BS EN 16207:2014

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

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

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

5 km/h has an equivalent value of 3 mile/h
20 km/h has an equivalent value of 10 mile/h
50 km/h has an equivalent value of 30 mile/h
220 km/h has an equivalent value of 135 mile/h
280 km/h has an equivalent value of 175 mile/h

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

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Bahnanwendungen - Bremse - Anforderungen an Funktion und Leistungsfähigkeit von Magnetschienenbremssystemen für Schienenfahrzeuge

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Foreword

This document (EN 16207:2014) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by February 2015 and conflicting national standards shall be withdrawn at the latest by February 2015.

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

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

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

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

1 Scope

This European Standard specifies the functionality, position, constraints and control of a magnetic track brake system (MTB system) installed in bogies for use in emergency braking and in low adhesion conditions on Mainline Trains with speeds up to 280 km/h. It covers high suspension types of MTB only and not high/low and low suspension type of MTB.

This document also contains test methods and acceptance criteria for an MTB system. It identifies interfaces with electrical equipment, bogie, track and other brake systems.

On the basis of the existing international and national standards, additional requirements are defined for:

— conditions of application for the MTB system;

— retardation and brake forces;

— functional and design features;

— strength requirements;

— type, series and vehicle implementation tests.

For design and calculation a "reference surface" is established.

2 Normative references

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

EN 10025-2, *Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels*

EN 13674-1, *Railway applications — Track — Rail — Part 1: Vignole railway rails 46 kg/m and above*

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

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

prEN 14531-2, *Railway applications — Methods for calculation of stopping and slowing distances and immobilisation braking — Part 2: Step by step calculations for train sets or single vehicles*

EN 15085 (all parts), *Railway applications — Welding of railway vehicles and components*

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

EN 15273-1:2013, *Railway applications — Gauges — Part 1: General — Common rules for infrastructure and rolling stock*

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

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

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

prEN 16185-1, *Railway applications — Braking systems of multiple unit trains — Part 1: Requirements and definitions*

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

EN 45545-2, *Railway applications — Fire protection on railway vehicles — Part 2: Requirements for fire behavior of materials and components*

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

EN 50124-1, *Railway applications — Insulation coordination — Part 1: Basic requirements — Clearances and creepage distances for all electrical and electronic equipment*

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

EN 50128, *Railway applications — Communications, signalling and processing systems — Software for railway control and protection systems*

EN 50129, *Railway applications — Communication, signalling and processing systems — Safety related electronic systems for signalling*

EN 60077-1:2002, *Railway applications — Electric equipment for rolling stock — Part 1: General service conditions and general rules (IEC 60077-1:1999, modified)*

EN 60529, *Degrees of protection provided by enclosures (IP Code) (IEC 60529)*

EN 61373, *Railway applications — Rolling stock equipment — Shock and vibration tests (IEC 61373)*

EN ISO 2409, *Paints and varnishes — Cross-cut test (ISO 2409)*

EN ISO 4628-3, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 3: Assessment of degree of rusting (ISO 4628-3)*

EN ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests (ISO 9227)*

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

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1
actuator
device to lower the MTB to the rail head, commonly a pneumatic cylinder with a return spring

3.1.2
end pieces
guide the magnets on the rails

Note 1 to entry: They also contribute to the braking force

Note 2 to entry: They are subject to wear.

3.1.3
high suspension
variation of the MTB in which the magnets are connected with each other by means of tie bars and, in their rest position, are fastened to centring elements situated at a rest position in the running gear where they are held by spring action, and in which, so as to apply the magnets, an energy source is used for lowering them onto the rails

3.1.4
high/low suspension
variation of the MTB in which the magnets are likewise connected with each other by means of tie bars and, in their rest position, are fastened to centring elements situated at a rest position in the running gear where they are displaced to their low position by using an external energy source, whereas, in their low position, however they are situated at a height which, when the magnets are energized, causes the magnets to get self-attracted by the rails, against a spring force

3.1.5
low suspension
variation of the MTB in which the magnets are suspended above the rail surface, by the action of a spring, at a level that allows the magnets, when they are energized, to become self-attracted by the rail

3.1.6
pole shoes
friction elements of the magnet that produce the braking force

Note 1 to entry: They are subject to wear and are therefore replaceable.

3.1.7
rest position
position of the MTB in which the magnets suspended at a significant distance from the rail surface, unless a brake application command has been issued and in which position the magnet is guided and positioned by the bogie

Note 1 to entry: This position corresponds to the geometrical defined rest position in case of high suspension and high/low suspension.

3.1.8
weld-ons
accumulation of metallic wear debris that attaches to the underside of the MTB pole pieces

Note 1 to entry: The presence of this material reduces the braking performance of the MTB and thus needs to be removed during maintenance activities.

3.1.9
working position
position of the MTB in which the magnets are in contact with the rail where it centres itself, due to the action of the magnetic field and in which, when the magnet is energized, the brake force is produced by friction

3.2 Abbreviations

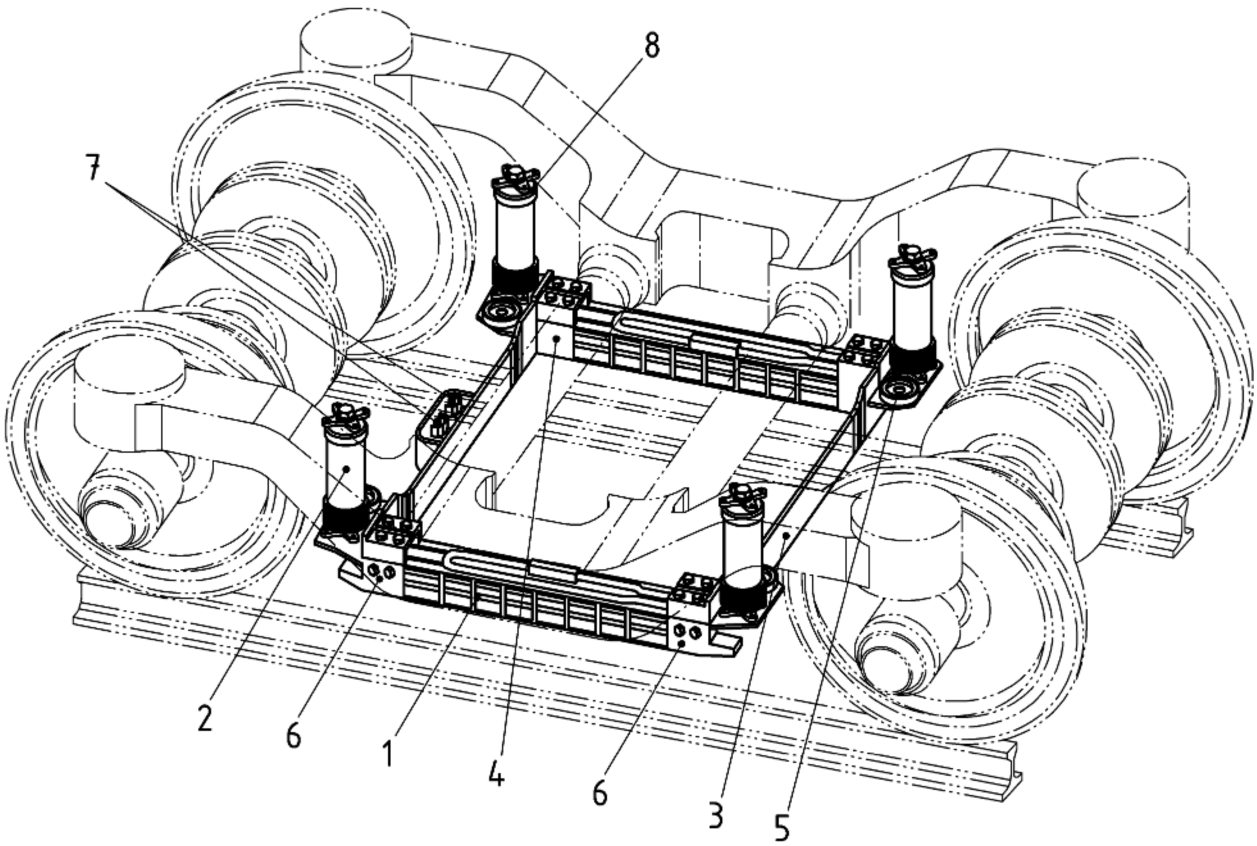
For the purposes of this document, the following abbreviations apply.

BP	Brake Pipe
CCS	Control Command and Signalling
DC	Direct Current
EMC	Electromagnetic Compatibility
FME(C)A	Failure Mode Effect (criticality) Analysis
g	acceleration by gravitation (9,81 m/s^2)
IP67	IP-Code: a coding system to indicate the degrees of protection by an enclosure against access to hazardous parts, ingress of solid foreign objects, ingress of water and to give additional information in connection with such protection, according to EN 60529
MTB	Magnetic Track Brake, equipment for one bogie/running gear
PD2	degrees of pollution for the purpose of evaluating creepage distances and clearances, according to EN 50124–1
q	clearance in mm between wheel set and lower part of the bogie frame in accordance with EN 15273–2
R+Mg	brake mode with the MTB function active in accordance with EN 14198
TSI	Technical Specification for Interoperability
U_N	nominal battery voltage
WSP	Wheel Slide Protection

4 Task and purpose of the MTB

The MTB is an additional braking device that directly acts on the rails and is therefore independent of wheel/rail adhesion. Its action is obtained by friction due to the magnetic attractive force. The magnetic attractive force can be generated electrically or by permanent magnets. The MTB is installed into the bogie or running gear, if required, to complement the brake depending on the wheel/rail adhesion. In the bogie the magnets are installed between the wheels.

Figure 1 shows an example of an MTB with high suspension fitted to a bogie, which is represented in a simplified version.



Key

1 magnet with segmented or rigid pole shoes

2 actuator

3 tie bar

4 brake reaction bracket, non-magnetic

5 centring device to restrict lateral movement in the rest position

6 special end pieces for negotiating point work

7 electrical interface

8 pneumatical interface

Figure 1 — Installation of an MTB into a bogie (example)

The MTB is generally used in the following cases:

a) Emergency brake applications:

The MTB is activated automatically in case of an emergency brake application. If the MTB is part of the emergency braking performance then it is subject to specific safety and reliability requirements with respect to its availability to be applied. In this situation the retardation rate can be included in the braked weight value/overall retardation of the vehicle.

b) Brake application under low adhesion conditions or steep slopes:

The MTB may be actuated at the driver’s discretion independently of the wheel/rail adhesion dependent brake.

If MTB is on vehicles that are to be run through shunting areas, the system shall allow the inhibition of MTB and the clearance restrictions in accordance with EN 15273-1:2013, Figure C.4 shall be observed.

NOTE 1 There is a risk that roll down humps, rail brakes and other shunting and retarding devices may contact MTBs particularly on track curves having a radius of R < 150 m.

NOTE 2 Vehicles which by reason of their design are liable to sustain damage when crossing shunting humps will be marked with EN 15877-2:2013, Figure 76. Vehicles which are not designed for passing rail brakes will be marked with EN 15877-2:2013, Figure 58.

5 Design requirements

5.1 Space envelope to be observed by the MTB

The position of the brake magnets above rail shall ensure a clearance which is sufficient under all operating configurations/conditions to prevent the magnets making contact with the rail if not activated (due to vibrations or suspension movements, independent of speed, even under extreme conditions with wheel wear and new brake magnets.

The clearances shall take into account the lateral excursion and the vertical height position of the MTB when the vehicle is in the operating condition. The clearances of the vehicles to be observed are generally guided by the following provisions:

a) The permissible clearances in accordance with EN 15273-1:2013, Figure C.4, including space "*e*", for the lower limitation of the vehicles shall not be exceeded by any parts of the MTB, neither in its rest nor in its working position. When the brake is in its working position, the magnets are centred on the rail, due to their magnetic force, as a consequence of which their gauge clearance only needs to be provided for the rest position of the brake.

b) For the short time during the transition from its rest to its working position and vice versa gauge clearance shall be equated with its working position.

c) In case space "*e*" should be used in working position and the magnets should contact with the track, e.g. when passing over switches, track or road crossings, their safe return to space "*d*" shall be ensured, without any functional impediment.

d) When performing the clearance check, the following criteria shall be taken into account:

    1) the wear condition of the wheels;

    2) the condition of the pole shoes;

    3) the suspension movements of the bogie.

5.2 Retardation force

The retardation of the MTB depends on its magnetic attractive force on the rail, the magnet length applied, the material of its magnets and their condition during the braking process. The braking force produced by friction between the magnets and the rail results from the combined effect of the magnetic force applied and the coefficient of friction element/rail.

For dimension and design purposes calculations shall be carried out in accordance with prEN 14531-2. The performance shall be verified by testing.

The MTB shall, whenever possible, reach its specified retardation rate under all environmental conditions that are typical for railway operation. It is permitted during winter control to use heating elements to reduce the build-up of ice on the pole shoes.

The magnetic attractive force of the MTB on to the rail head shall be defined in the technical documents of the manufacturer and is expressed and measured in accordance with the methods described in 9.1.2.

5.3 Guidance of the activated magnet when applied to the rails

As a rule, each magnet or both magnets jointly, arranged opposite each other, shall have an optimum contact with the rail head when activated. For this purpose, the MTB shall be provided with sufficient lateral freedom in the bogie in the working position. The MTB shall have an adequate lateral clearance. In EN 15273-1 the clearance between axle and bogie underframe is defined by q:

$$x = \text{lateral clearance} + q$$

The distance between the centre lines of the magnets shall be 1 510 mm for standard gauge (1 435 mm), see Annex C. When intended for use on different gauges the distance between the centre lines shall be adjusted accordingly.

A bogie shall always comprise two magnets with pole shoes of identical construction. Appropriate devices (e. g. tie bars) shall be provided to maintain the pole shoes in a parallel position to each other.

When the rail head is interrupted (switches, crossings), guidance of the magnet along the longitudinal axis of the rail head and its geometrical position, in relation to the vertical axis, shall be ensured in an optimum way to achieve a retardation rate that is as uniform as possible and to make sure that the MTB guiding elements in the running gear be subjected to the least possible mechanical load. The working MTB shall be capable of passing over switches and crossings (incorporating fixed crossings). A reference switch where the tangent of the crossing angle is tg $\alpha \geq 0{,}034$ is able to verify the capable function.

5.4 Rest position of the magnet above the rail surface

The MTB when in its rest position with the vehicle in working order, with fully worn wheels and taking into account static deflection of the running gear shall:

— remain within the space "b", as defined in EN 15273-1:2013, Figure C.4;

— be 40 mm to 100 mm above the rail surface.

It may be assumed that the stationary parts in the switch and crossing environment do not exceed a height of 80 mm above the rail surface.

5.5 Magnet elements

5.5.1 End pieces

The end pieces of a magnet have several tasks:

— they protect the magnet pole shoes transmitting the braking force from mechanical damage;

— they assist the passage of the magnet over switches and crossings when the magnets are in working position, to reduce the risk of derailment;

— they contribute to the overall retardation generated by the magnet.

To ensure these characteristics, the end pieces are fixed on the support frame of the magnets and shall have a suitable geometry. The present state of the art is documented in Annex C.

5.5.2 Pole shoes

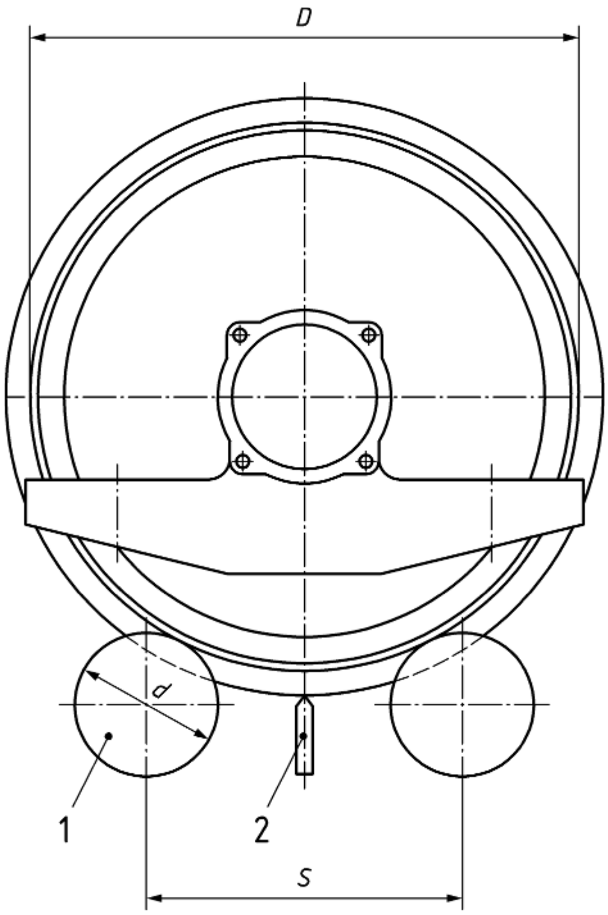
The magnet can have a single rigid pole shoe which is generally used in low speed applications. For Mainline operation the state of the art is a magnet body with several pole shoes, which are free to move within the support frame.

The width of the pole shoe that is in contact with the rail head shall be 65 mm to 72 mm and the maximum width of the magnet shall not exceed 140 mm. It is permitted for the magnets to be fitted with renewable friction plates to enable easy replacement while on the vehicle. The limit of wear of the pole shoe and/or the friction plates shall be clearly identifiable.

The total length L over which the MTB is in contact with the rail should be at least 1 000 mm.

5.6 Clearance for wheel lathe machines and wheel skates

The installation of the MTB shall be made in such a way that sufficient space is available in the vicinity of the wheel to perform maintenance or repair work with underfloor wheel lathe machines. An example of the clearance required for this purpose is represented in Figure 2.



Key

D wheel diameter

d diameter of driving roller

S distance between axis of driving rollers

1 driving roller of the wheel lathe

2 lathe tool

Figure 2 — Typical underfloor wheel lathe configuration

NOTE Typical dimensions for wheel lathe machines are:

— diameter of driving roller *d* = 220 mm;

— distance between axis of driving rollers *S* = 440 mm.

To permit the use of wheel skates, it shall be possible to remove the magnets or their end pieces without damage.

5.7 Strength requirements

The MTB (magnets, actuators, tie bar, brake reaction bracket – see Figure 1) should be designed so that:

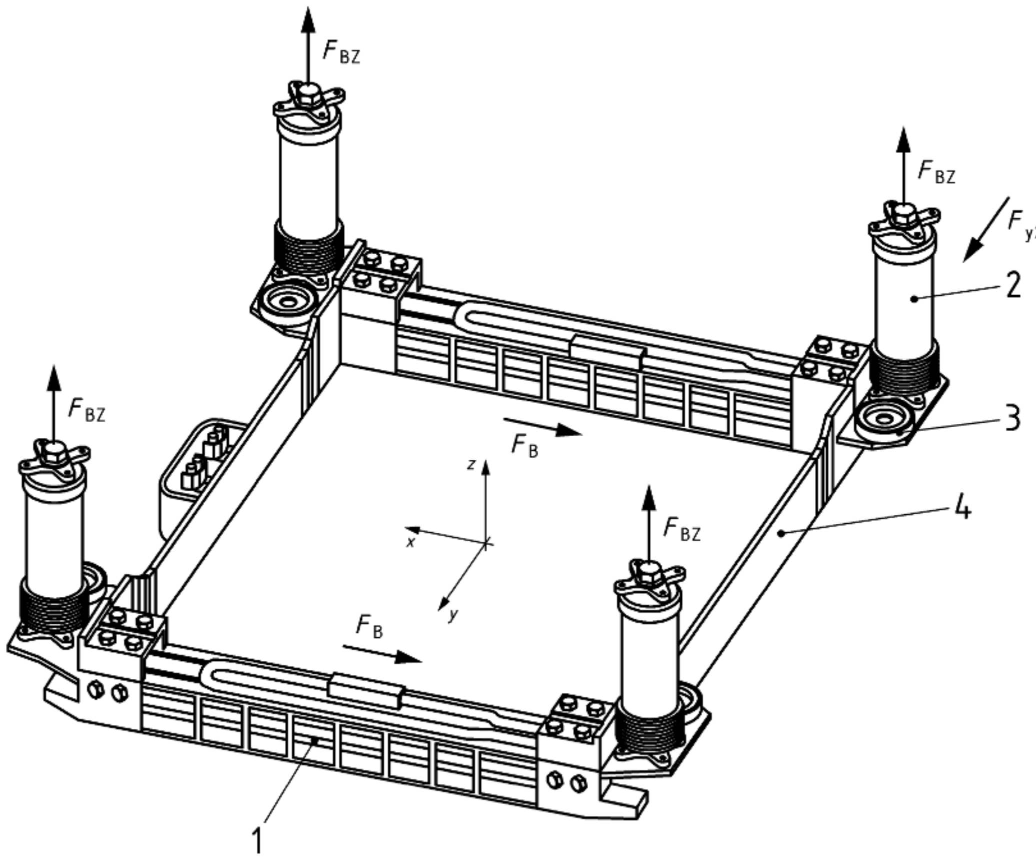
— no resonant vibrations are exerted on the bogie frame and the parts of the MTB;

— all movements and loads originating from the guiding elements of the bogie frame can be sustained without damage;

— when the brake is in its working position, the forces originating from faulty track conditions, switch interruptions and contacts with track guiding elements do not lead to instantaneous or permanent damage endangering the function of the MTB;

— the longitudinal forces resulting from the braking process can be transferred to the bogie frame.

Annex A gives the forces resulting from the interaction of the MTB with the track that shall be used for the design.



Key

1 magnet with segmented or rigid pole shoes

2 actuator

3 centring device to restrict lateral movement in the rest position

4 tie bar

Figure 3 — Designations

In its high suspension type the MTB is held in its rest position by spring force and is fastened to the running gear by means of centring devices. In this rest position the MTB is engaged with the bogie frame and is subject to a series of forces exerted on the latter, originating from elastic variations of the bogie frame.

To permit a comparable assessment to be made, independently of the real design, a square horizontal level with a lateral length of about 1 000 mm is defined as a „reference surface“. Any displacements, distortions and towing movements of the running gear are referred to the vertices of this "reference surface", independently of the real centring elements determined in the design stage; this data shall be defined.

5.8 Mechanical fastening of the MTB parts to the bogie

All parts of the MTB and their suspension to the vehicle/running gear shall be designed so that under the influence of the static and dynamic loads that are observed in operational service parts shall nor become loose nor get lost. If individual fastening elements fail, no part of the MTB shall get caught in the track. Screw connections shall be provided with a redundancy or safety-features ensuring that in case of a failure the MTB function is maintained.

With respect to safety features, cords and slings are considered inappropriate in this application.

The magnets shall be easily positioned or be capable of being positioned such that any weld-ons can be eliminated without any problems without the magnets having to be removed.

The energy supply cables and junction boxes of MTB shall be protected against impacts of stones and ice blocks.

5.9 Additional requirements for permanent magnets

It shall be possible to change the direction of the magnetic flow of the permanent MTB by a local device in order to suppress the attractive forces when required.

It is permitted to use the permanent MTB as a parking brake.

Consideration should be given to a loss of parking brake performance due to adverse rail head conditions such as when the vehicle is stationary on curves or canted tracks (it cannot be ensured that the MTB will centre on the rail head).

5.10 Control of the MTB

If the MTB shall be considered in the emergency brake performance, it shall be activated by an automatic brake control system such as in EN 14198, EN 15734-1 or prEN 16185-1. Using of software is allowed if the same level of safety can be demonstrated.

Emergency brake application shall be automatically detected either by pressure drop in brake pipe below 3 bar or directly through the emergency braking command.

MTB shall be used from the maximum operating speed of 280 km/h to 20 km/h if jerk limitation is provided. The MTB may be commanded independently from emergency brake application for use by the driver, e.g. under low adhesion conditions or slopes greater than 40 ‰. To permit this use to standstill the additional loads shall be considered in the design loads.

NOTE 1 Comfort limit values for the jerk in the passenger area are defined in EN 13452–1 for the vehicle.

NOTE 2 French infrastructure rule impose to not apply MTB when the speed is higher than 220 km/h.

It is permitted to deactivate MTB at speeds below 50 km/h to control excessive jerks. The MTB shall become effective again at the latest when exceeding a speed of 50 km/h. The MTB will deactivate independently of the speed when the emergency brake command is removed or in case of automatic air brake system the pressure in the BP exceeds 3 bar. The speed threshold shall be generated locally for each MTB control unit. The MTB control unit shall be designed in accordance with EN 50126, EN 50128 and EN 50129. If the speed signal is not generated by the WSP, the same level of safety as required for the WSP shall be demonstrated.

The MTB is energized to apply activated by means of contactors or electronic power switches. Each MTB control unit shall react individually and independently on the brake line command and shall control a maximum of one or two MTB sets in inseparable train units. The voltage supply shall be safeguarded and prioritized over other on board systems.

If the brake command is received the following shall happen:

a) the actuators shall be pressurized and the current shall be switched on;

b) the time for the application of the MTB (between the detection of emergency brake application and development of 50 % of the attraction force) shall be less than 3 s;

c) the bogie lifting force generated by the MTB per single magnet shall not exceed 10 kN (i.e. 20 kN per bogie) under all conditions of wheel wear with new magnets and suspension movements;

d) the MTB shall not apply as a result of an emergency application:

    1) in case of standstill (speed less than 5 km/h);

    2) in absence of the speed signal;

    3) when the train is in shut down mode;

e) it shall be possible to override the speed signal when carrying out functional testing of the MTB.

When the MTB is applied, it shall be ensured that the control is not limited to one side only.

The MTB shall only be operated when the train/vehicle is configured to operate in the "P+Mg" or "R+Mg" braking mode.

A device shall be provided to isolate the local control unit of the MTB without affecting other independent units in the train and the status shall be clearly indicated. This isolation should be on a bogie wise basis to maintain partial functionality.

6 Load combinations for component tests

6.1 MTB performance considered in the emergency brake performance

The supply of electric energy shall be from the on-board power supply of the vehicle using a high-capacity battery. The magnet current is directly applied by a switching device and shall remain available to operate the MTB whenever other vehicle systems are isolated.

The capacity of the battery shall be dimensioned in such a way that the MTB can be activated during ten consecutive brake applications from maximum speed, without necessity of the battery to be recharged, starting from U_N and full board power supply, without substantial power loss. Before performing the tenth brake application, the magnet shall still have a rated voltage of U_N –30 % (terminal voltage), the magnetic attractive force being allowed to be 5 % below the rated voltage of the magnet as a maximum.

Where the functioning of the vehicle battery rechargers is monitored, the battery capacity may be reduced to three consecutive emergency brakings from maximum speed.

The voltage drop rates to be expected on a vehicle, up to the terminals of the MTB due to the cable resistance, shall be declared.

The MTB shall be protected against short circuit by fuses in the positive and negative supply.

Standardized nominal voltage level for MTB are 24 V DC, 36 V DC, 72 V DC, 110 V DC.

The electrical control of the current to the magnet shall be designed to avoid the generation of interference that could affect other on board systems.

The MTB shall be supplied with compressed air from a dedicated reservoir recharged from the main reservoir pipe via a non-return valve.

In the event of a loss of main reservoir supply the reservoir for the MTB shall have sufficient volume to be capable of lowering the MTB two times.

The MTB shall not require a system pressure of more than 6 bar to deploy and shall tolerate pressure up to a maximum of 10 bar. The air supply is monitored as a part of the overall brake system design and therefore is not part of this document.

If energy supply systems other than compressed air are used for deploying the MTB, the provisions of this clause shall be applied accordingly.

6.2 MTB performance not considered in the emergency brake performance

The same general requirements as in 6.1 shall apply except the capacity of the battery and the reservoir. In the event of a loss of the energy supply it is recommended that the battery and reservoir have sufficient capacity to permit one MTB application to be performed from maximum speed with rated magnetic attractive force.

7 MTB diagnostics

If the MTB is considered in the emergency brake performance it shall be possible to test the proper function of the MTB within the brake test procedure either manually or automatically at vehicle standstill. When testing the brakes in the train, provision shall be made to test the function of the MTB. The proper function of the MTB is technically given, at standstill after an emergency brake application has been performed and the speed has been simulated, at least by the information „current is present“ and the „rest position is left“.

Testing devices shall be provided locally such that they are accessible to the operating staff including the means to check the provision with pneumatic and electrical energy supply and to simulate the speed signal.

To carry out the check automatically by an electronic diagnostic system, integrated into the train control system, a safety proof according to EN 50128 shall be provided. When a diagnostic brake test is made, all MTB along the train shall be operated and diagnosed from a central point. If the reliability of a centralized automatic test procedure cannot be demonstrated a local test facility shall be provided.

It shall be indicated when the MTB is disabled/isolated or when air or power supply levels prevent correct function. For operational requirements a warning shall be displayed on the vehicle. It should also be capable of being integrated into a train management system to provide a warning of non-function to the driver.

8 EMC and interfaces

8.1 Compatibility with train detection systems

Whether operating or not, MTB shall not interfere with train detection systems (compatible signalling devices and axle counter units).

NOTE 1 The tolerable limits for the electromagnetic compatibility at the interface between magnetic track brake (vehicle) and train detection systems (infrastructure) are not yet finally defined.

The compatibility of the MTB with train detection systems is achieved in the rest position when the position is higher than or equal to 40 mm above the surface of the rail and the MTB is not energized.

NOTE 2 The special condition for Germany as stated in the TSI Control/Command System (CCS), version dated 07.11.2006 (Chapter 7.4.2.1, Point 15 and A.1, Clause 5.2.3) does not apply if the installation complies with the above requirement. (Source: „Mitteilung der Regierung der Bundesrepublik Deutschland an die Europäische Kommission vom 5. November 2007” Sonderfälle in der Technischen Spezifikation für die Interoperabilität (TSI) zum Teilsystem „Zugsteuerung, Zugsicherung und Signalgebung (ZZS)” des konventionellen transeuropäischen Eisenbahnsystems – Entscheidung 2006/679/EG der Kommission vom 28.03.2006.

8.2 Bogie components in the area of MTB

For error-free functioning of antennae, they require surrounding spaces where no metal or ferromagnetic material may be present. These spaces may be considerably larger than the antennae itself. For the installation of MTB these spaces to be kept free are to be considered.

With regard to a bogie fitted with MTB which is located near on-board mounted antennas or sensors, it is recommended to check that magnetic transmission between ground and train is not disturbed by MTB.

8.3 EMC-proof in accordance with EN 50121-3-2

As the MTB is a passive element equipped with permanent magnets or energized by d.c. current from the vehicle battery for application (magnetic brake), no requirements of EN 50121-3-2 apply.

9 Type and series production tests

9.1 Type test

9.1.1 General

MTB or parts thereof which are to replace the original version shall, before series manufacture is started, be subjected to a type test according to the following specifications to verify that all technical requirements have been met. A type test protocol of the specified properties shall be delivered.

9.1.2 Magnetic test

The magnetic attractive force shall be measured paying particular attention to the following points:

— the magnetic attractive force shall be determined for the entire supply voltage range which is relevant for the respective vehicles (typically ± 30 % of U_N), with due consideration of the voltage drop caused by the resistance of the supply lines;

— the nominal rated magnetic attractive value of an individual magnet, shall be declared at U_N -10 % and the respective proof be provided;

— the magnetic attractive force shall not fall short of 95 % of the rated value at U_N -30 % (terminal voltage);

— the measuring method described in B.1 shall be used; the result of the test shall be recorded on appropriate graphs.

9.1.3 Electric test

The following tests shall be performed on the individual magnet and on the complete MTB, with the cables connected, in accordance with EN 60077-1 or EN 50124-1 respectively.

Unless different values have been specified, a contamination level of PD2 shall be the basis for the test:

— measurement of the electric resistance, with due consideration of the ambient temperature;

— measurement of the insulating resistance;

— test of the insulating strength;

— the insulating protection shall be at least of the IP67 class, referred to the entire assembly, which shall be evidenced by a proof performed in accordance with EN 60529.

9.1.4 Thermal test

The permissible duty cycle of the MTB shall be 100 % at rated voltage. Proof testing shall be undertaken with a heating test in accordance with EN 60077-1:2002. The steady-state temperature shall be declared for a magnet operating at U_N +30 %.

9.1.5 Mechanical test

Tests on a complete MTB to be made on the test bench according to the design loads laid down in Annex A. Components that are destined to replace the original version can also be subjected to component tests if the aforementioned design loads are referred to the component; vibration tests, shall be performed, for example, with an unbalanced mass vibration generator, with the accessory parts of the MTB, such as actuator, circular bellows suspension, spring suspensions, buffer switches and the like, in accordance with EN 61373.

9.1.6 Other tests and proofs

In addition to the tests mentioned under 9.1.2 to 9.1.5, the following tests shall be performed and the respective proof be furnished:

— salt spray tests in accordance with EN ISO 9227, the test period and the permissible rust degree according to ISO 4628-3 shall be determined: the tests shall be performed on parts in assembled condition; the assembly may be split up if the test result is not falsified thereby;

— cross-cut adhesion test for paints in accordance with EN ISO 2409, the required adhesion having to be specified and proven on the finished component;

— fireproofing certificate, e.g. in accordance with EN 45545-2;

— mass of the complete MTB (proof to be furnished by providing a weighing certificate);

— leakage test of the pneumatic components over the entire relevant temperature range;

— determination of the spring characteristics (actuator, circular bellows suspension, spring suspension, etc.);

— functional (icing) tests, in accordance with the design specification requirements;

— proof of the welding construction test in accordance with the EN 15085 series;

— dimensional check of the complete MTB, in particular with respect to the functional and interface dimensions between the running gear and the track assembly;

— stress calculation;

— functional test of the magnet heating system and its over temperature protection (if installed).

9.2 Series production testing

For testing the series-manufactured units the electric tests in 9.1.3 (without insulating protection test) and the leakage and dimensional tests in 9.1.6 shall be performed. To ensure the operability of the series-manufactured magnets comparison measurements shall be made by measuring the magnetic flux. The magnet coils shall be checked for lap and interturn short circuits by means of appropriate procedures.

10 Vehicle implementation tests

The vehicle implementation tests shall be performed in accordance with the related vehicle standard (EN 15179, EN 15734-2 or prEN 16185-2). It contains the following checks:

— clearance between the MTB and the rail, in the rest and in the working position;

— lowering and switching on of the MTB during an emergency brake application;

— lowering and raising up times for conformance to the design specification;

— activation of MTB only above the speed threshold or by simulated speed;

— correct filling of the MTB supply reservoirs and the sufficient energy supply capacity;

— correct diagnostic of the MTB and the capability to perform the MTB test;

— manual application of MTB if applicable.

To prepare an MTB for brake performance tests the following shall be met in the described sequence:

— at least 60 % of the contact face of the MTB shall conform with the rail head profile;

— the MTB contact face shall be cleaned of any wear debris cause by the bedding in phase;

— the MTB shall be subjected to a conditioning phase accumulating a total braking distance of 10 000 m representing emergency brake application from different speeds;

— after the conditioning phase the physical condition of the contact faces of the MTB shall be documented;

— if the MTB contact face uses segmented pole shoes the movement of the individual segments shall be established and rectified if necessary.

The MTB performance tests shall be carried out in accordance with UIC 544-1:2004, 2.5.2. The brake performance shall be evaluated from the results of these tests.

If additional MTB performance tests are required the physical inspections shall be repeated. If the contact faces need to be cleaned of any wear debris then the conditioning phase shall be repeated before undertaking the further MTB performance tests in accordance with UIC 544-1:2004, 2.5.2.

All MTB applications during the bedding in, conditioning and the performance tests phases shall be documented. This will assist in the generation of operational and/or maintenance rules for the subsequent use of the MTB that has been tested in this application.

Annex A
(normative)

Design loads (load assumptions) of the MTB

A.1 General

The design loads mentioned hereafter are applicable to configurations of the MTB according to the present document. All data of acceleration in this annex are always to be used as quasi-static values, if not otherwise indicated.

A.2 Rest position

A.2.1 Load case, explanation

A.2.1.1 Spring force of the actuators

The spring force of the actuators and the mass of the MTB are considered mean loads in the following load cases (A.2 – A.4).

A.2.1.2 Distortions and jammings resulting from fitting controls

Δx_M, Δy_M, Δz_M due to component and fitting tolerances, are in addition to the movements caused the loads mentioned A.2.2 to A.2.4.

Fitting tolerances Δx_M and Δy_M may occur, for example, due to inexact setting of the centring devices.

A distortion Δz_M may also be caused by the fact not all four centring devices in the bogie are situated in one plane and is primarily defined by the component tolerances of the bogie frame.

If the MTB frame is twisted, an additional distortion Δz_M, occurs in its rest position, too, which is predetermined by the fitting tolerance of the MTB.

The following approximate values are to be used:

— Δx_M = ± 2 mm (fitting tolerance);

— Δy_M = ± 2 mm (fitting tolerance);

— Δz_M = ± 3 mm (component tolerance of the bogie frame).

Any values deviating from those mentioned above shall be indicated by the bogie manufacturer (bogie frame and fitting tolerances) or by the MTB manufacturer (fitting tolerances of the brake frame).

A.2.1.3 Distortions and jammings in operational service

Δx_B, Δy_B, Δz_B due to the deformation of the bogie frame, tolerances are in addition to the movements caused by the loads mentioned under A.2.2 to A.2.4.

The data shown in the following schematics according to Figure A.1 and Figure A.2 are approximate values representing deformations resulting from longitudinal and transverse forces. Local deformations that may be obtained from transverse girders (e.g. tie bars) having a low torsional rigidity are to be considered separately. The deformations of the MTB are resulting from the deformations of the bogie frame and the spring stiffness of the centring devices.

Dimensions in millimetres

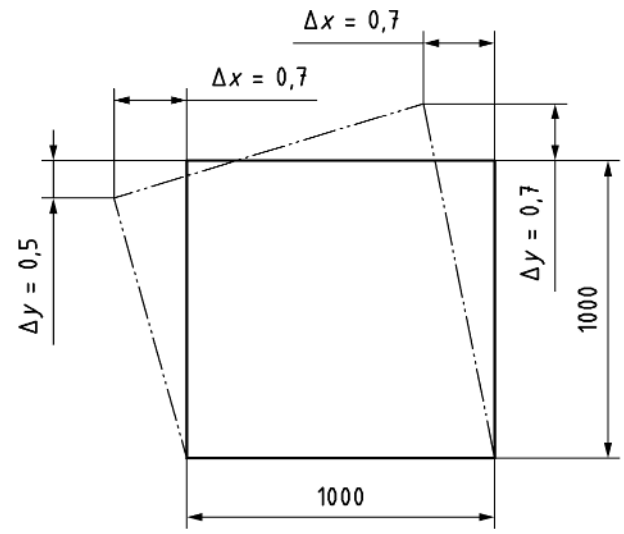


Figure A.1 — Representation of potential deformations of the bogie frame resulting from the usual longitudinal forces in the square (reference magnitude)

Dimensions in millimetres

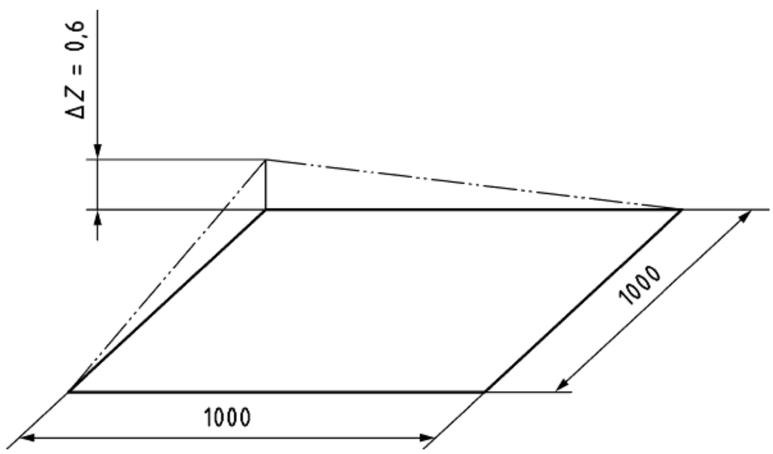


Figure A.2 — Representation of potential deformations of the bogie frame resulting from the lateral forces in the square (reference magnitude)

The deformations shown are each to be considered in both directions. Any values departing from those mentioned above, in particular such that are caused by local deformations, are to be indicated by the bogie manufacturer.

A.2.2 Acceleration

Accelerations acting on the masses of the MTB shall be in accordance with EN 61373 and field tests. Typically, these are:

— a_Z = 5 g;

— a_Y = 4,4 g;

— a_X = 2,3 g.

A.2.3 Excitation by wheel flats

The return springs in the actuators shall ensure the MTB does not leave its rest position at acceleration rates up to 2,5 g in vertical direction.

A.2.4 Jerk caused by bouncing up of the electromagnetic MTB

In the situation when there is a simultaneous de-energising of the MTB and a rapid venting of the actuators the MTB frame and its attachments shall be capable of withstanding a peak acceleration of a_Z = 30 g in accordance with EN 61373. As a consequence of this acceleration no relevant damage, such as gauge exceeding, incipient cracks or breaks of components are permissible. Local plastic deformations are permitted. The capability to withstand this acceleration shall be proven by calculation.

The MTB attachments to the bogie do not need to comply with the acceleration of a_Z = 30 g if appropriate design measures for jerk reduction are taken. Evidence of the capability of the measure is to be supplied.

A.3 Working position (brake application position)

A.3.1 Load case, explanation

A.3.1.1 Excess force in the actuator

The most unfavourable case shall be considered (e.g. worn wheelsets, maximum pressure, minimum stroke).

A.3.1.2 Distortion Δz_M

Distortion Δz_M, resulting from fitting tolerances of the MTB (also refer to A.2.1.2).

A.3.1.3 Longitudinal displacement ΔxB

Longitudinal displacement ΔxB of the magnets in relation to each other during the braking process, due to uneven clearances in the x direction of the brake force carriers at the left and right sides of the bogie (manufacture and fitting tolerances are about Δx = 3 mm, deformations of the bogie frame (refer to A.2.1.3) shall be considered additionally.

A.3.1.4 Bogie yaw movement

When bogies yaw, this will lead to a longitudinal displacement Δx_B and possibly to a lateral displacement Δy_B as well of the magnets in relation to each other. The magnitude of the longitudinal displacement depends on the geometric parameters, such as carrier gaps and the maximum turning angle of the bogie above the track. Usual values of the maximum turning angle amount to about 2,5° (composed of 1,9° maximum gauge clearance and 0,6° lateral suspension). Any deviating values shall be reconciled between the bogie and the MTB manufacturer.

A.3.1.5 Distortion Δz_B

Distortion Δz_B can occur due to curve transitions or gaps within crossings. Typical values are 10 mm in the standard square (refer to Figure A.2 and Figure A.3).

Dimensions in millimetres

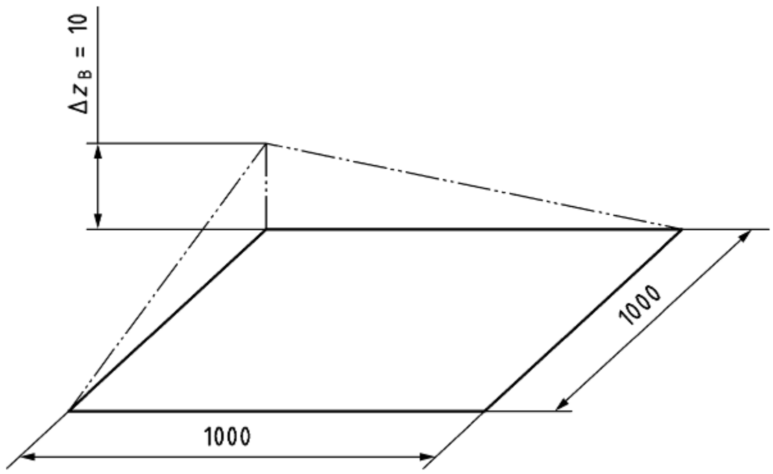


Figure A.3 — Distortion of the MTB frame, due to curve transitions, as explained under A.3.1.5, represented in the square

The deformations indicated are to be considered each in both directions.

A.3.2 Longitudinal force $F_{B,x}$ resulting from an MTB application

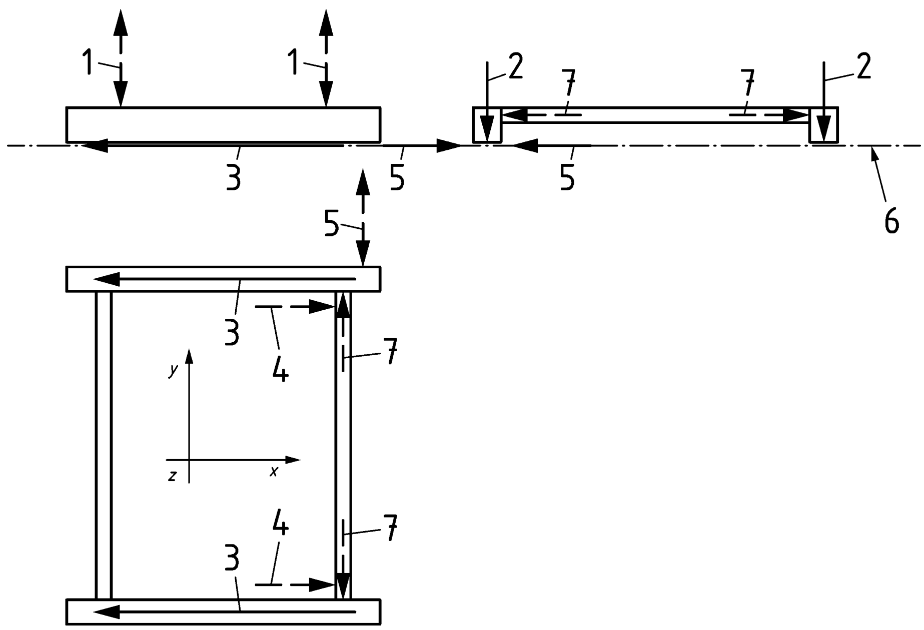
Action of a longitudinal force due to the braking jerk and the brake retardation: The magnitude of the impact force results from various design parameter, such as the gap between the carriers, the brake outset speed and the carrier stiffness rates. Usual values of longitudinal forces (resulting from braking jerk or brake force) for use of steel pole shoes amount to about 0,4 times the magnetic attractive force. Any deviating values shall be reconciled between the manufacturers of the bogie and the MTB.

A.3.3 Aspects for transmission of force

A.3.3.1 General

The considerations under A.3.3 are applicable to MTB with an application length of 1 m and end pieces.

Figure A.4 gives an overview to point transmission of force.



Key

1 interface forces with bogie frame F_{BZ}

2 attractive force F_{HZ}

3 longitudinal force $F_{B,x}$

4 brake force F_x

5 lateral force F_Q

6 top of the rail

7 interface forces

Figure A.4 — Overview of transmission of force

A.3.3.2 Lateral force F_Q and longitudinal force $F_{B,x}$ when running over switches and crossings in inside direction

Action of a lateral force equal to 0,18 times the magnetic attractive force in inside direction (toward the track centre) in the vicinity of the end pieces with a simultaneous longitudinal force of 0,2 times the magnetic attractive force shall be respected.

A.3.3.3 Lateral force F_Q and longitudinal force $F_{B,x}$ when running over switches and crossings in outside direction

Action of a lateral force equal to 0,12 times the magnetic attractive force in outside direction in the vicinity of the end pieces with a simultaneous longitudinal force of 0,2 times the magnetic attractive force shall be respected.

A.3.3.4 Exceptional lateral force F_Q in inside direction (toward the track centre) when running over switches and crossings

Measurements so far performed on vehicles have identified forces in inside direction up to about 0,35 times the magnetic attractive force (greatly dependent on the wear condition of the switch and crossing that has been traversed).

A.3.3.5 Exceptional lateral force F_Q in outside direction when running over switches and crossings

Measurements so far performed on vehicles have identified forces in outside direction up to about 0,23 times the magnetic attractive force (greatly dependent on the wear condition of the switch and crossing that has been traversed).

NOTE 1 The entire brake force is distributed over the magnet length in accordance with the respective perpendicular forces.

NOTE 2 The brake and impact forces for unfavourable overlapping conditions with respect to the carriers are considered) (new wheels, worn magnet, operative vehicle).

NOTE 3 The load impact of the lateral force takes place at the level of the upper rail surface at the approximate centre of the leading end piece. The lateral forces mentioned refer to versions according to this document. For other versions the loads exerted may partly be substantially higher.

A.4 Rail brakes

A.4.1 General

In the circumstances that an MTB fitted vehicle has traversed a rail brake no safety-relevant damage, such as gauge exceedance, incipient cracks or ruptures of components, shall occur. On account of the high safety requirements, however, the load cases in A.4.2.1 and A.4.2.2 are to be considered.

The representation of the loads exerted by the action of the rail brakes refers to the MTB rest position. In the MTB working position the same loads are apply in addition those generated by the MTB forces.

A.4.2 Load case, explanation

A.4.2.1 Unilaterally acting rail brake

Actuating forces resulting from the **unilateral action** of the rail brake at the outside of the magnets (projecting beyond the inner front face of the wheel) result in a path-dependent deformation of the tie bar of:

— 10 mm maximum per side toward the inside for a magnet width of 140 mm and a magnet distance of 1 510 mm (for the gauge of 1 435 mm) or

— 5 mm maximum per side toward the inside for a magnet width of 130 mm and a magnet distance of 1 510 mm (for the gauge of 1 435 mm);

together with a possible tolerance in lateral direction (between wheel and magnet outsides). An analogous consideration is made for the main dimensions. The force application takes place at 120 mm above the rail surface in each case.

The retardation of the vehicle, resulting from the braking effect of the rail brake, generates longitudinal forces acting on the magnets which are transmitted, via the centring devices, to the vehicle frame. The magnitude of the longitudinal forces results from the above deformation, the spring stiffness of the brake frame and the respective friction conditions.

The friction coefficient strongly depends on the configuration of the rail brakes shoes. As an approximate value a coefficient of μ = 0,4 is proposed.

A.4.2.2 Bilaterally acting rail brake

The possible deformation in transverse direction is limited by the application of the rail brake to the inside surfaces of the wheels. The retardation of the vehicle, obtained as a result of the action of the bilaterally acting rail brake on the MTB, generates a load which is exerted on the centring devices. In case the magnet width should be greater than the wheel width, the maximum contact force is only limited by the actuating force of the rail brake (up to 250 kN per magnet for heavy rail brakes) minus the force required to deform the tie bars. The force application takes places at a height of 120 mm above the rail surface.

When the MTB slides on the rail brake, the vehicle may possibly be lifted up to 50 mm (at maximum wheel tyre wear) (only possible if the magnet projects from the wheel profile outline, if the end pieces have been broadened and in case of high transverse displacements of the bogie). Figure C.1 shows examples of possible designs.

The relevance of this load case for all designs (e.g. magnet centre distance, end piece geometry, magnet width) should be checked in each individual case. The primary suspension movements should be taken into account.

A.5 FME(C)A

The following special load cases should be checked within the FME(C)A, beyond the load cases mentioned above:

— rail brakes;

— collision with guard rails;

— unilateral braking effect;

— rupture of a tie bar;

— failure of an actuator;

— failure of a centring device;

— bouncing up of the MTB frame as a result of a malfunction.

The volume and contents of the FME(C)A are to be reconciled between the bogie and the MTB manufacturer.

A.6 Load collective for operational safety proof

With respect to the load cycles with rare application (e.g. vehicles in long-distance control) of the MTB, one application per day is assumed. When the MTB is frequently used (e.g. in mass transit control), a number of 15 brake applications per day is assumed. Thus, a number between 10 000 and 150 000 brake applications is obtained in a period of 30 years. Table A.1 gives the load collective for operational safety proof.

Table A.1 — Load collective for operational safety proof

Load combination	Load cycles		Load cases to superpose	Note
	From	to		
1	10 000	150 000	A.2.1.1 + A.2.1.2 A.3.1.1 + A.3.1.2	distortion, jamming depending on the number of actuations
2	3×10^5 main lines	$1{,}2 \times 10^6$ winding lines	A.2.1.1 [a] + A.2.1.2 [a] + A.2.1.3	stress, due to curve passage
3	1×10^7	1×10^7	A.2.1.1 [a] + A.2.1.2 [a] + A.2.2	accelerations in the three directions, expressed individually (not superimposed)
4	3	3	A.2.1.1 [a] + A.2.4	30 g jerk
5	10 000	150 000	A.3.1.1 [a] + A.3.1.2 [a] + A.3.1.3+ A.3.2	longitudinal force
6	30	450	A.3.1.1 [a] + A.3.1.2 [a] + A.3.1.4+ A.3.1.5+ A.3.2	longitudinal force in a narrow curve with track distortion; bogie yaw
7	800	12 000	A.3.1.1 [a] + A.3.1.2 [a] + A.3.1.3+ A.3.1.5+ A.3.3.1	braking in the switch and crossings (inside) The load combinations 7 and 8 are together considered as alternating load.
8	800	12 000	A.3.1.1 [a] + A.3.1.2 [a] + A.3.1.3+ A.3.1.5+ A.3.3.2	braking in the switch and crossings (outside) The load combinations 7 and 8 are together considered as alternating load.
9	100	1 500	A.3.1.1 [a] + A.3.1.2 [a] + A.3.1.3+ A.3.1.5+ A.3.3.3	exceptional lateral force (inside) The load combinations 9 and 10 are together considered as alternating load.
10	100	1 500	A.3.1.1 [a] + A.3.1.2 [a]+ A.3.1.3 + A.3.1.5 + A.3.3.4	exceptional lateral force (outside) The load combinations 9 and 10 are together considered as alternating load.
11	10	150	A.3.1.1 [a] + A.3.1.2 [a]+ A.3.1.3 + A.3.1.4 + A.3.1.5 + A.3.3.3	exceptional lateral force (inside) + (bogie yaw) The load combinations 11 and 12 are together considered as alternating load.
12	10	150	A.3.1.1 [a] + A.3.1.2 [a] + A.3.1.3+ A.3.1.4+	exceptional lateral force

			A.3.1.5+ A.3.3.4	(outside) + bogie yaw The load combinations 11 and 12 are together considered as alternating load.
[a] To be considered as a mean stress.				

A.7 Load collective for component tests on the example of 10 000 brake applications

Load combinations for tests are to be defined from structure analysis. The following is an example:

— 10 000 load cycles (refer to table, load combination 5): longitudinal force $F_{B,x}$ = 0,4 * magnetic attractive force with jamming Δx_B = ± 3,7 mm;

— 100 load cycles (refer to table, load combination 9 + 10): transverse force F_Q = + 0,35 (−0,23) * magnetic attractive force;

— 10 load cycles (refer to table, load combination 11 + 12): transverse force F_Q = + 0,35 (−0,23) * magnetic attractive force with jamming Δx_B = ± 20 mm;

— 30 load cycles (refer to table, load combination 6): longitudinal force $F_{B,x}$ = 0,4 * magnetic attractive force with jamming Δx_B = ± 20 mm.

A.8 Test procedure

1) Load step standard loads:

   Load cycle number corresponding to 10 times the number of brake applications;

2) Load step elevated loads:

   Loads increased by the factor 1,5;

   Load cycle number corresponding to the number of brake applications.

On account of the smaller load cycle numbers and the greater dispersion in the upper fatigue strength area, a multiplier of 10 is obtained in load cycle direction and of 1,5 in stress direction. The tests are to be conducted with a component manufactured under series conditions.

A.9 Test result

Load steps 1 and 2: without incipient crack, permanent deformation or rupture.

Annex B
(normative)

Measurement of the magnetic attractive force — Functional test of brake magnets

B.1 Measurement of the magnetic attractive force of MTB magnets

The magnetic attractive force of all MTB magnets shall be measured on a representative sample of the rails over which they can operate. Typical rail profiles are 60E1 or 49E1 in accordance with EN 13674-1, typical rail material are R200 in accordance with EN 13674-1 or E360 in accordance with EN 10025-2.

The measuring rail shall at least have a sufficient length to ensure that the pole shoes can be applied with their full length. The rail head is levelled down until the contact surface has a width of $63 = \frac{54+72}{2}$ mm, corresponding to the average pole width of standard magnets. The surface has a roughness value of $R_a \leq 1{,}6$ µm (refer to Figure B.1). Both pole surfaces of the pole shoes are to be jointly levelled down and have a roughness value of $R_a \leq 1{,}6$ µm.

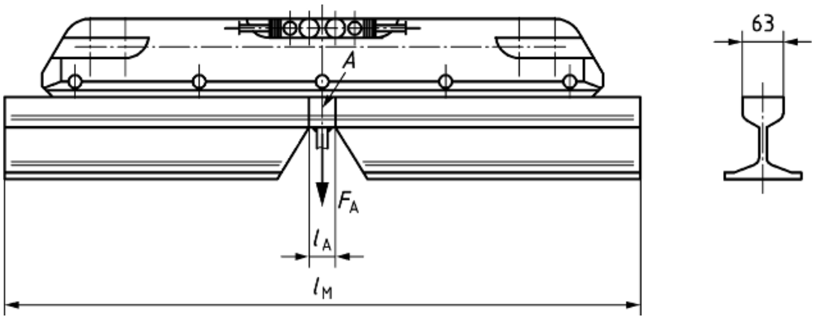


Figure B.1 — Measurement of the magnetic attractive force by means of a tear-off piece of the measuring rail

Definitions:

F_A tear-off force of the tear-off piece of the rail

l_A length of the tear-off piece A of the rail (about 40 mm)

F_{Am} mean tear-off force resulting from three measurements made at the same place

F_{Hm} mean magnetic attractive force of the magnet or magnet section

l_M length of the magnet

l_E length of the end piece

l_Z length of the intermediate piece

n_Z number of intermediate piece

A tear-off part

The tear-off force can be produced mechanically, hydraulically or pneumatically. When determining the magnetic attractive force, only the real metallic contact surfaces l_M, l_E und l_Z are to be considered in the calculation. The wear height "h", at which the measurement was made, shall always be indicated, in addition to the magnetic attractive force (refer to Figure B.2 and B.3).

The tear-off piece shall be pulled off in perpendicular direction to the pole surface. No tipping movement of the tear-off piece A shall occur. Depending on the type of magnet, the magnetic attractive force shall be measured at several points. At each point a minimum of three measurements shall be made. After each measurement the poles shall be changed. The values measured at the different points shall be added together and a mean value F_{Am} be formed of them.

B.2 Formation of the mean magnetic attractive force for rigid magnets

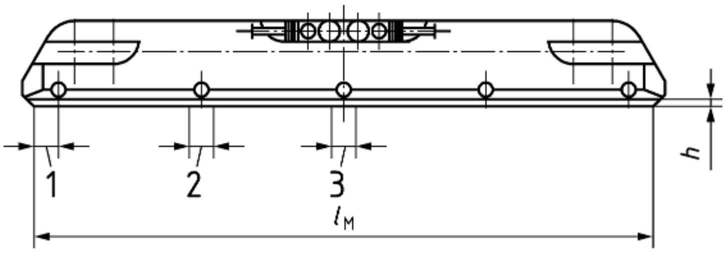


Figure B.2 — Measuring points (1, 2, 3) of rigid magnets

For rigid magnets the force F_{Am} required to pull off the tear-off piece of the rail at a minimum of three points, i.e. at the centre, at one end of the brake shoes and between these two measuring points, shall be determined.

The magnetic attractive force F_{Hm} of the MTB magnet is obtained from the mean value of the three measurements, in accordance with the following formula:

$$F_{Hm} = (F_{am1} + F_{am2} + F_{am3}) / 3$$

B.3 Formation of the mean magnetic attractive force for articulated magnets

For articulated magnets the end and intermediate pieces shall be measured separately from each other.

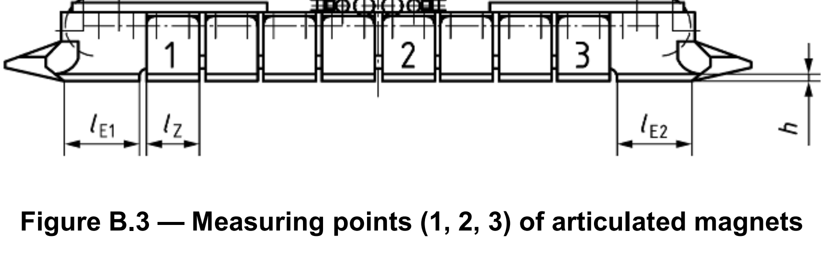


Figure B.3 — Measuring points (1, 2, 3) of articulated magnets

For these magnets three measurements each shall be made on the two end pieces (front, rear) and mean values be formed of them. With regard to the intermediate pieces, the first, a centrally located and the last intermediate member shall be measured and the mean value formed of them.

— end piece 1 E1:

$$F_{\mathrm{HE1m}} = \left(F_{\mathrm{AmEV}} + F_{\mathrm{AmEM}} + F_{\mathrm{AmEH}}\right) * \frac{l_{\mathrm{E1}}}{3 * l_{\mathrm{A}}}$$

— end piece 2 E2:

$$F_{\mathrm{HE2m}} = \left(F_{\mathrm{AmEV}} + F_{\mathrm{AmEM}} + F_{\mathrm{AmEH}}\right) * \frac{l_{\mathrm{E2}}}{3 * l_{\mathrm{A}}}$$

— intermediate piece Z:

$$F_{\mathrm{HZm}} = \left(F_{\mathrm{AmZ1}} + F_{\mathrm{AmZ2}} + F_{\mathrm{AmZ3}}\right) * \frac{l_{\mathrm{Z}}}{3 * l_{\mathrm{A}}}$$

Magnetic attractive force of the articulated magnet:

$$F_{\mathrm{Hm}} = F_{\mathrm{HE1m}} + F_{\mathrm{HE2m}} + F_{\mathrm{HZm}} * n_{\mathrm{Z}}$$

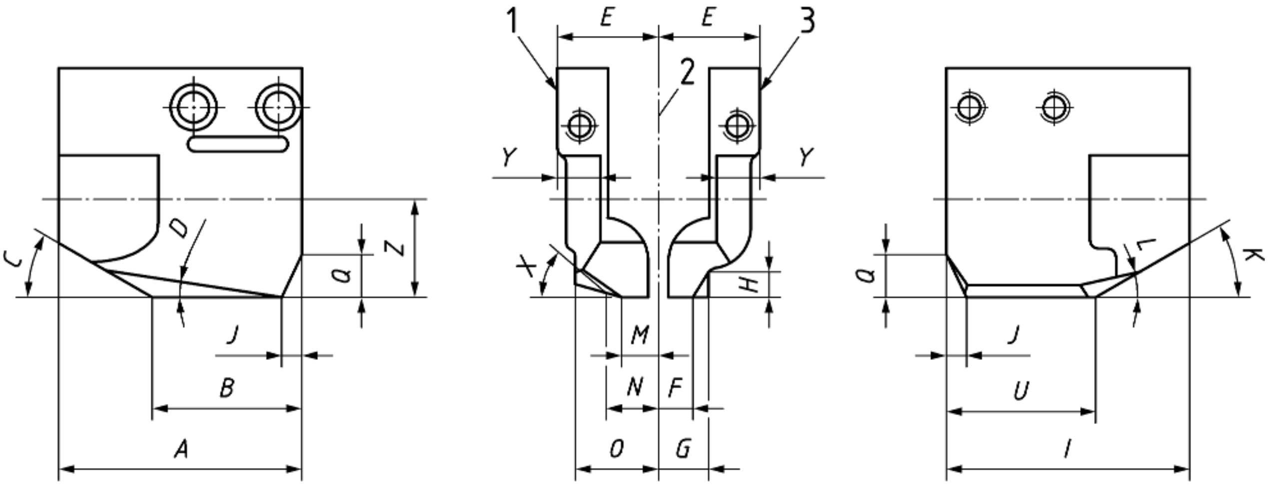
The check is considered to have been passed if the magnetic attractive force is equal or higher than the declared value.

Annex C
(normative)

End pieces of MTB

Figure C.1 to C.4 contain schematic diagrams of different forms of end pieces with main dimensions.

Table C.1 contains different forms of end pieces which are currently being used and which comply with the requirements of 5.5.1.



Key

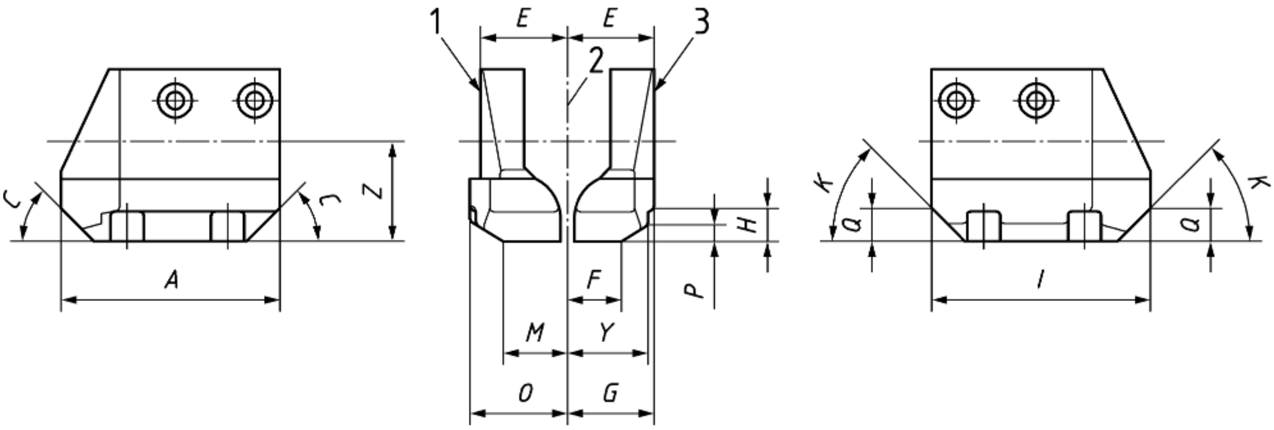
1 outer side

2 centerline

3 inner side

NOTE Source: UIC 541–06; Appendix 3, Type 1 (SNCF).

Figure C.1 — End piece – Form 1



Key

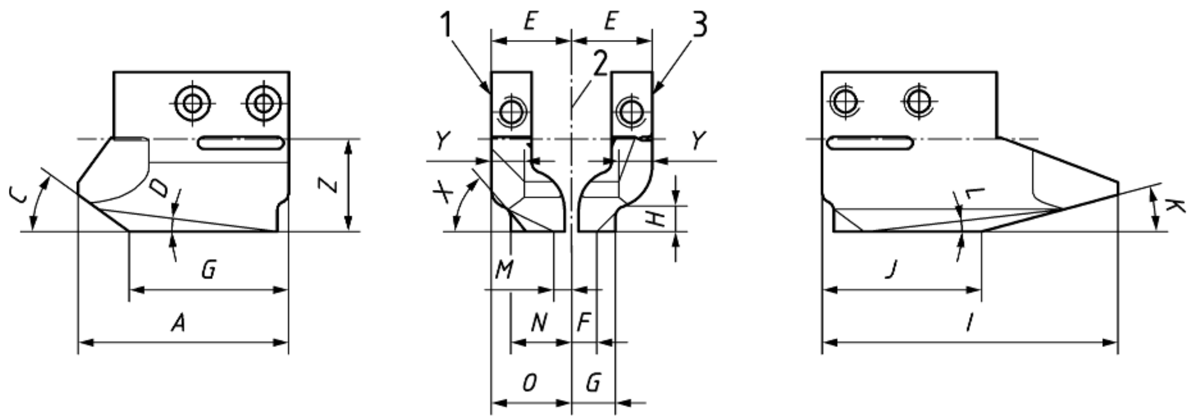
1 outer side

2 centerline

3 inner side

NOTE Source: UIC 541–06; Appendix 3, Type 2 (SNCF, Origin: SAM F 102).

Figure C.2 — End piece – Form 2



Key

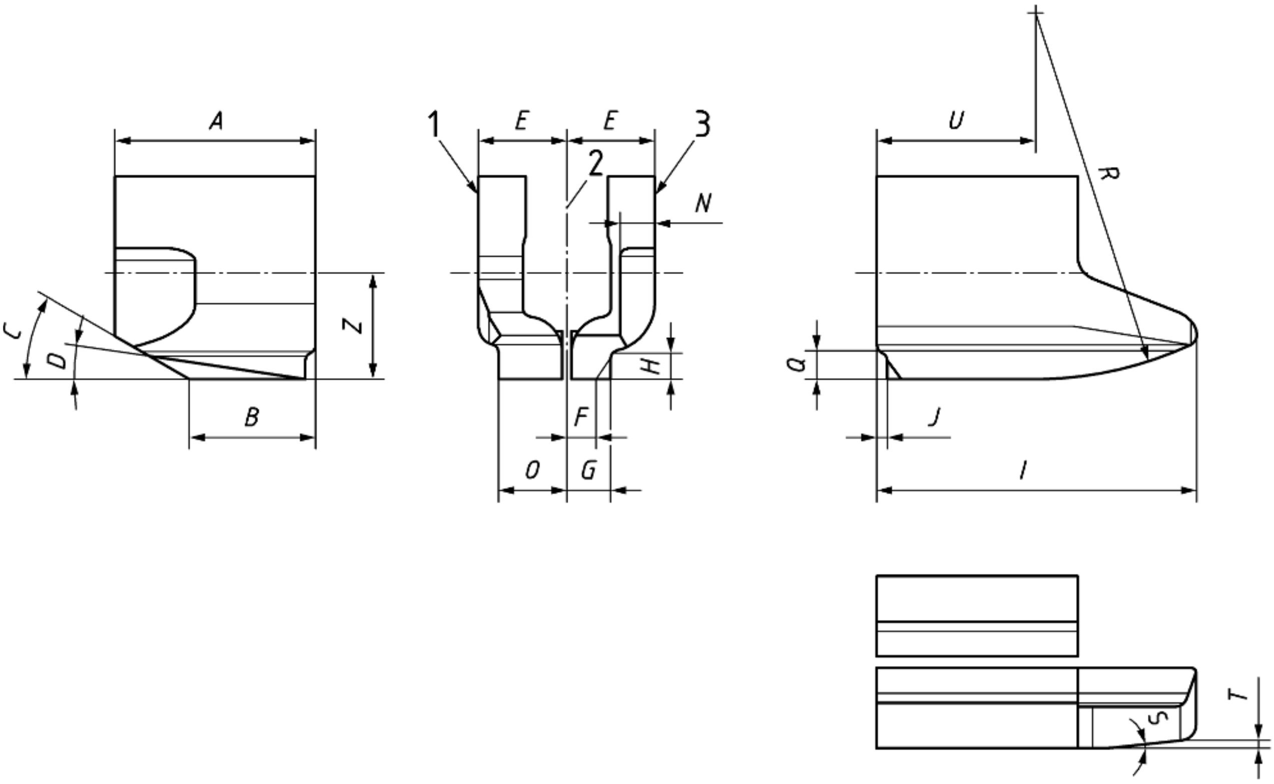
1 outer side

2 centerline

3 inner side

NOTE Source: UIC 541–06; Appendix 3, Type 3 and 6 (DB; Origin: KB).

Figure C.3 — End piece – Form 3



Key

1 outer side

2 centerline

3 inner side

NOTE Source: UIC 541–06; Appendix 3, Type 4 and 5 (DB; Origin: FT).

Figure C.4 — End piece – Form 4

Table C.1 — List of end pieces and main dimensions

		UIC 541–06 Appendix 3, Type 1	UIC 541–06 Appendix 3, Type 2	UIC 541–06 Appendix 3, Type 3	UIC 541–06 Appendix 3, Type 4	UIC 541–06 Appendix 3, Type 5	UIC 541–06 Appendix 3, Type 6
		SNCF (Origin KB)	SNCF (SAM F 102)	DB AG (Origin KB)	DB AG (Origin FT)	DB AG (Origin FT)	DB AG (Origin KB)
		End piece					
		Form 1	Form 2	Form 3	Form 4	Form 4	Form 3
Dimension	A	171	≥ 155	163	260	260	171
	B	108	—	105	103	103	130
	C	45°	45°	30°	30°	30°	36°
	D	13°	—	7°	9°	9°	7°
	E	70	—	70	70	65	65
	F	22	40/35 (++) [a]	20	18	18	20
	G	32,5	65/61,5 (++)[a]	36	36	36	36
	H [c]	20	20	20	20	20	20
	I	171	≥ 155	258	260	260	240
	J	10/16	—	—	8	8	—
	K	30°	45°	15°	—	—	15°
	L	15°	—	7°	—	—	7°
	M	26	47,5	14	—	—	14
	N	—	—	33 (+) [b]	—	—	33 (+) [b]
	O	57,5	72,5	55	55	51	49
	P	—	15	—	—	—	—
	Q	20/35	25	—	21	21	—
	R	—	—	—	300	300	—
	S	—	—	—	500	500	—
	T	30	—	24	10	10	27
	U	103	—	150	130	130	130
	V	—	—	—	—	—	—
	W	—	—	—	—	—	—
	X	—	—	45° (+) [b]	26	21	45° (+) [b]
	Y	30	60	27	—	—	23
	Z	75	75	75	75	75	75

[a] (++) Preferred in future.

[b] (+) Bevel edge.

[c] Wear height.

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 mandates given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the Directive 2008/57/EC.

Once this standard is cited in the Official Journal of the European Communities 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 and Table ZA.2 for the current TSIs at the time of the publication of this standard and Table ZA.3 for the new approved TSI, within the limits of the scope of this standard, give a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard, the HS TSI RST published in the OJEU dated 26 March 2008 and Directive 2008/57/EC

Clause/ subclauses of this European Standard	Chapter/§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
The whole standard applies.	4. Characterisation of the subsystem 4.2 Functional and technical specification of the subsystem 4.2.4 Braking 4.2.4.1 Minimum braking performance	Annex III, Essential requirements 1 General requirements 1.1 Safety Clauses 1.1.1, 1.1.2, 1.1.3, 1.1.5 1.2. Reliability and availability 1.5 Technical compatibility §1 2 Requirements specific to each subsystem 2.4 Rolling stock 2.4.1 Safety §2, §3 2.4.2 Reliability and availability 2.4.3 Technical compatibility §1, §3	This table will be obsolete with the publication of the TSI “LOC and PAS” and superseded by Table ZA.3.

Table ZA.2 – Correspondence between this European Standard, the CR TSI Locomotives and Passenger RST (CR Loc and Pass TSI) published on 26.05.2011 in the OJEU. and Directive 2008/57/EC

Clause/ subclauses of this European Standard	Chapter/§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
The whole standard is applicable.	4.Characterisation of the Rolling stock subsystem 4.2 Functional and technical specifications of the subsystem 4.2.3 Track interaction and gauging § 4.2.3.3.1 Rolling stock parameters which influence ground based systems, Rolling Stock characteristics for the compatibility with train detection systems 4.2.4 Braking § 4.2.4.8 Braking system independent of adhesion conditions	Annex III, Essential requirements 1 General requirements 1.1 Safety Clauses 1.1.1, 1.1.2, 1.1.3, 1.1.5 1.2. Reliability and availability 1.5 Technical compatibility §1 2 Requirements specific to each subsystem 2.4 Rolling stock 2.4.1 Safety §2, §3 2.4.2 Reliability and availability 2.4.3 Technical compatibility §1, §3	This table will be obsolete with the publication of the TSI “LOC and PAS” and superseded by Table ZA.3.

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

Clause/ subclauses of this European Standard	Chapter/§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
The whole standard is applicable.	4.2 Functional and technical specification 4.2.3 Track interaction and gauging 4.2.3.3 Rolling Stock parameters which influence ground based systems §4.2.3.3.1 Rolling Stock characteristics for the compatibility with train detection systems §4.2.3.3.1.2 Rolling stock characteristics for compatibility with train detection system based on axle counters 4.2.4 Braking 4.2.4.8 Braking system independent of adhesion conditions §4.2.4.8.1 General §4.2.4.8.2 Magnetic track brake	Annex III, Essential requirements 1 General requirements 1.1 Safety Clauses 1.1.1, 1.1.2, 1.1.3, 1.1.5 1.2. Reliability and availability 1.5 Technical compatibility §1 2 Requirements specific to each subsystem 2.4 Rolling stock 2.4.1 Safety §2, §3 2.4.2 Reliability and availability 2.4.3 Technical compatibility §1, §3	Annex C of this EN covers the index 31 of Annex J.1 of the TSI (Appendix 3 of UIC 541-06, Jan 1992).

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

[2] EN 15877-2:2013, *Railway applications - Markings of railway vehicles - Part 2: External markings on coaches, motive power units, locomotives and on track machines*

[3] EN 50125 (all parts), *Railway applications — Environmental conditions for equipment*

[4] UIC 541-06, *Brakes — Specifications for the construction of various brake components — Magnetic brakes*

[5] VDE 0580, *Electromagnetic devices and components — General specifications*

[6] B012, *Ergänzungsregelung Nr. B 012 für die technische Gestaltung der Magnetschienenbremse in Schienenfahrzeugen Stand: Rev. 5.4, 22.05.2012*

[7] SAM F 102, *Freins magnétiques*

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