EUROPEAN RAILWAY AGENCY

ERTMS Unit

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<tr><td colspan="3" align="center">**ERTMS/ETCS UNIT**</td></tr>
<tr><td colspan="3" align="center">**INTERFACES BETWEEN
CONTROL-COMMAND AND SIGNALLING TRACKSIDE
AND OTHER SUBSYSTEMS**</td></tr>
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Amendment record

Version	Date	Section number	Modification/description	Author
0.1	17/02/2010	All	First Draft	
0.2	04/03/2010	All	different modifications proposed	AC
0.3	12/03/2010	All	after EIM comments	AC
0.4	15/06/2010	All	ERA proposal: specific cases deleted and different clarifications	
0.4 modified			first proposal to insert emc requirements for magnetic fields	AC
0.5	29/09/2010	all	review meeting	AC
0.6	11/10/2010	all	language check; requirements for metal free space and use of magnetic brakes; requirements for 1520 mm gauge systems	AC
0.7	26/10/10	all	review meeting	AC
0.8	27/10/10	3.1.4.1; 3.1.4.2; 3.1.5; 3.1.6	editorial improvement	AC
0.9	03/12/10	different sections	review meeting: axle load; sanding; EMC	AC
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0.11	03/02/2011	2	interface table added	AC
0.12	07/03/2011	all	Clarification for DC and low frequency currents Open point for vehicle impedance (moved to section 3.2.2) EMC requirements for magnetic fields	AC
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1.3	17/01/2013	Table 1 3.1.5 3.1.7 3.2.2.2	Editorial improvements and clarifications	AC

Version	Date	Section number	Modification/description	Author
1.4	04/02/2013	3.1.6	Deletion of the reference to an obslolete technical document	AC
		3.1.7	Modification of a value of resistance	
1.5	14/03/2013		Editorial improvement	AC
1.6	12/09/2013	3.1.1.3; 3.1.1.4	Alignement with rolling stock TSIs	AC
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2.3	26/11/2015		Updates according to NSA LV comments. Review before new official version	AC
3.0	04/12/2015		Publication	AC
3.1	21/03/2018	All	Inclusion of outcome of technical opinions Closing open points for 1520mm network Integration of Frequency Management for track circuits	DB, MS
3.2	18/04/2018	All	Changes after feedback from TDC WP and CCS WP New chapter 3.3. related to safety	MS
3.3	19/04/2018	3.1	Editorial changes	MS
3.4	13/06/2018	All	Changes discussed during TDC WP 44	MS
3.5	03/08/2018	3.2.2.4/ 3.2.2.6/ 3.2.3	Changes to FM, proposal to close OP Magnetic/Eddy Current Brake	MS,BD
3.6	21/08/2018	3.2.3	Update Magnetic/Eddy Current Brake Axle Counter test procedure	MS,BD
4.0	20/09/2018	All	Changes discussed in TDC 45 Metal Free Space, IC axle counter, Loops	MS

Table of Content

1.   INTRODUCTION

This document defines the interoperability requirements that are applicable at the interface between the Control-Command and Signalling Track-side and other subsystems (mainly, but not exclusively, rolling stock).

Since different types of trackside equipment originate different compatibility requirements, in this document traceability is provided, by mean of "justifications" explaining the source of each requirement.

2. SCOPE

This specification is limited to requirements related to compatibility of train detection systems with other subsystems.

The possible effects of parameters on equipment other than train detection systems are not taken into account (e.g., rolling stock and operation are involved in respecting the requirement on maximum amount of sand, not to disturb track circuits operations, while the possible effects of sand on infrastructure elements like switches are not in the scope of this specification).

The requirements specified in this document have been identified on the basis of compatibility requirements of train detection systems, by reference to the train detection systems intended for use in interoperable lines, i.e.,

1. Axle counters (with electromagnetic wheel detectors)
2. Track circuits
3. Loops
4. Other train detection systems like wheel detectors (e.g., for level crossing operations)

Train detection systems, which are part of the Control-Command and Signalling Track-side, shall be designed in such a way that they are able to detect a vehicle or consist under the conditions specified by the parameters in this specification.

In addition, these requirements apply to the relevant other subsystems as identified in the table below.

Table 1

Parameter	Subsystem involved				
	CCS on-board	**Rolling Stock**	**Energy**	**Infra-structure**	**Operation and Traffic Management**
Maximum axle distances		X			X (train composition)
Minimum axle distances		X			X (train composition)
Distances between end of train and first axle		X			X (train composition)
Wheel geometry		X			
Maximum amount of sand		X (technical characteristics of sanding devices)			X (use of sanding devices)

Parameter	Subsystem involved				
	CCS on-board	**Rolling Stock**	**Energy**	**Infra-structure**	**Operation and Traffic Management**
Sand characteristics		X			
On-board flange lubrication		X			X (activation of lubrication)
Use of composite brake blocks		X			
Vehicle axle load and metal construction		X			
Use of shunting assisting devices (such devices are not required by CCS TSI, so no impact for subsystems compliant with TSIs; specific cases exist)					
Impedance between wheels		X			X
Combination of rolling stock characteristics influencing shunting impedance					X
Electromagnetic fields	X (emissions of Eurobalise antenna)	X			
Vehicle impedance		X	X		X (resulting impedance between rails and pantographs, in case of consists with more locomotives)
Traction current at fundamental power supply frequency			X		

Parameter		Subsystem involved			
	CCS on-board	Rolling Stock	Energy	Infra-structure	Operation and Traffic Management
Conducted interference limits for traction current		X	X		X (number of trains running in the same power section)
Use of magnetic/eddy current brakes		X (technical characteristics of brakes)			X (operation of brakes)

Unless otherwise indicated, the values of the parameters specified in this document apply for networks with the following nominal track gauges: 1435 mm, 1520 mm, 1524 mm, 1600 mm, and 1668 mm.

If, for a certain parameter, different values apply according to the track gauge, this is explicitly indicated in the corresponding section.

3. INTERFACE CHARACTERISTICS

3.1. VEHICLE DESIGN AND OPERATION

3.1.1. Definitions

For the definition of the longitudinal vehicle dimensions Figure 1, (which shows an example for a three-axle twin-bogie vehicle), applies, where:

a_i = distance between following axles, where i = 1, 2, 3, …, n-1, where n is total number of axles of the vehicle

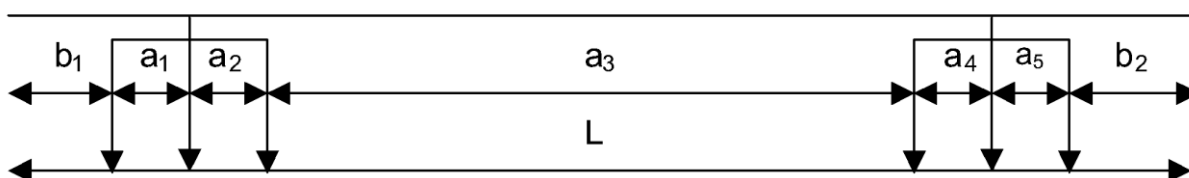b_x = distance from first axle (b_1) or last axle (b_2) to the nearest end of the vehicle, i.e. nearest buffer/nose

L = total length of the vehicle

Figure 1: Longitudinal vehicle dimensions

If more vehicles are connected in a consist, the characteristics stated in the remainder of this section 3.1 and related to a_i apply to the relevant distance of the axles belonging to each vehicle individually, while the characteristics related to b_i only apply to the two ends of the complete consist.

For definition of wheel dimensions Figure 2 applies, where:

D = wheel diameter

B_R = width of the rim

S_d = thickness of the flange measured at the line 10mm above the running tread as given in Figure 2

S_h = height of the flange

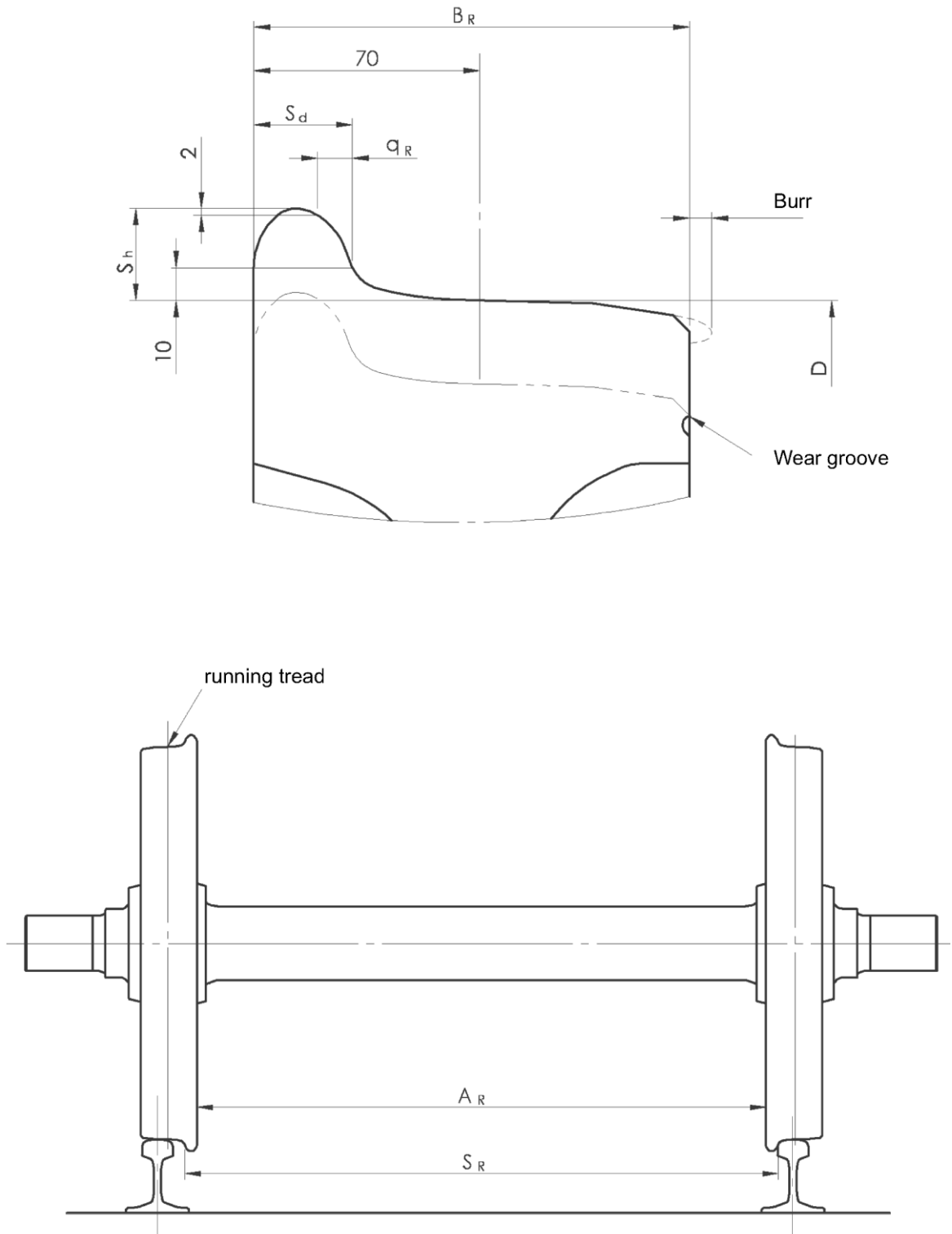Other dimensions in Figure 2 are not relevant in this document.

Figure 2: Wheel and wheelset dimensions

The values quoted in the following paragraphs are absolute limit values including any measurement tolerances.

The term wheelset applies to any pair of opposite wheels, even those not connected by a common axle. Except where stated, wheelset assemblies are assumed to have continuous wheel centres and not have spoke wheels. Any references to wheel sets concern centre of wheels.

3.1.2. Axle distances

3.1.2.1. Maximum axle distance

Harmonised parameter for 1435 mm, 1600 mm and 1668 mm track gauge:
The distance a_i (Figure 1) does not exceed 20 000 mm.

Harmonised parameter for 1520 mm and 1524 mm track gauge:
The distance a_i (Figure 1) does not exceed 19 000 mm.

Justification:
This requirement is related to the minimum length of a signalling section, so that a vehicle or consist does not bridge it, making the train detection system report it as "unoccupied".

3.1.2.2. Minimum axle distance (I)

Harmonised parameter:
The minimum axle distances (a_i) shall be dependent to the speed of the vehicle v [km/h] as follows:

Table 2

Maximum Speed v [km/h]	Minimum axle distances ai [mm]
v ≤ 100	720
100 < v ≤ 300	v×7.2
300 < v ≤ 400	2160
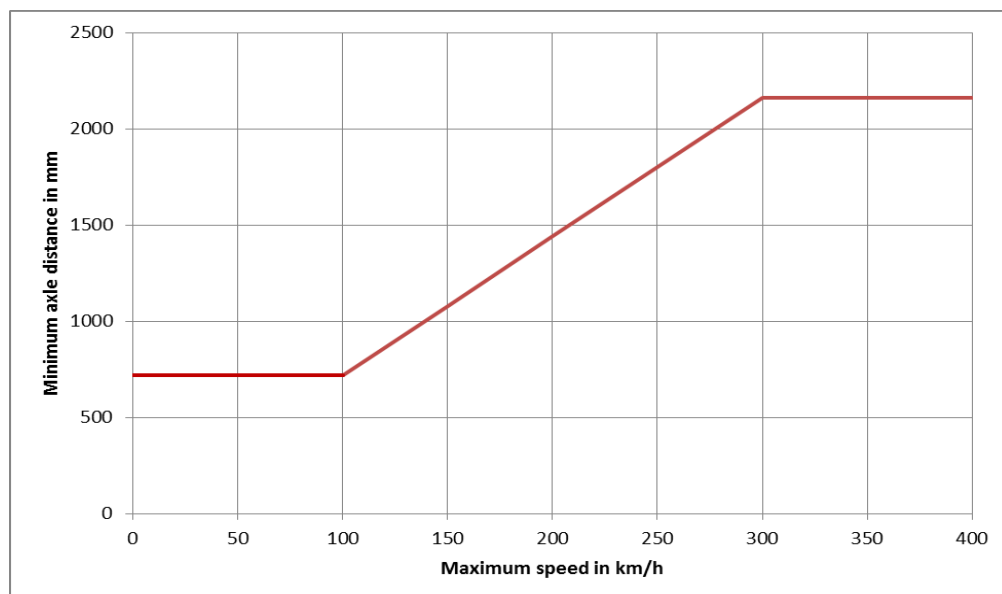
Figure 3

Justification:

Axle counter systems have to be able to distinguish the detection of an axle by 2 subsequent counters with sufficient resolution; otherwise the result will be a count-error.

3.1.2.3. Minimum axle distance (II)

Harmonised parameter:
The distance between first and last axle $L - (b_1 + b_2)$ (Figure 1) is at least 3 000 mm

Justification:
The electrical joints between adjacent track circuits may have an area where the detection of an axle of a vehicle is not ensured.

3.1.2.4. Distances between end of train and first axle on new High Speed lines

Harmonised parameter:
The distance b_x (Figure 1) does not exceed 5 000 mm.

Justification:
A train detection system shall be able to detect:
- the first axle before the nose of the train reaches a danger point ahead
- the last axle until the tail of the train has passed the danger point.

3.1.2.5. Distances between end of train and first axle on other lines

Harmonised parameter for 1435 mm, 1524 mm, 1600 mm and 1668 mm track gauge:
The distance b_x (Figure 1) does not exceed 4 200 mm.

Harmonised parameter for 1520 mm track gauge:
The distance b_x (Figure 1) does not exceed 3 500 mm

Justification:
A train detection system shall be able to detect:
- the first axle before the nose of the train reaches a danger point ahead
- the last axle until the tail of the train has passed the danger point.

3.1.3. Wheel geometry

3.1.3.1. Minimum wheel rim width

Harmonised parameter:
The dimension B_R (Figure 2) is (this value is in line with what specified for geometrical characteristics of wheels in "Locomotives and Passenger rolling stock" and in the "Freight wagons" TSIs)

Table 3

Wheel rim width as a function of the wheel diameter D

Track gauge [mm]	Wheel diameter D [mm]	Wheel rim width B_R [mm]
1435	D ≥ 330	133 to 140
1520	D ≥ 330	126 to 146
1524	D ≥ 400	133 to 145
1600	690 ≤ D ≤ 1016	137 to 139
1668	D ≥ 330	133 to 140

Justification:
The detection field of the axle counter is influenced by the wheel which passes. The rim width has to be big enough to influence the field sufficiently in order to ensure appropriate detection

3.1.3.2. Minimum wheel diameter

Harmonised parameter:
For the maximum speed v, the dimension D (Figure 2) is at least

Table 4

v [km/h]	D [mm] Hooped and Massive Wheels	D [mm] Spoked Wheels
v ≤ 100	330	600
100 < v ≤ 250	150 + 1.8 x v	600
250 < v ≤ 350	50 + 2.2 x v	50 + 2.2 x v
350 < v ≤ 400	750 + 0.2 x v	750 + 0.2 x v
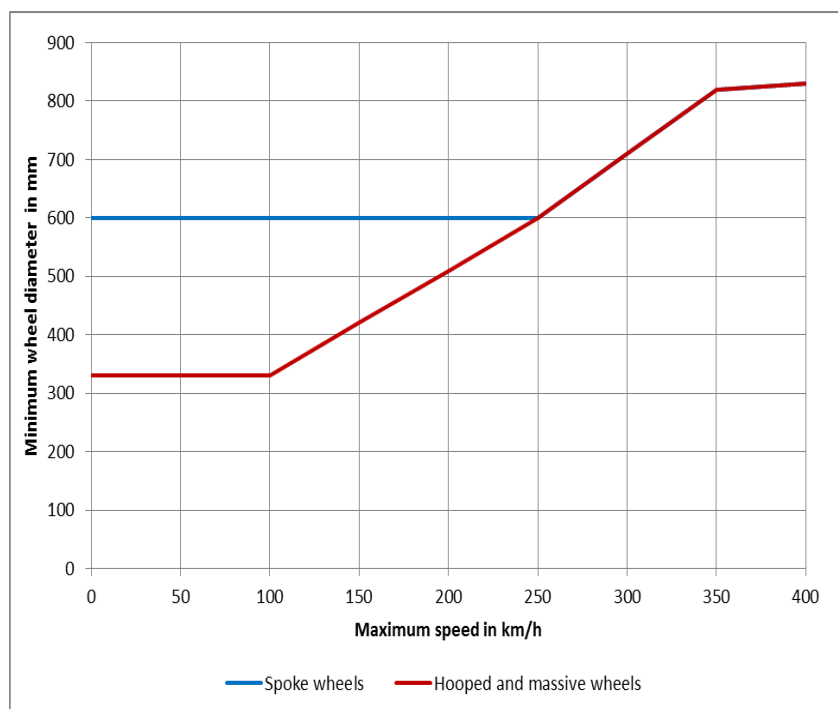
Figure 4

Justification:
The length of the influence of the detection field of the axle counter is related to the wheel diameter

3.1.3.3. Minimum flange thickness

Harmonised parameter:
The dimension S_d (Figure 2) is (this value is in line with what specified for geometrical characteristics of wheels in "Locomotives and Passenger rolling stock" and in the "Freight wagons" TSIs)

Table 5

Flange thickness as a function of the wheel diameter D

Track gauge [mm]	Wheel diameter D [mm]	Flange thickness S_d [mm]
1435	$330 \leq D \leq 760$	27.5 to 33
	$760 \leq D \leq 840$	25.0 to 33
	$D \geq 840$	22.0 to 33
1520	$330 \leq D \leq 1220$	21 to 33
1524	$400 \leq D \leq 760$	27.5 to 33
	$760 \leq D \leq 840$	25.0 to 33
	$D \geq 840$	22.0 to 33
1600	$690 \leq D \leq 1016$	26 to 33
1668	$330 \leq D \leq 840$	27.5 to 33
	$D \geq 840$	22 to 33

Justification:
The detection field of the axle counter is influenced by the wheel which passes. The flange thickness has to be big enough to influence the field sufficiently to ensure appropriate detection.

3.1.3.4. Flange height

Harmonised parameter:
The dimension S_h (Figure 2) is (this value is in line with what specified for geometrical characteristics of wheels in "Locomotives and Passenger rolling stock" and in the "Freight wagons" TSIs)

Table 6

Flange height as a function of the wheel diameter D

Track gauge [mm]	Wheel diameter D [mm]	Flange height S_h [mm]
1435	330 ≤ D ≤ 630	31.5 to 36
	630 ≤ D ≤ 760	29.5 to 36
	D ≥ 760	27.5 to 36
1520	330 ≤ D ≤ 1220	28 to 32
1524	400 ≤ D ≤ 630	31.5 to 36
	630 ≤ D ≤ 760	29.5 to 36
	D ≥ 760	27.5 to 36
1600	690 ≤ D ≤ 1016	28 to 38
1668	330 ≤ D ≤ 630	31.5 to 36
	630 ≤ D ≤ 760	29.5 to 36
	D ≥ 760	27.5 to 36

Justification:
The detection field of the axle counter is influenced by the wheel which passes. The flange height has to be big enough to influence the field sufficiently to ensure appropriate detection

3.1.3.5. Metal and inductive components-free space between wheels

Harmonised parameter:
Only wheels and their parts (gearboxes, brake parts) or non-metallic and non-inductive components are permitted to be mounted in the sensitive area of Figure 5.

Sanding pipes of sanding devices and rail guards are allowed to be mounted in a vertical (z-) distance ≥30 mm above the top of the rail. For sanding pipes below 40 mm to the top of the rail a maximum diameter of 60 mm is allowed.
Other metal parts (e.g. sanding pipe support, heating elements, magnetic brakes or eddy current brakes in rest position) are allowed to be mounted in a vertical distance ≥40 mm above the top of the rail. Inside of the shaded area in Figure 5, a metal part with the lateral dimension of maximum 130 mm is allowed.

These requirements shall be met:

- under all operational conditions (running in a curve, over switch, ..)
- for the maximum allowed wear of the wheel or the maximum wear of the wheel between two re-adjustments
- for the maximum spring compression of the primary and the secondary vehicle suspensions, considering:
    a. static load
    b. additional dynamic stimulation
    c. tolerances of the stiffness
    d. for air springs the totally evacuation of the air-suspension bellow („emergency suspension")

Requirements on steel springs and rubber springs:

Locomotive:
Spring compression for an overload of 30% of the suspended mass

Freight wagon:
Complete spring compression (till touchdown)

Passenger wagon, baggage wagon, specific freight wagon and train set:
Spring compression for an overload of 30% of the suspended mass (maximum load)
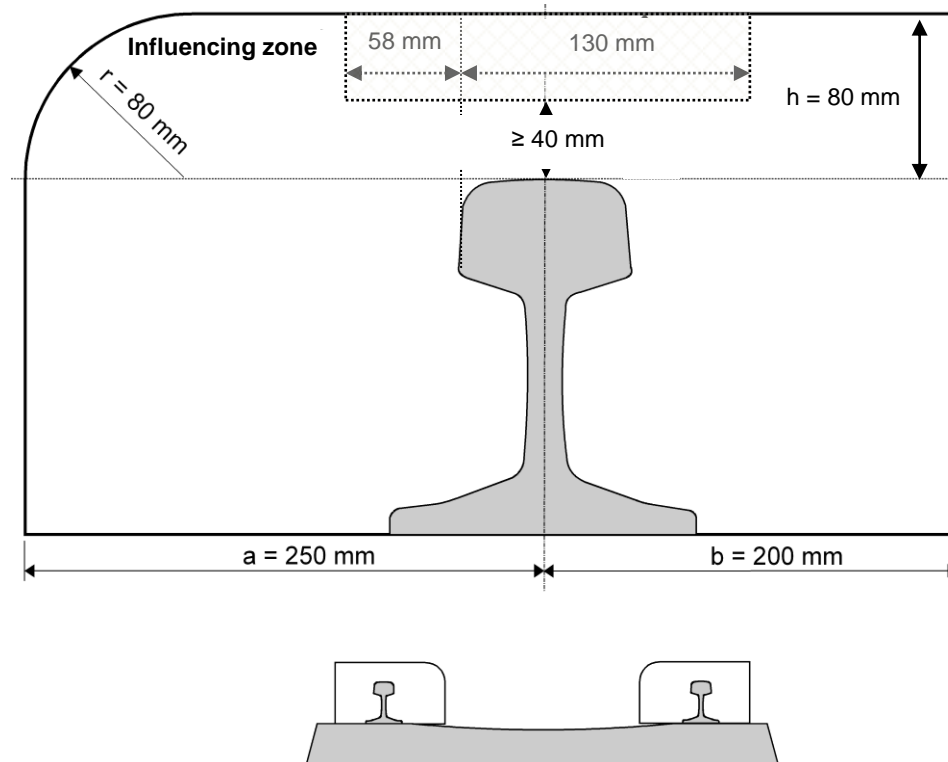

Figure 5: Sensitive area

Justification:
The principle of axle counters is based on the distortion of an electromagnetic field. The distortion should occur only with the passage of the wheel and not with the passage of surrounding parts of rolling stock, like other ferromagnetic components or inductive coils.

3.1.3.6. Wheel material

Harmonised parameter:
The wheels have ferromagnetic characteristics and are electrically conducting.

Justification:
This characteristic is necessary to generate the distortion of the electromagnetic field of axle counters, to ensure appropriate detection.

3.1.4. Use of sanding equipment

3.1.4.1. Maximum amount of sand

Harmonised parameter for 1435 mm, 1524 mm, 1600 mm and 1668 mm track gauge:
In case where an automatic sanding function is provided, it is possible for the driver to suspend its use.

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

1.   For speed v < 140 km/h; 400 g + 100 g
2.   For speed v > 140 km/h; 650 g + 150 g

The number of active sanding devices does not exceed the following:

1.   For multiple units with distributed sanding devices: first and last car and intermediate cars with a minimum of 7 intermediate axles, between two sanding devices that are not sanded. It is permissible to couple such multiple units and to operate all sanding devices at the coupled ends.

2.   For loco-hauled trains
     a. For emergency and full service braking: all available sanding devices
     b. In all other cases: a maximum of 4 sanding devices per rail

Harmonised parameter for 1520 mm track gauge:

In case where an automatic sanding function is provided, it is possible for the driver to suspend its use.

The allowed amount of sand per sanding device within 60 s is:
-    1.2 to 1.5 kg for the front wheelsets
-    0.7 to 1.2 kg for all other wheelsets for passenger and
freight locomotives respectively

This parameter shall be taken into account jointly with 3.1.4.2 (Sand Characteristics).

Justification:
Sand is applied to the tracks to improve braking and traction performance.
Sand can create an isolating layer between wheels and rails increasing the contact resistance, with risk of not detecting trains on tracks equipped with track circuits.

3.1.4.2. Sand characteristics

Harmonised parameter for 1435 mm, 1524 mm, 1600 mm and 1668 mm track gauge:
The characteristics of sand applied to the tracks are: [open point].

Harmonised parameter for 1520 mm track gauge:
The characteristics of sand applied to the tracks are:
The regular or high quality sand shall satisfy the requirements in respect of granularity, mineralogical and chemical composition and moisture content.

Granularity, same as quartz content, is the main indicator of the quality of the sand and is characterised by the distribution of grains by size expressed in percentage of

the total mass of the sand. The size of the granules in the regular and high quality sand shall comply with the following table:

Table 7

Quality of sand	Regular size (inside) of the screen mesh side, mm					Flour particles, max	
	2.0	1.0	0.5	0.2	0.1	Residue in a basin*	Clay component
Regular	Should not be present	Max 10	Max 30	Min 30	Max 25	7.0	3.0
High	Should not be present	Max 10	Max 30	Min 35	Max 25	4.0	1.0

Mineralogical composition of the regular and high quality sand for locomotives shall satisfy the requirements of the following table

Table 8

Quality of sand	Grain content in the washed sand, %	
	Quartz, min	Feldspar and other minerals and rock, not exceeding
Regular	75	25
High	90	10

Chemical composition of the regular and high quality sand for locomotives shall satisfy the requirements of the following table:

Table 9

Quality of sand	Loss by calcination, max, %	Silicon dioxide (silica) SiO_2, min, %	Aluminium oxide (alumina) Al_2O_3, max, %	Other sand components: CaO; MgO; (K_2O+Na_2O), etc., max, %
Regular	1	85	5	9
High	1	92	3	4

This parameter shall be taken into account jointly with 3.1.4.1 (Maximum amount of sand).
This parameter is to enable the margins related to contact resistance between wheels and rails to be taken into account for the use of track circuits.

Justification:
The composition of the sand which is used is relevant for the risk of not detecting trains on tracks equipped with track circuits.

3.1.5. On-board flange lubrication

Harmonised parameter:
If the vehicle is equipped with flange lubricators, it shall be possible to activate/deactivate them.

The characteristics of flange lubricators applied by a vehicle to the tracks are:

[open point]

Justification:
Lubricant can create an isolating film between wheels and rails increasing the contact electrical resistance, with risk of not detecting trains on tracks equipped with track circuits.

3.1.6. Use of composite brake blocks

Harmonised parameter:
The vehicles use brake blocks assessed for the effects on the contact electrical resistance between wheel and rail[2].

[2] The approved types are listed in the technical document referred in Commission Decision 2006/861/EC as amended by Commission Decision 2009/107/EC, art.1 and 2.

Justification:
Composite brake blocks can create an isolating film between wheels and rails increasing the contact electrical resistance, with risk of not detecting trains on tracks equipped with track circuits.

3.1.7. Vehicle axle load and metal construction

3.1.7.1. Vehicle axle load

Harmonised parameter for 1435 mm, 1524 mm, 1600 mm and 1668 mm track gauge:
The axle load is

1. at least 3,5 t for vehicles with more than 4 axles and wheel tread brakes,
2. at least 4 t for vehicles with 4 axles and wheel tread brakes,
3. at least 5 t for other vehicles (that is, vehicles that do not fall into categories 1 or 2).

Harmonised parameter for 1520 mm track gauge:
The axle load is at least 11 t for all vehicles.

Justification:
A minimum axle load will activate pedals and treadles. Also, minimum axle load will have a beneficiary effect on the resistance between wheel and track, which is important for the operation of track circuits. Friction elements acting on the surface of wheels contribute to keep them clean and limit the increase of contact resistance.

3.1.7.2. Vehicle metal construction

Harmonised parameter for 1435 mm track gauge:

In the following, "length" refers to the direction in parallel to the track and "width" refers to the direction orthogonal to the track.

The description of this parameter is done with reference to the figure below:

a: section (distance) between the inner axles of two adjacent bogies or wheel sets

b: section (distance) between the first (respectively the last) axle and the nearest end of the vehicle (excluding the coupling systems)

c: distance between top of rail and vehicle floor (bottom side)

d: distance between adjacent conducting cross connections / length of short circuit rings (electrically conducting loops) formed by frame beams and conducting cross connections

e: distance of adjacent longitudinal frame beams

f, g, h: dimensions of electrically connected conducting constituents (X)

i, k: dimensions of short circuit rings (electrically conducting loops) formed by electrically connected conducting constituents (X)

o: distance between adjacent short circuit rings

p: distance between short circuit rings and adjacent wheel sets

X: conductive constituents mounted below vehicle floor
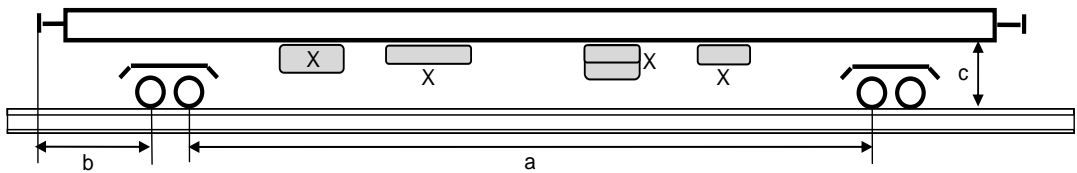
A: Defined distances and areas *(the illustrated bogies with two axles are only an example; a bogie can consist of different numbers of axles)*
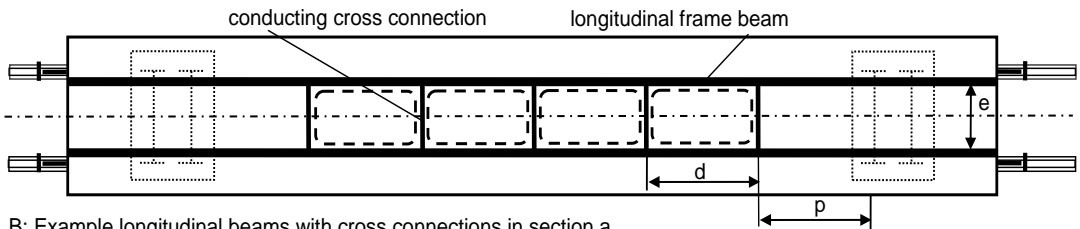
B: Example longitudinal beams with cross connections in section a
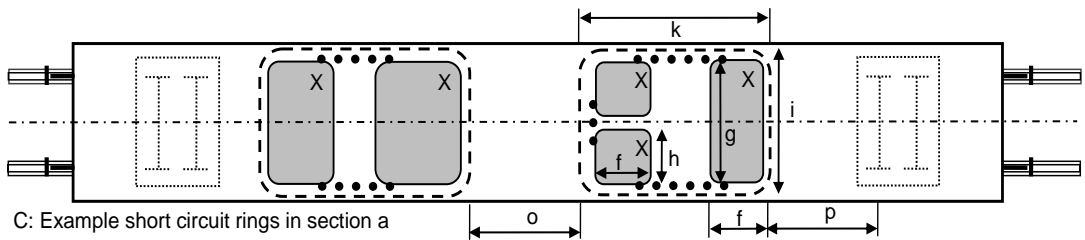
C: Example short circuit rings in section a

 Resulting short circuit ring (electrically conducting loop)

• • • • • Principle routing of the cables for the electrical connection of electrically conductive constituents

Figure 6: Vehicle layouts

For the scope of this parameter, the vehicle is subdivided in different sections as shown in Figure 6A: a central section (a), two outer sections (b) and the sections of the bogies or single wheel sets. The parameter is respected when the design of the vehicle is such that at least one of the conditions 1, 2 or 3 is fulfilled in section (a) and section (b) and condition 4 (or alternatively at least one of the conditions 1, 2 or 3) is

fulfilled in the sections of bogies or single wheel sets (in case of vehicles without bogies):

1. The distance (c) between rail level and vehicle floor (bottom side) is less than 1.06 m and the vehicle has a metal floor over its full length (excluding the coupling systems) with a minimum width of 2 m and with a conductivity greater than 1 m/(Ω mm^2).

2. The vehicle has constructive structures at least inside section (a) and (b) consisting of longitudinal frame beams symmetrically on both sides with a minimum distance (e) of 1.0 m. These are electrically connected with conducting cross connections in a distance (d) less than or equal to 3 m to form short circuit rings (electrically conducting loops) as illustrated in Figure 6B, showing an example for section (a).

   The electrical DC resistance of the resulting short circuit rings is lower than 1 Ω.

   The distance (o) between adjacent short circuit rings does not exceed 3 m. The distance (p) between a short circuit ring and an adjacent wheel set of a bogie does not exceed 3 m, the distance to a single wheel set does not exceed 1.5 m.

   The distance between rail level and short circuit rings on the bottom side of vehicle floor is less than 1.06 m.

3. The vehicle has electrically conducting constituents (X) mounted below the floor at least inside section (a) and (b). These are electrically connected to form short circuit rings (electrically conducting loops) as illustrated in Figure 6C, showing an example for section (a). The dimensions of the constituents fulfil at least one of the following conditions:
   a) minimum width (g) of 2 m and minimum longitudinal length (f) of 1 m,
   b) minimum width (h) of 1 m and minimum longitudinal length (f) of 1 m on both long sides of the vehicle.

   The electrical connection is done in a way that short circuit rings with a length (k) equal or more than 2.5 m but less or equal than 3 m and a minimum width (i) of 2 m result. Figure 6C illustrates the principle routing of the cabling.

   The conductivity of the conducting constituents is greater than 1 m/(Ω mm^2). The electrical DC resistance of the resulting short circuit rings is lower than 1 Ω.

   The distance (o) between adjacent short circuit rings does not exceed 3 m. The distance (p) between a short circuit ring and an adjacent wheel set of a bogie does not exceed 3 m, the distance to a single wheel set does not exceed 1.5 m.

   The distance between rail level and short circuit rings on the bottom side of vehicle floor is less than 1.06 m.

4. Bogies consist of metal parts with a conductivity greater than 1 m/(Ω mm^2). Constructive supporting metal parts of a bogie frame are electrically connected with an electrical DC resistance lower than 1 Ω. The distance between rail level and the bottom side of the bogie frame is less than 1.06 m.
   Alternatively, if these requirements are not fulfilled at least condition 1, 2 or 3 shall be fulfilled in the section of the bogie.

This parameters ensures compatibility with loops.
Other equivalent solutions (e.g. field tests demonstrating that the passing vehicle creates sufficient change of inductivity of trackside loops) to demonstrate compatibility with such trackside loops are allowed.

Harmonised parameter for 1520 mm, 1524 mm, 1600 mm and 1668 mm track gauge:

No requirement on vehicle metal construction exist.

Justification:
This parameter specifies the requirements on the metal construction of a vehicle ensuring its detection by trackside inductive loops.

3.1.8. Use of shunt assisting devices

Harmonised parameter for 1435 mm, 1524 mm, 1600 mm and 1668 mm track gauge:
The use of shunting assisting devices is not required.

Harmonised parameter for 1520 mm track gauge:
The use of shunting assisting devices is required if the axle load < 11 t.

Justification:
Shunting assisting devices can improve the shunting behaviour between wheel and rail.

3.1.9. Impedance between wheels

Harmonised parameter:
The electrical resistance between the running surfaces of the opposite wheels of a wheelset does not exceed 0.05 Ohm, measured by a voltage between 1.8 VDC and 2.0 VDC (open circuit).

Justification:
A track circuit is only able to detect rolling stock if the impedance between rails does not exceed a certain value, given by the impedance of the opposite wheels of the wheelsets and the contact resistance at the wheel-rail surface.
The interface requirement given here is only related to the electrical resistance between the running surfaces of the opposite wheels of a wheelset.

Remark: operational rules may apply to ensure that a sufficiently low value of the contact resistance is maintained during service: see 3.1.4 (Use of sanding equipment), 3.1.5 (On board flange lubrication) and 3.1.6 (Use of composite brake blocks)

3.1.10. Combination of rolling stock characteristics influencing shunting impedance

Harmonised parameter:
The rules for combination of characteristics listed above (3.1.2 to 3.1.9) for vehicles or trains to ensure adequate operation with train detection systems are: [open point].

Justification:
These rules refer to possible conditions / limitations for the use of vehicles and trains on lines where track circuits are installed. The operation of track circuits relies on the contact resistance between wheels and rails that is influenced by the combination of several factors. The dynamic shunt behaviour differs from the static shunt behaviour. Even for vehicles or trains compliant with the single parameters defined in this specification, rules for the vehicles or consist may be necessary to cover this.

3.2. ELECTROMAGNETIC COMPATIBILITY

The requirements related to electromagnetic compatibility are expressed by means of "frequency management", the purpose of which is to define the frequency ranges and the associated limits required for compatibility between rolling stock and track-side equipment.

3.2.1. Electromagnetic fields

3.2.1.1. Frequency management

The compatibility requirements specified in this section apply for 1435 mm, 1600 mm, 1520 mm, 1524 mm and 1668 mm track gauge network.

The frequency management defines three frequency bands:

1. 27 kHz – 52 kHz for band 1
2. 234 kHz – 363 kHz for band 2
3. 740 kHz – 1250 kHz for band 3

The subsequent figures illustrate the compatibility limits for x, y and z directions.
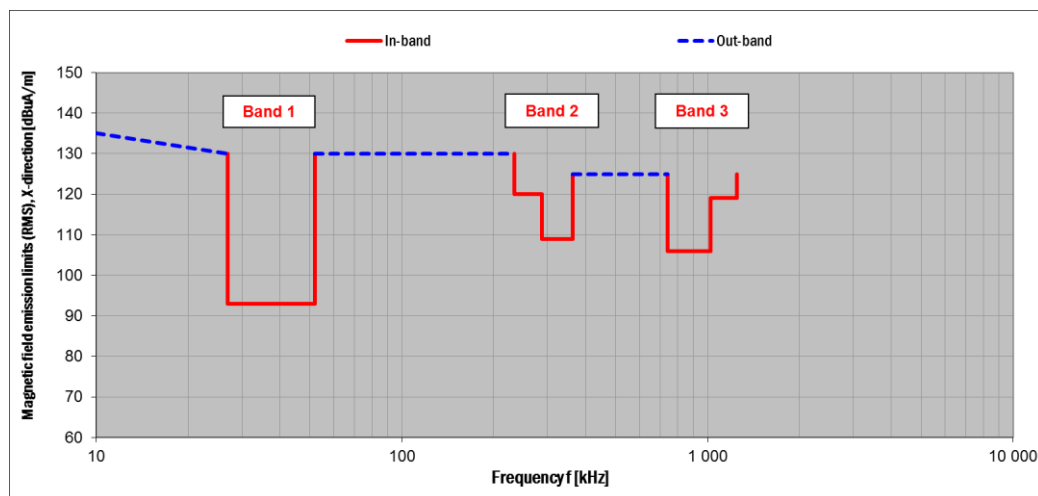

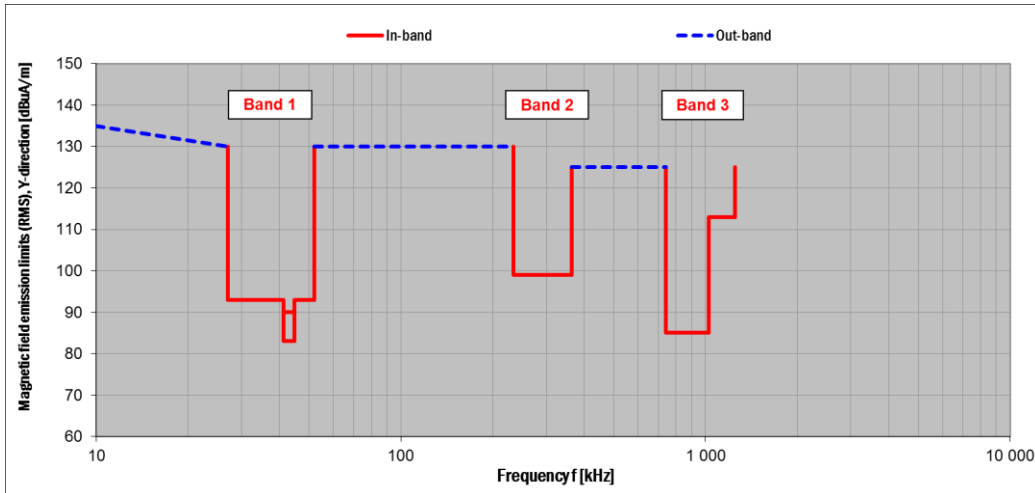*Figure 7: Compatibility requirements for X direction*

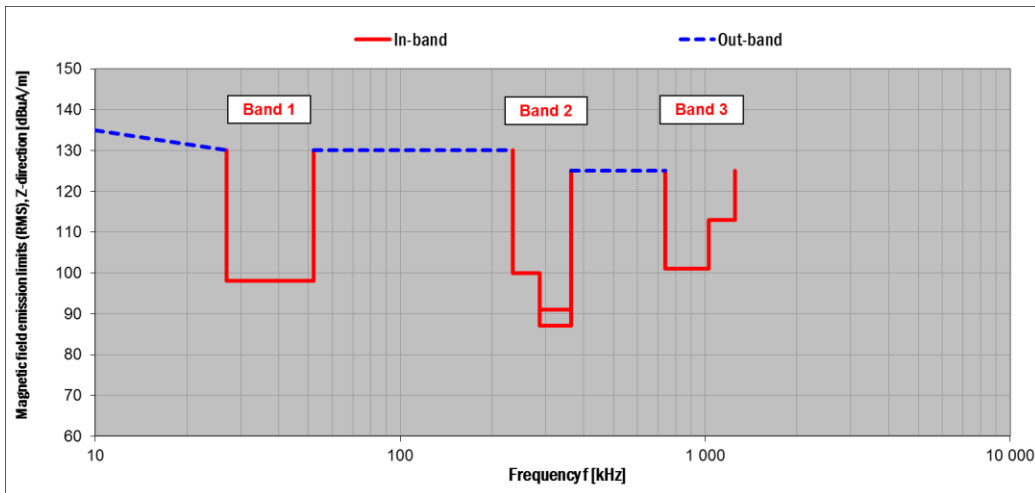*Figure 8: Compatibility requirements for Y direction*

Figure 9: Compatibility requirements for Z direction

Justification:
The magnetic fields generated by rolling stock can potentially interfere with the operation of train detection systems.

3.2.1.2. Vehicle emission limits and evaluation parameters

The limits and associated parameters for the evaluation of rolling stock emissions against the requirements in 3.2.1.1 are provided in the following table 10. For in-band evaluation with band-pass filters a 20 % overlap of the 3 dB-bandwidth and a time overlapping of 75 % are required.
Compatibility with in-band limits can also be demonstrated by broadband evaluation using Fast Fourier Transformation with Hanning window, 75% of time overlapping and time windows of 1 ms for Band 1 and 0.5 ms for Band 2 or Band 3.

Table 10

Band	Frequency range defined by the centre frequency [kHz]	Emission limit X Axis [dBµA/m] (RMS)	Emission limit Y Axis [dBµA/m] (RMS)	Emission limit Z Axis [dBµA/m] (RMS)	Evaluation method**	Filter order (butterworth) and 3 dB-bandwidth	Evaluation parameters
Out of band	10 to 27	straight line from 135 to 130 in dB/log(f)	straight line from 135 to 130 in dB/log(f)	straight line from 135 to 130 in dB/log(f)	FFT		Record time 1 ms, Hanning window, 50% overlap, max hold
Band 1	27 to 41.2 and 44.8 to 52	93	93	98	BP	4th order 300 Hz	20% overlap (3dB points) integration time: 1ms
Band 1	41.2 to 44.8	93	83*/90*	98	BP	4th order 320 Hz	20% overlap (3dB points) integration time: 1ms
Out of band	52 to 234	130	130	130	FFT		Record time 1ms, Hanning window, 50% overlap, max hold
Band 2	234 to 287	120	99	100	BP	4th order; 7500 Hz	20% overlap (3dB-points), integration time: 1.5 ms
Band 2	287 to 363	109	99	91	BP	4th order; 7500 Hz	20% overlap (3dB-points), integration time 1.5 ms
Band 2	287 to 363	--	--	87	BP	4th order; 4000 Hz	20% overlap (3dB-points), integration time: 1.5 ms
Out of band	363 to 740	125	125	125	FFT		record time 1ms, Hanning window, 50% overlap, max hold
Band 3	740 to 1026	106	85	101	BP	4th order; 10 kHz	20% overlap (3dB-points), integration time: 1.5 ms
Band 3	1026 to 1250	119	113	113	BP	4th order; 10 kHz	20% overlap (3dB-points), integration time 1.5 ms

* 90 dBµA/m for emissions under the train, defined by the distance between the middle of the first and the last axle of the train + 0.5m on both sides, independently of the radius of the wheels. See Figure 10 below.
83 dBµA/m for emissions measured before the first axle and after the last axle of the train has passed over the measurement sensor, see Figure 10 below.
** FFT= Fast Fourier Transformation; BP= Band-pass Filtering.

0.5 m

area between the
first and the last axle

0.5 m

area after the last axle
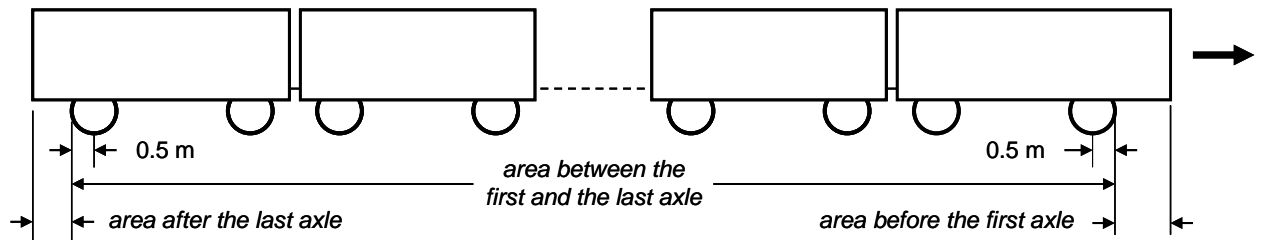
area before the first axle

Figure 10

The uncertainty of the whole measurement chain shall be no more than +/- 3 dB of the defined magnetic field limit.

3.2.1.3. Evaluation of exceedances of limits defined in Table 10.

In case there are exceedances of the limits specified in Table 10 shorter than the integration time and the minimum time interval between two exceedances is greater than the integration time T_{int} specified in Table 10, further evaluation can be done using shorter integration time as defined in Table 11.

Table 11

Frequency range	Field direction	Increasing of magnetic field limits for a reduced integration time of 0,5 x T_{int} [dB]	Increasing of magnetic field limits for a reduced integration time of 0,25 x T_{int} [dB]
27 to 52 kHz	X	2	6
27 to 52 kHz	Y, Z	6	12
234 to 287 kHz	X, Y, Z	6	12
287 to 363 kHz	X, Y, Z	3	6
740 to 1026 kHz	X, Y, Z	6	12
1026 to 1260 kHz	X, Y, Z	0	0

3.2.1.4. Measurement, test and evaluation specification

The magnetic field limits specified in table 10 and additional table 11 shall be measured using the antennas defined below (figure 11).

A rectangular 3-dimensional magnetic loop antenna with a common centre point with the following geometrical dimensions shall be used:

  1.   5 cm x 5 cm (X-direction)
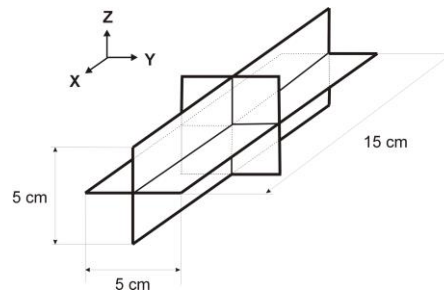 2.   5 cm x 15 cm (Y- and Z- direction). The longest arm is always in X-direction.

Figure 11: Loop antenna

The following table shall be used to define the mounting position of the measurement antennas MA for the frequency range considered.

Table 12

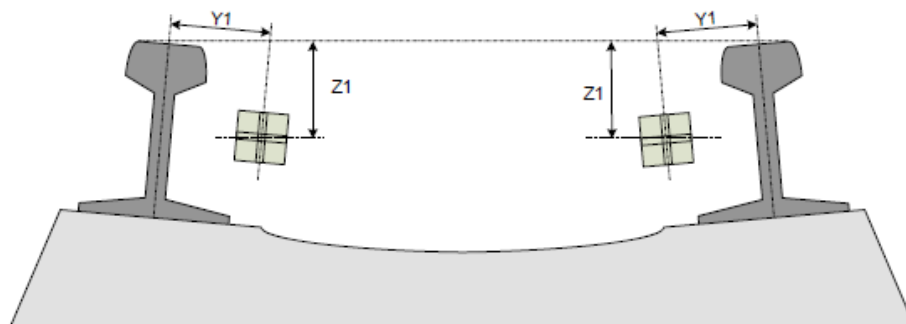|	Y1 (tolerances) [mm]	Z1 (tolerances) [mm]
MA centre position (10 kHz to 1.3 MHz)	96 (-3; +3)	73 (-5; +5)

Figure 12: Position of the measurement antenna (internal between the rails)

3.2.2. Conducted interference

3.2.2.1. Vehicle impedance

The minimum impedance between pantograph and wheels of the consist (complete train) is: [open point]

Justification:
In train detection systems, to prevent interferences from harmonics generated in the traction system and to prevent (in case of track circuits) cross-over effect through the catenary system from one track to another, a sufficiently high impedance of the train is necessary.

3.2.2.2. Substation impedance

For DC networks only:
The minimum impedance between catenary and return path is: [open point]

Justification:
In train detection systems, to prevent interferences from harmonics generated in the traction system and to prevent (in case of track circuits) cross-over effect through the catenary system from one track to another, a sufficiently high impedance of the substation is necessary.

3.2.2.3. *Traction current at fundamental power supply frequency*

There is no requirement applicable to rolling stock for a maximum harmonised value of the traction current at the fundamental power supply frequency.

Justification:
The traction current in the rails can potentially interfere with the operation of train detection systems.
The upper limit of this parameter is linked to the short circuit current of the traction power supply: this is a design issue of trackside subsystems and it is not directly associated with requirements for rolling stock.

Note: The requirements on harmonics of the traction current, which are applicable to rolling stock, are covered in the following points 3.2.2.4 to 3.2.2.7.

3.2.2.4. *25 kV AC, 50 Hz Electromagnetic interference limits for traction current*

The subsequent figure illustrates the compatibility limits for interference current emissions from rolling stock (per influencing unit):
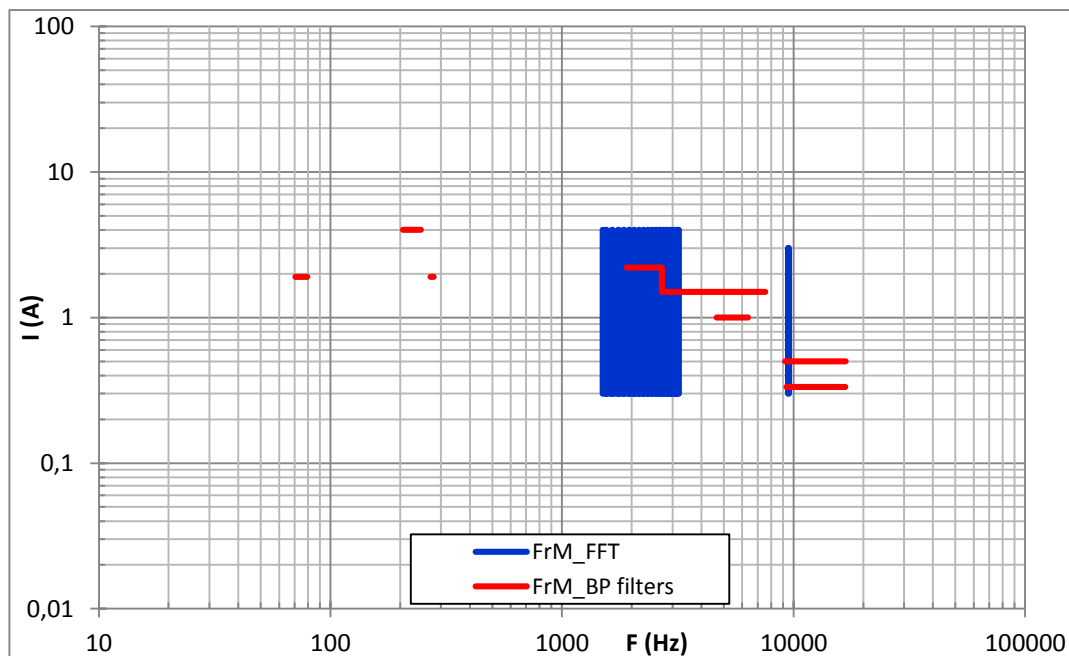

Figure 13: Frequency Management 25kV AC 50 Hz traction

Two types of limits have been defined according to the two methods of evaluation to be used (FFT and band pass filters).

The limits and associated parameters for the evaluation of rolling stock emissions are provided in the following table:

Table 13

Frequency range	Interference current limit [rms value]	Evaluation method	Evaluation parameters
70.5 – 79.5 Hz	1,9 A	Band-Pass Filter	▪ BP filter characteristics: Centre frequencies range: 73, 75, 77Hz 3dB-Bandwidth: 5 Hz Butterworth, order 2*4 ▪ RMS calculation: Integration time: 0.5 s Time overlap: min 75 %
205.5 - 245.4 Hz	4 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 208.75, 225.45, 242.15 Hz 3dB-Bandwidth : 6,5Hz Butterworth, 6th order (2 x 3rd order) ▪ RMS calculation : Integration time : 0,5s Time overlap : 50%
270.5 – 279.5 Hz	1,9A	Band Pass Filter	▪ BP filter characteristics: Centre frequencies range: 273, 275, 277 Hz 3dB-Bandwidth: 5 Hz Butterworth, order 2*4 ▪ RMS calculation: Integration time: 0.5 s Time overlap: min 75 %
1500 - 3200 Hz	0,3A (except in bands here below) 4A in bands $(30+n) \times 50 \pm 5Hz$ (n=1,3,5, …,33)	FFT	Time window 1s, Hanning window, 50% overlap
1900 - 2700 Hz	2,2 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 2100, 2500 Hz 3dB-Bandwidth : 400Hz Tchebyshev, BP ripple 0.01dB, 10th order (2 x 5th order) ▪ RMS calculation : Integration time : 1s Time overlap : 50 %
2700 - 5100 Hz	1,5 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 2900, 3300, 3700, 4100, 4500, 4900 Hz 3dB-Bandwidth : 400Hz Tchebyshev, BP ripple 0.01dB, 10th order (2 x 5th order) ▪ RMS calculation : Integration time : 1s Time overlap : 50 %

Frequency range	Interference current limit [rms value]	Evaluation method	Evaluation parameters
3450 - 7550 Hz	1,5 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 3750, 4250, 4750, 5250, 5750, 6250, 6750, 7250 Hz 3dB-Bandwidth : 600Hz Tchebyshev, BP ripple 0.01dB, 10th order (2 x 5th order) ▪ RMS calculation : Integration time : 1s Time overlap : 50 %
4650 - 6360 Hz	1 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 4750, 5250, 5750, 6250 Hz 3dB-Bandwidths : 200, 206, 214, 220 Hz Butterworth, 6th order (2 x 3rd order) ▪ RMS calculation : Integration time : 40ms Time overlap : 50 %
9450 - 9550 Hz	0,3 A	FFT	Time window 1s, Hanning window, 50% overlap
9200 - 16800 Hz	0,5 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 9500, 10500, 11500, 12500, 13500, 14500, 15500, 16500 Hz 3dB-Bandwidth : 600Hz Tchebyshev, BP ripple 0.01dB, 10th order (2 x 5th order) ▪ RMS calculation : Integration time : 1s Time overlap : 50 %
9320 - 16755 Hz	0,33 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 9500, 10500, 11500,12500, 13500, 14500, 15500, 16500 Hz 3dB-Bandwidths : 360, 380, 400, 425, 445, 470, 490, 510 Hz Butterworth, 6th order (2 x 3rd order) ▪ RMS calculation : Integration time : 40ms Time overlap : 50 %

Out-band limits are: [open point]

The contribution of substations is included in the margin taken into account in the limits of frequency management.

Justification: The harmonics in the traction current in the rails can interfere with the operation of train detection systems.

3.2.2.5. 15kV AC, 16,7Hz Electromagnetic interference limits for traction current

The subsequent figure illustrates the compatibility limits for interference current emissions from rolling stock (per influencing unit):
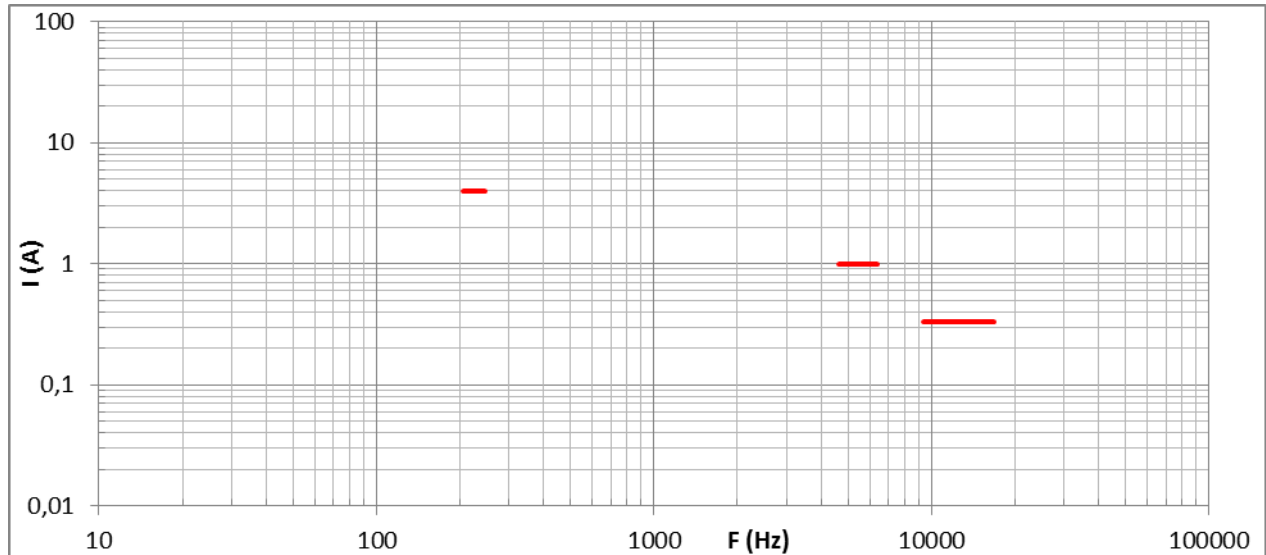

Figure 14: Frequency Management 15kV AC 16,7 Hz traction

The limits and associated parameters for the evaluation of rolling stock emissions are provided in the following table:

Table 14

Frequency range	Interference current limit [rms value]	Evaluation method	Evaluation parameters
205.5 - 245.4 Hz	4 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 208.75, 225.45, 242.15 Hz 3dB-Bandwidth : 6,5Hz Butterworth, 6th order (2 x 3rd order) ▪ RMS calculation : Integration time : 0,5s Time overlap : 50%
4650 - 6360 Hz	1 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 4750, 5250, 5750, 6250 Hz 3dB-Bandwidths : 200, 206, 214, 220 Hz Butterworth, 6th order (2 x 3rd order) ▪ RMS calculation : Integration time : 40ms Time overlap : 50 %

Frequency range	Interference current limit [rms value]	Evaluation method	Evaluation parameters
9320 - 16755 Hz	0,33 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 9500, 10500, 11500,12500, 13500, 14500, 15500, 16500 Hz 3dB-Bandwidths : 360, 380, 400, 425, 445, 470, 490, 510 Hz Butterworth, 6th order (2 x 3rd order) ▪ RMS calculation : Integration time : 40ms Time overlap : 50 %

Out-band limits are: [open point]

The contribution of substations is included in the margin taken into account in the limits of frequency management.

Justification: The harmonics in the traction current in the rails can interfere with the operation of train detection systems.

3.2.2.6. DC (3kV, 1.5kV) Electromagnetic interference limits for traction current

The subsequent figure illustrates the compatibility limits for interference current emissions measured on rolling stock (including substation contribution):
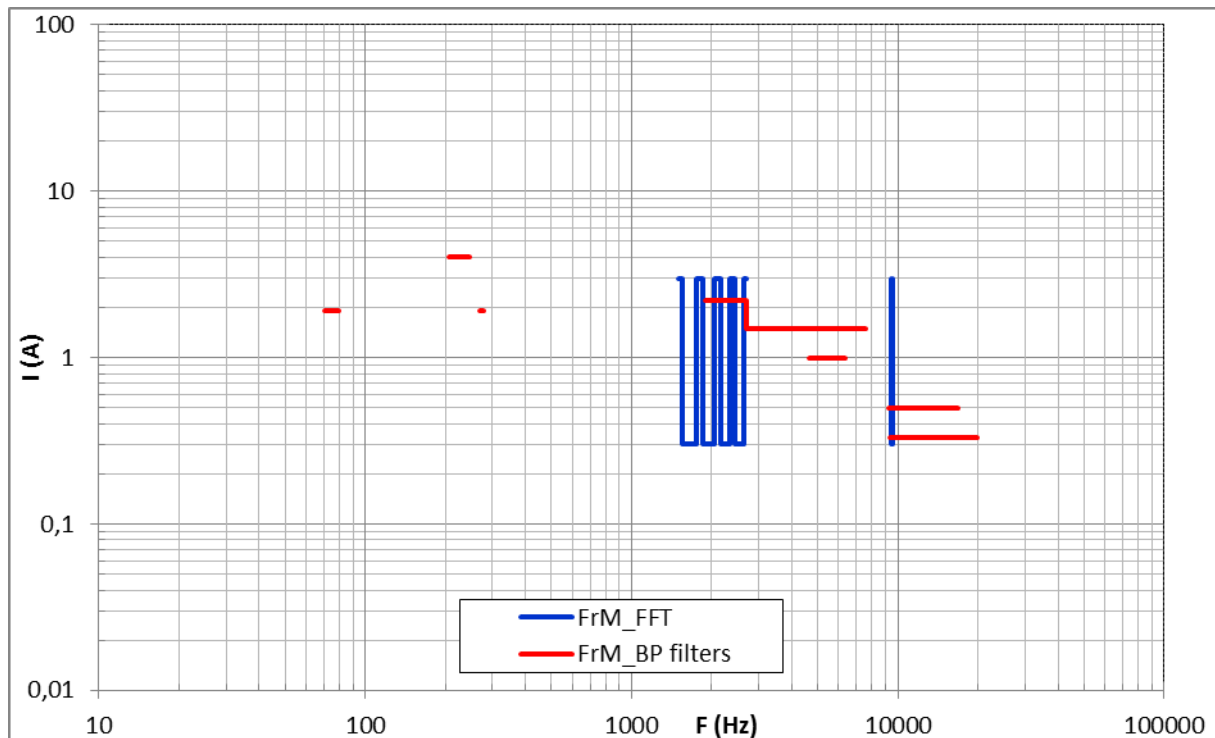

Figure 15: Frequency Management DC traction

Two types of limits have been defined according to the two methods of evaluation to be used (FFT and band pass filters).

The limits and associated parameters for the evaluation of rolling stock emissions are provided in the following table:

Table 15

Frequency range	Interference current limit [rms value]	Evaluation method	Evaluation parameters
70.5 – 79.5 Hz	1,9 A	Band-Pass Filter	▪ BP filter characteristics: Centre frequencies: 73, 75, 77 Hz 3dB-Bandwidth: 5 Hz Butterworth, order 2*4 ▪ RMS calculation: Integration time: 0.5 s Time overlap: min 75 %
205.5 - 245.4 Hz	4 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 208.75, 225.45, 242.15 Hz 3dB-Bandwidth : 6,5Hz Butterworth, 6th order (2 x 3rd order) ▪ RMS calculation : Integration time : 0,5s Time overlap : 50%
270.5 – 279.5 Hz	1,9A	Band-Pass Filter	▪ BP filter characteristics: Centre frequencies: 273, 275, 277 Hz 3dB-Bandwidth: 5 Hz Butterworth, order 2*4 ▪ RMS calculation: Integration time: 0.5 s Time overlap: min 75 %
1500 - 2700 Hz	0,3A (except in bands here below) 3A in bands 6xnx50±55Hz (n=5,6,7,8,9)	FFT	Time window 1s, Hanning window, 50% overlap
1900 - 2700 Hz	2,2 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 2100, 2500 Hz 3dB-Bandwidth : 400Hz BP ripple 0.01dB, 10th order (2 x 5th order) ▪ RMS calculation : Integration time : 1s Time overlap : 50 %

Frequency range	Interference current limit [rms value]	Evaluation method	Evaluation parameters
2700 - 5100 Hz	1,5 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 2900, 3300, 3700, 4100, 4500, 4900 Hz 3dB-Bandwidth : 400Hz Tchebyshev, BP ripple 0.01dB, 10th order (2×5th order) ▪ RMS calculation : Integration time : 1s Time overlap : 50 %
3450 - 7550 Hz	1,5 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 3750, 4250, 4750, 5250, 5750, 6250, 6750, 7250 Hz 3dB-Bandwidth : 600Hz Tchebyshev, BP ripple 0.01dB, 10th order (2×5th order) ▪ RMS calculation : Integration time : 1s Time overlap : 50 %
4650 - 6360 Hz	1 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 4750, 5250, 5750, 6250 Hz 3dB-Bandwidths : 200, 206, 214, 220 Hz Butterworth, 6th order (2×3rd order) ▪ RMS calculation : Integration time : 40ms Time overlap : 50 %
9450 - 9550 Hz	0,3 A	FFT	Time window 1s, Hanning window, 50% overlap
9200 - 16800 Hz	0,5 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 9500, 10500, 11500, 12500, 13500, 14500, 15500, 16500 Hz 3dB-Bandwidth : 600Hz Tchebyshev, BP ripple 0.01dB, 10th order (2×5th order) ▪ RMS calculation : Integration time : 1s Time overlap : 50 %
9320 - 19755 Hz	0,33 A	Band-Pass Filter	▪ BP filter characteristics : Centre frequencies : 9500, 10500, 11500,12500, 13500, 14500, 15500, 16500, 17500, 18500, 19500 Hz 3dB-Bandwidths : 360, 380, 400, 425, 445, 470, 490, 510, 510, 510, 510 Hz Butterworth, 6th order (2×3rd order) ▪ RMS calculation : Integration time : 40ms Time overlap : 50 %

The interference current limits attributed to the substations and attributed to the rolling stock are: [open point]

Out-band limits are: [open point]

Justification: The harmonics in the traction current in the rails can interfere with the operation of train detection systems.

3.2.2.7. Measurement, test and evaluation specification

The test and evaluation specification including software configuration for testing trains according to the frequency management, test tracks, summation rules is: [open point]

Justification:
As for axle counters, a test and evaluation method for the vehicle is necessary to proof conformity with the frequency management.

3.2.3.   Use of magnetic / eddy current brakes

Harmonised parameter:
If the vehicle is equipped with magnetic or eddy current brakes, it shall be possible to activate and deactivate them.

Justification:
The rules for the use of magnetic or eddy current brakes are defined by the infrastructure manager.

4.   CONFORMITY ASSESSMENT

For the different kinds of train detection systems the following parameters are assessed either for the IC (Interoperability Constituent) certification or at subsystem level:

Table 16

Train Detection System	Parameters	Relevant for IC certification	Relevant for application engineering (assessed at subsystem level)
Axle Counter	Axle distances		
	3.1.2.2 Minimum axle distance (I)	X	
	3.1.2.4 Distances between end of train and first axle on new High Speed lines		X
	3.1.2.5 Distances between end of train and first axle on other lines		X
	Wheel geometry		
	3.1.3.1 Minimum wheel rim width	X	
	3.1.3.2 Minimum wheel diameter	X	
	3.1.3.3 Minimum flange thickness	X	
	3.1.3.4 Flange height	X	
	3.1.3.5 Metal and inductive components-free space between wheels	X	
	3.1.3.6 Wheel material	X	
	Electromagnetic fields		
	3.2.1.1 Frequency management	X	
	3.2.1.2 Vehicle emission limits and evaluation parameters	X	
	3.2.1.3 Evaluation of exceedances of limits	X	
	3.2.1.4 Measurement specification	X	
Track Circuits		Assessed at subsystem level	
Loops		Assessed at subsystem level	
Other train detection systems	[all] depending on technology used for train detection system	Assessed at subsystem level: Check if the system does not impose any additional requirements (3.1,3.2) at vehicle side as those specified in the interface document	

4.1. INTEROPERABILITY CONSTITUENT AXLE COUNTER

The EC declaration of conformity for axle counter products shall cover all parameters applicable for IC certification of axle counters (see Table 16).

For the frequency management defined in chapter 3.2.1 for the immunity level of axle counter (magnetic field), a margin of at least +9dB inband and +3dB outband shall be observed.

If the architecture of the axle counter product does not allow the declaration of conformity for all parameters applicable for axle counters, the EC declaration for conformity shall explicitly mention these parameters. Theses parameters have to be checked at subsystem level according chapter 6.3 of the CCS TSI.