prevent their locking function. The control devices shall be designed as fail safe concept.

NOTE It is preferable that the control of locking should be possible from inside the machine.

Only where a moveable part is able to fall on to the track or to exceed the gauge, locks shall be doubled by slings, chains or similar devices in order to prevent them from falling onto the track in case of a failure of the locking mechanism.

It shall be obvious to anyone checking the machine that these parts of the machine are locked in their stowed position. This check shall be possible either by direct sight from one side of the track or by other means. Furthermore, for self-propelled machines a warning light shall illuminate on the driver's desk to indicate if a moveable part of the machine is not locked.

When travelling, all control circuits not related to travelling, including locking devices, shall be deactivated.

6 Frame

6.1 Principal dimensions

Except as shown below, the total length over the buffers and the distance between axles or bogies centres shall be in accordance to UIC 530-2.

6.2 Design of the machine frame

The machine frame shall be able to withstand either the static loads of EN 12663-1:2010, subclauses 6.1 to 6.5 or the static loads according to EN 12663-2:2010, subclauses 5.2.1 to 5.2.4, without exceeding the permissible values given therein.

The corresponding structural category of EN 12663-2 is as follows:

- for machines not permitted to be loose shunted or hump shunted: F-II;
- for all other machines: F-I.

The acceleration in x-direction according to EN 12663-1:2010, Table 13 or EN 12663-2:2010, Table 10 shall be ± 3 g.

6.3 Lifting and jacking points

The machine frame shall incorporate lifting points by which the whole machine is capable of being safely lifted or jacked. The location of the lifting and jacking points shall be defined.

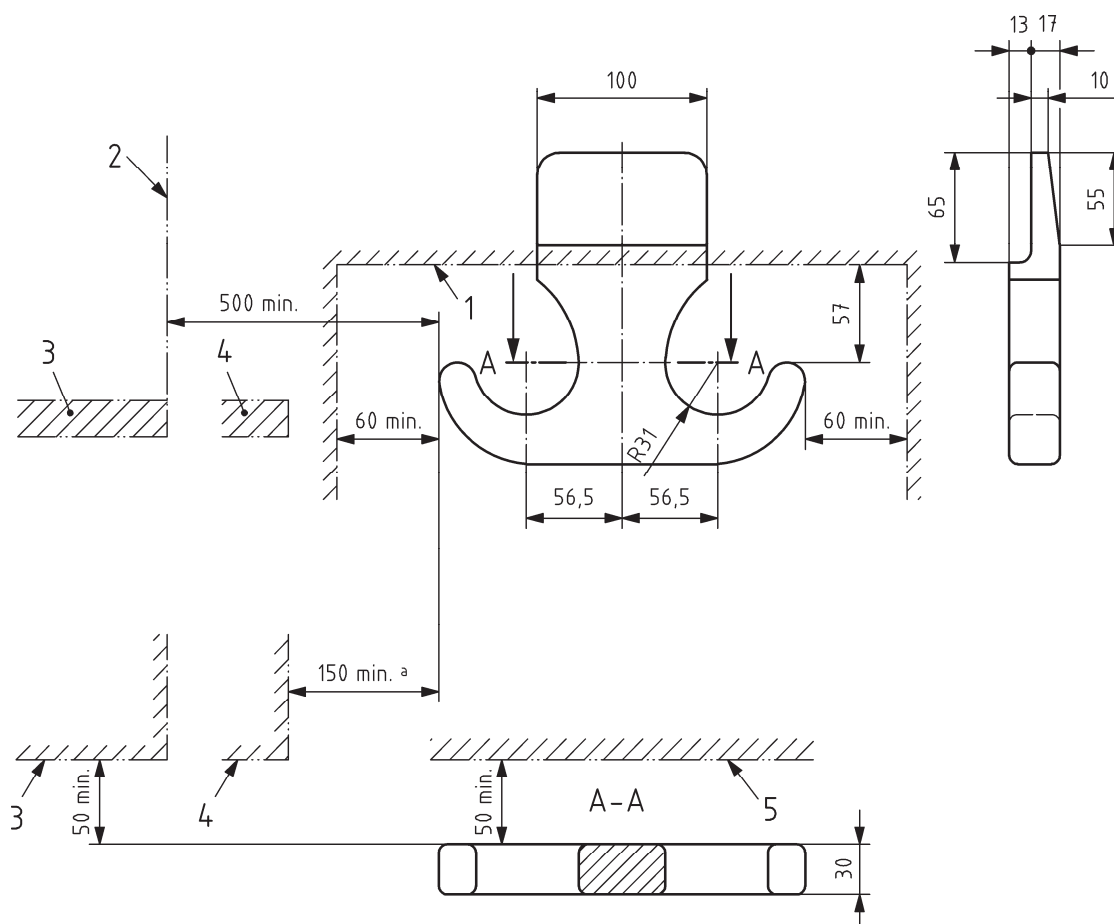
To facilitate the work during repair or inspection or when on-tracking the machine, the machine shall be provided on both long sides with at least two lifting points, at which the machine can be lifted in empty or laden condition. These lifting points shall be identified according to 17.1.

NOTE It is recommended to provide these lifting points at a distance of 1 400 mm from the middle of the individual wheelsets.

To allow positioning of jacking devices, clearances shall be provided under the lifting points which shall not be blocked by the presence of non removable parts. The lifting and jacking load cases according to EN 12663-2 shall apply for lifting and jacking under workshop and servicing conditions.

6.4 Stowage points for transport on boats

Machines suitable for transport on boats shall be fitted with stowage hooks in accordance with the Figure 1.



Key

- | | | | |
|---|--|---|--|
| 1 | Space required for projecting parts | 4 | Gangway or end platform step board |
| 2 | Buffer fixing plane | 5 | Other projecting parts, e.g. control-handles |
| 3 | Step board | | |
| a | If the dimension cannot be complied with, protective plates shall be mounted above the draw-hook | | |

Figure 1 — Stowage hook

7 Running gear

7.1 General

The requirements of this clause do not concern wheels or rollers used for specific working conditions and which are retracted during running.

The running gear shall be able to negotiate the horizontal and vertical radii given in Table B.1.

7.2 Wheel diameter

The nominal wheel diameter should preferably be between 920 mm and 1000 mm. However, wheels with a nominal diameter less than 920 mm may be used to meet particular design requirements. The minimum worn diameter shall not, however, be smaller than 330 mm.

7.3 Static axle loading

The maximum permissible static axle load depends on the wheel diameter. In the running condition, the limits shall comply with the values given in Table 2.

Table 2 — Static axle loading

Wheel diameter $\varnothing$ d^a mm	Maximum permissible static axle load t
$\varnothing \geq 840$	22,5
$840 > \varnothing \geq 760$	20
$760 > \varnothing \geq 680$	18,5
$680 > \varnothing \geq 630$	17
$630 > \varnothing \geq 550$	14,5
$550 > \varnothing \geq 470$	12,5
$470 > \varnothing \geq 390$	10,5
$390 > \varnothing \geq 330$	9
^a d = minimum worn diameter $\varnothing$ = diameter	

7.4 Wheel profile

The wheel profile shall comply with the requirements of EN 13715 or another profile if satisfactory riding as required in Clause 8 can be achieved.

7.5 Shape and dimensions of the axles and wheelsets

The axles shall comply with the requirements of EN 13261, EN 13103 and EN 13104. The design of the axles shall additionally take into account the forces generated when working.

Except as shown below, the wheels shall comply with the requirements of EN 13262 and EN 13979-1.

Other types of wheels made of ferromagnetic steel may also be used, if verification can be provided of the ability to safely transmit horizontal, vertical and braking forces.

The wheelsets shall comply with the requirements of EN 13260, EN 13103 and EN 13104. The design of the wheelsets shall additionally take into account the forces generated when working.

The axle bearings shall be according to the requirements of EN 12080.

7.6 Axle arrangement and axle loads

In running configuration the distribution of the wheelsets and their loads shall comply with the requirements of EN 15528.

Except as shown in sub-clause 10.3 of this standard, the distance from the buffer face to the first axle shall be less than or equal to 3 830 mm for machines with individual axles. For machines with bogies, the distance from the buffer face to the bogie centre shall be less than or equal to 3 830 mm.

NOTE 1 Special conditions for overhang can exist for certain infrastructures, see Annex B.

NOTE 2 It is recommended that the axle arrangements and measured loads do not exceed the values contained in EN 15528 applicable to class C2 lines.

The distances between the axles of machines shall comply with the conditions shown in the Table 3.

Table 3 — Distance between wheelsets

Characteristics	Minimum	Maximum
Machines with bogies		
Distance between axles of 2 axle bogies	1 500 mm ^a	
Distance between the axles of a bogie		4 500 mm
Distance between axles of a bogie having more than 2 axles	1 500 mm ^a	
Distance between bogie centres		15 500 mm ^b
Machines with individual axles		
Distance between outside axles		
- 2 axle machine	6 000 mm	10 000 mm
- 3 axle and single underframe machine	f	f
- 3 axle and articulated underframe machine	2 × 6 000 mm	c
Ratio: C/L	≥ 0,54 ^e	
C = distance between axles L = length of vehicles over uncompressed buffers ^d		
Articulated underframe machines		
Machines with bogies	c	c
Machines with individual axles	c	c
Machines with bogies and individual axles	g	g
^a Special bogies with small wheels can be designed with smaller axle spacing providing they meet the requirements of EN 13715, EN 13260 and EN 15528. ^b Machines having a greater bogie centre distance require special running conditions. ^c For articulated machines, the ability to negotiate curves shall be demonstrated. ^d In case of asymmetry, L = the distance between the axles plus twice the value of the greatest of the two overhang lengths. ^e Limiting value of 0,45 is acceptable for machines of categories 4, 5, 6 and 7. ^f A 3-axle machine is acceptable if the central axle does not transmit lateral guiding force to the rails. ^g The ability to negotiate curves shall be demonstrated.		

Machines which are required to operate spring operated points without risk of derailment shall have axle loads of at least 5 t.

7.7 Design for longitudinal compressive forces

Except as shown below, the requirements for designing for longitudinal compressive forces shall comply with prEN 15839 for running machines in any position in regular hauled freight trains:

- Machines with an overhang between 2 520 mm and 3 830 mm and a spacing between 6 500 mm and 15 500 mm between bogie centres are considered satisfactory to be incorporated in goods trains with the brake position in the passenger (P) or goods (G) mode without any restrictions for accommodating longitudinal compressive forces.
- Where a machine exceeds an overhang of 3 830 mm and/or a bogie centre spacing of 15 500 mm the machine shall either be restricted from incorporation into a goods train next to a two axle wagon, or tests according to prEN 15839 or calculations shall be carried out to establish whether the longitudinal compressive forces are acceptable.
- Where buffers and screw couplings are in use or the automatic traction coupling (Z-AK) the machine shall be designed to transmit longitudinal compressive forces ≥ 200 kN. The mandatory conditions for machines $\leq 10\,000$ mm axle spacing and with an overhang between 2 520 mm and 3 830 mm are the requirements of prEN 15839 and for machines $> 10\,000$ mm axle spacing and/or with an overhang greater than 3 830 mm a compression test according to the requirements of prEN 15839 or a calculation shall be effected.
- Where automatic couplings (AK) are in use the machine shall be constructed to transmit longitudinal compressive forces ≥ 500 kN.
- Within a train consisting of railbound machines the internal couplings between the machines are considered satisfactory for incorporation in goods trains with the brake position in the passenger (P) or goods (G) mode without any restrictions for accommodating longitudinal compressive forces.

7.8 Lifeguards

Machines shall be equipped with lifeguards at both ends in front of the outer axles. They shall be installed with the aim of reducing as far as reasonably practicable the risk of derailment due to impact with small obstacles on the line.

A lifeguard shall:

- a) be made of a ductile material;
- b) be able to resist, without permanent deformation, a sustained concentrated proof load of at least 20 kN applied at its bottom edge horizontally and in a longitudinal direction towards the adjacent wheel. During deformation beyond the proof load, the lifeguard shall resist without failure an ultimate load of at least 35 kN applied;
- c) be able to resist the proof load of 20 kN as defined in (b) combined with a transverse load, in either direction, of at least 10 kN;
- d) be designed so that, as the load in (b) or (c) is increased up to the maximum dynamic load that it can sustain during impact with the obstacle, it deforms plastically so as to maximise the amount of energy absorbed;
- e) be designed so that, during plastic deformation, it does not foul the track or running gear and that contact with the wheel tread, if it occurs, does not pose a risk of derailment;
- f) be designed so that, under the conditions described above, it remains securely attached.
- g) The height of the lower end of the life guard above the plain rail shall be:

- 30 mm minimum in all conditions;
- 130 mm maximum in all conditions;

taking into account in particular wheel wear and suspension compression.

8 Running safety

8.1 Running tests

The running characteristics of a machine or a machine type are permitted to be determined by running tests or by reference to a similar type approved machine or by simulation, see 8.3.

A "similar type approved machine" is a machine with similar configuration and travelling under similar conditions, and can be used as a reference for the test exemption of a new machine, according to the requirements of EN 14363:2005, subclause 5.2.1 and Table 1 (the column for freight stock is applicable unless the special vehicle is similar to a locomotive, multiple unit or a passenger coach).

NOTE When running tests are required, they should be carried out by an authorised testing body or by the manufacturer of the machine, if the manufacturer is authorised as a testing body.

For railbound machines running at a speed of $V \leq 120$ km/h, the requirements for special vehicles in accordance with EN 14363 are applicable. These requirements also apply to machines running at a speed $V > 120$ km/h, when the conditions of EN 14363, allow the use of an accelerometric simplified method for the type of vehicle to which the machine is similar.

Special vehicles may be designed with very high or low axle loads, unusual axle arrangements or distances, non-standard suspensions, moveable or retractable running gear etc. If, due to such design features and lacking positive operating experiences the machine could be considered as a new technology vehicle and shall be tested as such. If not, the requirements according to EN 14363 for special vehicles apply.

Possible fault modes of the machine which adversely affect the running behaviour shall be identified. Some of these fault modes could need to be submitted to specific running tests, the extent, conditions and assessment of which shall be defined.

The following deviations from EN 14363 apply:

- when running tests according to EN 14363 are done with wheel profile in new condition, these are valid for a maximum distance of 50 000 km. After 50 000 km it is necessary to:
 - either reprofile the wheels;
 - or calculate the equivalent conicity of the worn profile and check that it does not differ more than 50 % from the value of the test of EN 14363 with a maximum difference of 0,05;
 - or make a new test according to EN 14363 with worn wheel profile;
- normally, tests to determine the applicability of a machine to a series as set out in EN 14363:2005, 5.4.3.2 are not necessary;
- if the required test speed cannot be obtained by the machine itself, the machine shall be hauled for the tests;
- when test zone 3 according to EN 14363:2005, Table 9 is used it is sufficient to have a minimum of 25 conformant track sections.

NOTE It is not possible to find suitable test sites for all combinations of requirements of EN 14363 and this matter is receiving further consideration in a revision of the standard.

8.2 Running safety on track twists

Safety against derailment when running on track twists is permitted to be proved by an approved calculation method, e.g. according to EN 14033-2 and this in the configuration of machine as it is in its running configuration. If this is not possible, tests according to the requirements of EN 14363 shall be carried out.

8.3 Running simulation

Running behaviour is permitted to be proven by simulation when there is a proven model of the machine.

A model of a machine for simulation of running characteristics shall be proven by comparing the model results against the results of running tests when the same input of track characteristic is used.

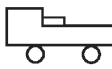
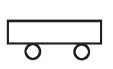
A proven model is a simulation model that has been verified by an actual running test that excites the suspension sufficiently and where there is a close correlation between the results of the running test and the predictions from the simulation model over the same test track.

9 Brakes

9.1 Compulsory braking equipment

Mandatory braking equipment for different machine categories is shown in the Table 4.

Table 4 — Compulsory braking equipment

	a		b		c		d		e		f	
												
Machine Category	1, 2, 4	6	3, 5	7	3, 5	7	3, 5	7	3, 5	7	3, 5	7
Continuous and automatic brake UIC ⁱ	x		x		x		x		x		x	
Continuous and automatic brake		x		x		x		x		x		x
Direct brake	x	x					x	(o)				
Operation of the automatic brake	x ^g	x ^g					x ^g	x ^g				
Operation of the emergency brake	x	x			x	x	x	x			x	x
Operation of the direct brake	x	x					x					
Dynamic brake	x ^h	x ^h										
Parking brake	x	x	x	x	x	x	x	x				
^a Self-propelled machine ^b Non-self-propelled machine, not intended to carry personnel ^c Non-self-propelled machine permitted to carry personnel ^d Non-self-propelled machine with driver's cab ^e Permanently coupled single axle or bogie articulated machine not intended to carry personnel ^f Permanently coupled single axle or bogie articulated machine permitted to carry personnel ^g See 9.2.3 simplified drivers brake valve ^h Imposed on specific lines with steep gradients, see Annex B ⁱ Shall be as defined in EN 14198:2004, 5.4 (o) optional												

For Category 1, 2, 3, 4 and 5 in various train formations a continuous and automatic UIC brake is mandatory. Its architecture shall be compliant with the requirements of EN 14198. Category 6 and 7 machines shall also be equipped with a continuous and automatic brake, but it is not necessary to follow the UIC architecture. If the continuous and automatic brake fitted to Category 6 and 7 machines is not compatible with an automatic UIC brake the connections shall be designed such that it is not possible to connect them to standard UIC connections.

The continuous and automatic brake should operate on all wheelsets. If it is incompatible with working conditions, it can be acceptable that some wheelsets are not equipped with brake components; provided that they are not outer wheelsets and that the required brake performance is obtained. Additional equipments may be required depending on the running speed and the utilization of adhesion.

If the machine is fitted with a

- Direct brake system it shall be in accordance with 9.2.4;
- Dynamic brake system it shall be in accordance with 9.2.6;
- Parking brake system it shall be in accordance with 9.2.5.

9.2 Characteristics

9.2.1 Performance

By principle, no single failure shall lead to a total brake loss.

The maximum adhesion coefficient, the use of WSP, the brake performance and its thermal capacity shall be consistent with wagons for Category 3 and 5 machines and locomotives for 1, 2 and 4 machines.

NOTE Further information is given in TSI WAG 4.2.4.1.2.2 or in TSI CR LOC&PAS 4.2.4.6.1 and 4.2.4.6.2.

When percentages of brake power are used, the values in Table 5 will apply.

For all authorised load conditions, the machine braking mechanism shall ensure compliance with the following minimum braked-weight percentages (ratio of braked weight in each braking position to total weight on rails), see Table 5.

Table 5 — Minimum brake-weight percentage

Machine Type		Minimum brake-weight percentage λ	
		P position	
		100 km/h	120 km/h
I	Machines without "empty-loaded" changeover device or without self-adjusting load-proportional braking equipment (wagons with invariable total weight on rails or a maximum load and tare, which are such that the values given opposite can be observed)	65	100
II	Machines fitted with the "empty-loaded" changeover device (manual or automatic)	65	100
III	Machines which can run empty at 120 km/h in the "empty" position		100

The brake performance shall be calculated in accordance with EN 14531-6 and shall be determined in accordance with UIC 544-1:2004.

When the machine is in the working mode the brake performance shall be in accordance with EN 14033-2.

9.2.2 Mechanical characteristics of the brake

Both disc brakes and tread brakes are acceptable.

Brake discs mounted on axles shall be in accordance with EN 14535-1. Brake discs mounted on wheels shall be in accordance with prEN 14535-2:2007. Brake pads shall comply with the requirements of EN 15328. Disc brakes shall be arranged that they do not affect the operation of hot box detectors.

The friction material of the brake block shall be made of cast iron or "LL" or "K" material. Composite brake blocks according to UIC 541-4:2007 are permitted to be used in the configuration in which the brake blocks have been validated. Measures shall be taken to reduce the side play of brake blocks or brake block holders on the tread area of the wheel. The brake block holder shall be in accordance with prEN 15329 and so arranged that they do not prevent the use of wheel scotches on the machine. If brake blocks with different friction values are specified, the brake block holders shall be so designed that it is impossible to use the wrong friction material.

All moving parts shall be designed and/or protected against falling on to the track.

A brake rigging slack adjuster shall be provided. These should be automatic or the maintenance plan shall cover the adjustment process.

For disc brakes an indicator, visible from the trackside, shall be provided on both sides of the machine, red to indicate the brake is on, and green to indicate the brake is off. Such an indicator shall also be provided for tread brakes if the state of the brake cannot be verified from outside of the machine. Brake indicators shall comply with the requirements of EN 15220-1.

9.2.3 Automatic compressed air brake

The characteristics of the local brake control devices used in conjunction with the UIC automatic brakes shall comply with EN 15355 and EN 15611. All machines of categories 1, 2, 3, 4 and 5 fitted with a compressed-air brake shall have a manual-release valve and shall be equipped with both braking modes "passenger" (short form "P") and "goods" (short form "G").

The compressed air from the brake pipe shall not be used for other purposes than braking.

The internal diameter of the brake pipe shall be the same as for freight wagons, namely 32 mm. If a main reservoir pipe (MRP) is fitted, its internal diameter shall be at least 18 mm.

The metal pipes used shall meet the requirements of EN 10220 or EN 10305-4 or EN 10305-6. The number of pipe connections is to be limited to the strictly necessary minimum and pipe connections shall be accessible without having to disassemble other equipment. The connections made by thread on pipes are not allowed.

Flexible piping shall be limited to areas impossible to fit with rigid pipes. A failure of these flexible pipes shall not lead to a total brake loss. When flexible piping is used between gauges and pneumatic circuit, a restriction choke shall be inserted to minimize air flow in case of flexible failure.

The maximum brake pipe volume of 25 l shall be assigned to any distributor valve.

Where the operational weight of the machines can vary, they shall be equipped with an load dependent brake to ensure that the adhesion limits specified in 9.2.1 are respected. If the maximum speed is less than 120 km/h a manual empty/loaded change over device in accordance with EN 15624 is permitted. For machines having a travel speed of ≥ 120 km/h this function shall be automatic and meet the requirements of EN 15625.

Machines controlling trains longer than 150 m and/or with more than 12 wheelsets shall be equipped with a driver's brake application device following the requirements of UIC 541-03:1984. For machines controlling shorter trains a more simple design is sufficient. It shall provide as a minimum a:

- running/release position;
- graduated service brake application;
- emergency brake application;
- isolating function.

The majority of train operators are accustomed to apply the emergency brake by moving the lever of the device towards the driver as set out in Figure 4.

If a local brake control device can be overcharged provision shall be made that the pressure in the brake pipe can be adjusted by raising the brake pipe pressure to a defined value. This subsequently shall be followed by slow reduction of the brake pipe pressure to the nominal value in accordance with UIC 541-03:1984 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 there are multiple driving positions, it shall not be possible to release the brakes from any driving position, which is not in use.

9.2.4 Direct brake

If a self propelled unit can be operated as a single vehicle it shall be equipped with an additional direct brake or alternatively two separate and independent brake control units.

After a maximum of 4 s all the brake units shall have developed 95 % of their brake force.

The exhaust time of the brake cylinders from the maximum pressure to 0,4 bar shall of (4 ± 1) s.

The brake performance for the direct brake shall be equal to or better than that achieved with the continuous and automatic brake in brake mode "P" as given in 9.2.1.

The majority of train operators are accustomed to apply the direct brake by moving the lever of the device towards the driver as set out in Figure 4.

The direct brake shall be designed to:

- provide a running/release position and graduated brake application;
- allow the maximum pressure from either direct or automatic brake to be fed in to the brake cylinders;
- be isolated in the cab, which is in not in use.

9.2.5 Brake functions to keep a machine stationary

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

9.2.5.1 Holding brake using the automatic or direct brake

The purpose of a holding brake is to secure the train at standstill temporally and to secure the train on a gradient during a hill start.

The holding brake shall be capable of holding a machine under the conditions of maximum load and a gradient which shall be defined by the operator or shall follow the default value of at least 40 ‰.

To hold in a stationary position the machine with maximum load (design mass under exceptional payload) for at least two hours, in the event of the braking energy supply being disrupted or the power supply failing.

9.2.5.2 Parking brake

The purpose of a parking brake is to keep the train stationary in shut down configuration for an indefinite period of time without energy supply.

The parking brake performance shall hold the machine on a gradient of 40 ‰ without exceeding a coefficient of friction between the rail and wheel of 0,12. If the machine is used on steep sections of line, a steeper gradient may be required on specific railway infrastructures, see Annex B.

If the parking brake is applied by a hand wheel or hand crank manually, the operator shall not exert a force exceeding 500 N. The brake shall apply by a clockwise movement.

The hand wheel/crank shall have an effective minimum diameter of 400 mm and if they are located outside the cab, they shall be accessible from both sides of the machine. If the parking brake control is located inside the cab, it shall also be accessible from outside.

Any spring apply air release parking brake actuator shall be provided with a mechanical release, accessible from the outside. It shall be possible to operate such a release from a convenient position with consideration of the risk of contact with an electrified rail of the infrastructure. The parking brake actuators shall reset automatically by filling with compressed air. The parking brake actuators shall still be capable of manual release even when the full service brake is applied.

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

In the case of a manually operated spring applied brake the status of the actuator (applied = red, released = green, indication not valid) should be indicated in a clear and concise manner and without using electrical energy.

9.2.6 Dynamic brake

A dynamic brake may be considered for track machines. In case of dynamic brake, the following characteristics shall be considered:

- a) a manual device to isolate the dynamic brake;
- b) an isolating or a loss of dynamic brake shall be indicated to the driver;
- c) it is permitted for a dynamic brake control to be independent from the automatic brake controller;
- d) the brake force generated by the dynamic brake should be used in preference to the friction brake;
- e) It is permitted to supplement the dynamic brake with the friction brake to achieve the braking force demanded.

9.2.7 Emergency brake

Devices, which are capable of applying the continuous and automatic brake in an emergency, shall be fitted in all locations where personnel are permitted to be present during travelling. They shall be unique to the application of the emergency brake, clearly visible and easily accessible.

The devices for this shall vent the brake pipe or de-energise the brake loop in order to apply the emergency brake and cut-off all traction forces. The re-starting of the traction shall be possible only when the emergency braking control is cancelled and the traction command is cancelled by the driver

If an OTM is used as a locomotive for coupled wagons with unknown configuration, the capacity of the exhaust shall be such that the compressed air contained in a reservoir of at least 400 l attached to the brake pipe and charged to 5 bar shall be exhausted to 1,5 bar in less than 4 s (measured on the reservoir). If the OTM is provided

only for pulling a pre-defined train configuration, the test shall be carried out with this configuration. The air exhaust shall be vented outside of the machine.

An override device for the emergency brake for use by the driver shall be provided where there is the possibility of the emergency brake being applied remotely from the driving cab.

9.2.8 Brake distributor controls

The following brake valve controls shall meet the requirements of EN 15355, EN 15624 or prEN 15877:

- train brake isolating valve;
- brake purging valve;
- goods/passenger valve;
- empty/loaded valve (if fitted).

9.2.9 Other brake systems

Machines of category 6 and 7 may be equipped with other types of brake providing they are fail safe, have graduated application and release and at least meet the brake performance given in 9.2.1. It shall not be possible for the machine to travel unless the brakes are fully operative.

9.3 Air reservoirs

As a minimum the reservoir capacity shall provide 2 emergency applications under maximum load conditions. If the machine is fitted with WSP the brake supply reservoirs shall be dimensioned such that the air consumption by WSP does not impair the performance of the pneumatic brake. The type and mounting of air reservoirs shall be in accordance with the requirements of EN 286-3 and/or EN 286-4.

9.4 Compressed air production of self-propelled machines

As a minimum, the compressed air production of self-propelled machines shall ensure sufficient air supply for the number of hauled vehicles fitted with air brakes that the machine is designed to haul.

The quantity of compressed air that can be produced and the number of braked wheelsets of hauled wagons shall be given in the technical documentation, see Annex I.

The minimum capacities based on a maximum pressure of 10 bar are given in Table 6.

Table 6 — Minimum compressor output number of braked, hauled wheelsets

Compressor output in l/min at the maximum speed of the compressor	300	500	800	1 000	1 250	1 500	2 000	2 500	3 000
Maximum number of braked wheelsets of hauled wagons	6	12	28	44	52	80	104	136	160
Minimum capacity of main air reservoirs in l	200	200	280	440	520	800	800	800	800

If the same compressor fills the different air reservoirs and auxiliary air reservoirs, the filling of the brake system shall have priority.