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Railway applications — Testing of rolling stock for electromagnetic compatibility with axle counters

bsi.

National foreword

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Bahnanwendungen - Prüfung von Fahrzeugen auf elektromagnetische Verträglichkeit mit Achszählern

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European foreword

This document (EN 50592:2016) has been prepared by CLC/SC 9XB "Electromechanical material on board rolling stock" of CLC/TC 9X "Electrical and electronic applications for railways".

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2017-07-22
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For relationship with EU Directive 2008/57/EC amended by Commission Directive 2011/18/EU, see informative Annex ZZ, which is an integral part of this document.

Introduction

This European Standard is being developed to permit compliance with the Railway Interoperability Directives. The vehicle test methodology presented in this European Standard is also applicable to the demonstration of compatibility with all types of axle counters which have established compatibility limits according to EN 50617-2.

Compliance with the limits for rolling stock is necessary for a reliable and safe operation of the railway system.

1 Scope

This European Standard defines, for the purpose of ensuring compatibility between rolling stock and axle counter systems, the measurement and evaluation methods of rolling stock emissions to demonstrate compatibility. The established limits for compatibility are defined as magnetic field strength that can disturb the axle counter detectors, as part of the axle counter system.

In the relevant frequency range of the axle counter detectors the magnetic field is dominant and only this type of field is considered. Experience has shown that the effects of electric fields are insignificant and therefore not considered.

NOTE 1 For axle counters systems whose limits are not defined in terms of magnetic fields at a detector level, National Rules apply where they exist (for more details, see also 4.1).

NOTE 2 The influence from metal parts or inductively coupled resonant circuits on the vehicle, eddy current brakes or magnetic brakes is out of the scope of this EN. Compatibility is established through individual testing according to the EN 50238 series or National Notified Technical Rules.

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 50238-1, *Railway applications — Compatibility between rolling stock and train detection systems — Part 1: General*

CLC/TS 50238-2, *Railway applications — Compatibility between rolling stock and train detection systems — Part 2: Compatibility with track circuits*

CLC/TS 50238-3, *Railway applications — Compatibility between rolling stock and train detection systems — Part 3: Compatibility with axle counters*

EN 50617-2, *Railway Applications — Technical parameters of train detection systems for the interoperability of the trans-European railway system - Part 2: Axle counters*

CISPR 16-4-2, *Specification for radio disturbance and immunity measuring apparatus and methods — Part 4-2: Uncertainties, statistics and limit modelling — Measurement instrumentation uncertainty*

ERA/ERTMS/033281, *Interfaces between Control-Command and Signalling Trackside and Other Subsystems*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms, definitions and abbreviations given in EN 50238 (all parts) and the following apply.

3.1.1
axle counter detector
detector consisting of the axle counter sensor and of the detection circuit, which includes in general filters and rectifiers

[SOURCE: EN 50617-2:2015, 3.1.2]

3.1.2
axle counter sensor
sensor head mounted in the track

[SOURCE: EN 50617-2:2015, 3.1.3]

3.1.3
axle counter system
whole system, including the axle counter detector with its sensor and the evaluation unit

[SOURCE: EN 50617-2:2015, 3.1.4]

3.1.4
EMC plan
plan prepared during the rolling stock design which defines how to provide compliance with EMC requirements, including test evidence

3.1.5
European Train Control System
ETCS
signalling, control and train protection system utilizing balise transmission technology

3.1.6
in-band
working frequency area of an axle counter detector

[SOURCE: EN 50617-2:2015, 3.1.9]

3.1.7
influencing unit
IU
rolling stock influencing the train detection system

Note 1 to entry: One influencing unit comprises all coupled/connected vehicles, e.g. a complete train with single or multiple traction, single vehicle, single wagon, multiple connected/coupled vehicles and wagons. For locos and coaches, if conditions in 4.2.3.1 are clarified, it is considered sufficient to test only one of them if only identical ones are used in one IU.

3.1.8
integration time
parameter for evaluation defined as the window size over which the root mean square (rms) of the output of the band-pass filter is calculated

[SOURCE: EN 50617-2:2015, 3.1.12]

3.1.9
measurement antenna
antenna, mounted on the rail to capture three dimensional magnetic field

Note 1 to entry: The measurement covers the axes X, Y and Z as follows:

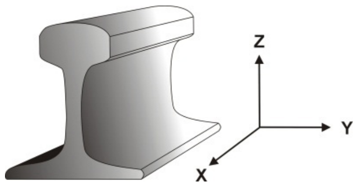


Figure 1 — Orientation of the coordinates

[SOURCE: EN 50617-2:2015, 3.1.13]

3.1.10
traction unit
locomotive, motor coach or train unit

Note 1 to entry: For the purposes of this standard, the traction unit is defined as a subset of one locomotive, motor coach or train-unit.

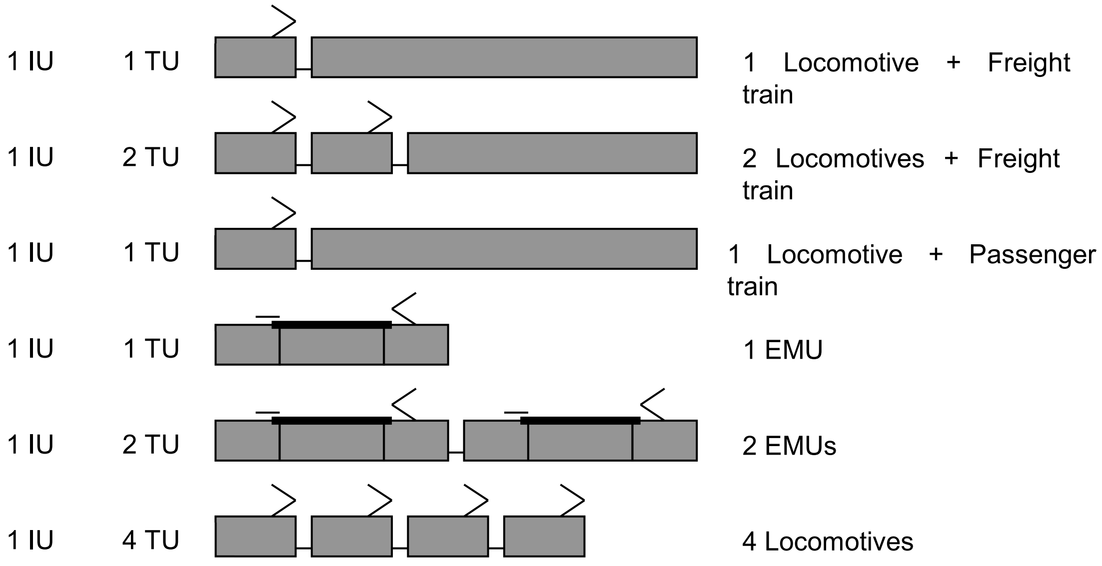


Figure 2 — Examples of IUs

[SOURCE: IEC 60050-811: CDV2015, 811-02-04]

3.1.11
$\mathbf{F_{start}}$
start frequency
lowest frequency of the axle counter detector's operating band which also defines the centre frequency of the first of the series of band-pass filters for data processing

3.1.12
$\mathbf{F_{stop}}$
stop frequency
highest frequency of the axle counter detector's operating band which also defines the centre frequency of the last of the series of band-pass filters for data processing

3.1.13
$\mathbf{V_{pp}}$
speed (velocity) power point
transition point of the tractive effort from a linear to a hyperbolic function, which corresponds to the highest speed achieved by that force

3.2 Abbreviations

For the purposes of this document, the abbreviations given in EN 50238 (all parts) and the following apply.

4QC Four Quadrant Converter

AC Alternating current

A/D Analogue to Digital converter

CCS Control Command and Signalling

DC Direct Current

EMC Electromagnetic Compatibility

EMU Electrical Multiple Unit

EUT Equipment Under Test

ETCS European Train Control System

FFT Fast Fourier Transformation

HFR Higher Frequency Range

IU Influencing Unit

LFR Lower Frequency Range

MA Measurement Antenna

NNTR Notified National Technical Rules

PWM Pulse Width Modulation

rms Root Mean Square

RST Rolling Stock

Tint Integration time

TSI Technical Specification for Interoperability

TU Traction Unit

VSWR Voltage Standing Wave Ratio

4 Measurement specification for vehicle emissions

4.1 Rolling stock emission limits

In the scope of interoperability, limits are defined in the TSI Interface document ERA/ERTMS/033281. Outside interoperability, individual limits are defined in CLC/TS 50238-3 or in NNTRs where these exist. In specific application cases outside the scope of Interoperability Regulations, limit values may be notified by the axle counter manufacturer, according to the process, defined in EN 50617-2. The RST under test shall be defined in the context of the definition for an influencing unit. The influencing unit shall be defined in an EMC Management Plan, depending on the sources of magnetic fields.

4.2 Methodology for the demonstration of vehicle compatibility

4.2.1 General approach

Measurements shall be performed using specified measurement antennas described in 4.2.2, under specified operational conditions of rolling stock. Compatibility tests of vehicles can be executed with any rail type. The influence of the type of rail on the measurement result is accounted for in the compatibility limits and the associated margin.

The train shall be tested under the electrification system(s) for which it is to be authorized. The methodology is also applicable to other type vehicles, as explained in 4.2.3.3.

Emissions caused by vehicles are measured as magnetic fields in X, Y and Z directions.

Ambient noise measurements shall be conducted before the tests.

If at specific frequencies or in specific frequency ranges the ambient noise is higher than the limit values less 6 dB, the measurements at these frequencies need not be considered provided there is clear evidence that the emissions are attributable to ambient sources. These frequencies shall be noted in the test report. If the ambient noise within the frequency bands in ERA/ERTMS/033281 or the individual limits in CLC/TS 50238-3 is so severe (e.g. wide band noise) that it makes the assessment of the vehicle to the frequency bands impossible, a new test at an alternative test location is required, which is not influenced by the identified ambient disturbance.

The RST is normally tested under conditions at which maximum emissions are expected in the frequency range considered for compatibility. Specific requirements are derived in 4.2.3.2.

NOTE Usually, it is possible to capture these emissions at low vehicle speeds. The repetition rate of the interference is partly independent of the vehicle speed (e.g. rolling stock with four-quadrant traction and auxiliary converters) and for rolling stock with motor inverters it is even lower at higher speeds.

4.2.2 Measurement antenna

4.2.2.1 Frequency range

The measurement chain shall cover the 10 kHz to 1,3 MHz range between the 3 dB points.

Due to the fact that the range of operating frequencies of the axle counter detectors used in Europe is from tens of kilohertz up to 1,3 MHz, it may not be possible to achieve an acceptably low measurement uncertainty with only one measurement antenna, to cover both the lower and the higher frequency range. The frequency range applicable to each antenna, shall be specified:

- Lower Frequency Range (LFR): 10 kHz to 100 kHz;
- Higher Frequency Range (HFR): 100 kHz to 1,3 MHz.

4.2.2.2 Electrical surface

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

- 5 cm x 5 cm (25 cm^2) (loop for measurement of field along x-axis), named X-coil;
- 5 cm x 15 cm (75 cm^2) (loops for measurement of field along Y- and Z- axis), named Y and Z coils. The longest arm is always in X-direction.

Depending on the size of the wire and the number of windings, small deviations from the ideal shape of the transducer are permitted but such deviation shall not exceed 5 %. As far as possible, the electrical surface and the ratio shall be kept.

NOTE 1 The arm length of 15 cm is chosen such that it represents a practical optimum between the averaging of gradient magnetic fields and the picking up of interference source with low repetition rates.

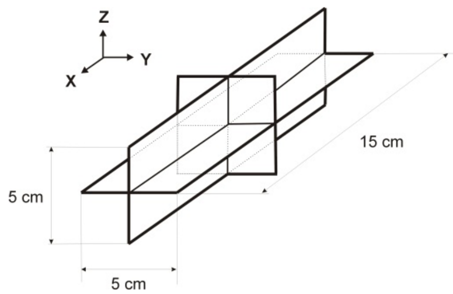


Figure 3 — Measurement antenna

NOTE 2 Additional information regarding the layout of the measurement antennas is provided in a design guide in Annex A.

4.2.2.3 Mounting position

Table 1 shall be used to define the mounting position of the measurement antennas for the frequency range considered. The centre point (Y1, Z1) of the measurement antenna is derived from the arithmetic mean value of all relevant axle counter sensor types per frequency range (LFR, HFR).

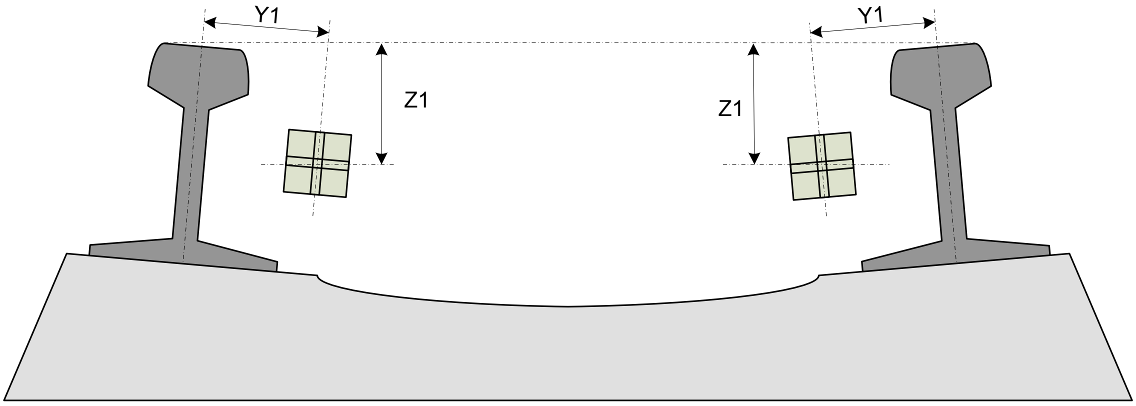


Figure 4 — Centre point coordinates

The centre point of the measurement antennas shall have the following coordinates with reference to the central line of the rail web for Y1 and the line connecting the highest position of both railheads for Z1:

Table 1 — Y1 and Z1 coordinates of the measurement antennas centre point

	Y1 (tolerances) (mm)	**Z1 (tolerances) (mm)**
MA centre position (10 kHz to 1,3 MHz)	**96 (−3 ; +3)**	**73 (−5 ; +5)**

NOTE 1 Experience has demonstrated that the position of the measurement antenna within these tolerances has negligible influence on the test result (max measured variation was below 1 dB in laboratory for Z1 between 68 mm and 78 mm).

NOTE 2 To reduce the amount of measurements it is recommended to mount the measurement antennas on both rails to do the measurements covering from 10 kHz to 1,3 MHz frequency range for both sides of the vehicle simultaneously.

4.2.2.4 Metal free zone

To minimize influence from earth currents and any other parasitic effects the measurement antenna shall be placed between two sleepers, see Figure 5.

In the case of using two or more antennas, a minimum distance of 400 mm shall be utilised.

Measurements shall not be performed on a metal/iron bridge or steel sleepers.

NOTE 1 Simulation has shown that reinforcing metal in slab track or concrete metal reinforced sleepers can influence the test results by approximately 5 %, which is considered negligible.

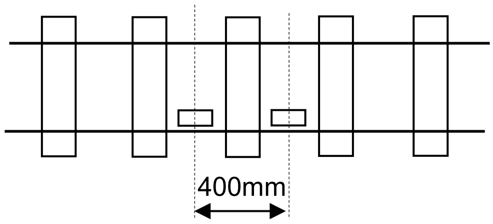


Figure 5 — Mounting measurement antenna between two sleepers

NOTE 2 Antennas can be mounted closer if it is verified that mutual coupling (crosstalk) does not influence the accuracy of the result.

4.2.2.5 Other Requirements

The antenna shall have cross polarization rejection higher than 30 dB without a rail being present.

NOTE In the case of using a preamplifier, precautions are usually taken to prevent saturation during measurement.

4.2.3 Vehicle test conditions

4.2.3.1 General

The operational requirements for compatibility tests of rolling stock depend on the technical design of rolling stock and passenger coaches.

Any electronic apparatus with semiconductors (4QC, motor inverter, auxiliary converter, brake chopper, battery charger, etc.) is a potential source of interference. Generally, the amplitudes of magnetic fields, generated by railway vehicles utilizing traction converters with DC voltage link, increase proportionally to the DC link voltage. For a disturbance of the axle counter detector at lower speeds rolling stock will, in general, be using a fast switching (PWM) approximation of an ideal three phase sinusoidal supply. Due to the variation of the pulses it is more likely to find a disturbance in this speed area.

The amplitude of fields induced from rail current depends on many factors, for example earthing philosophy, the construction of the motors, gear boxes and bearings.

The actual current draw at the fundamental frequency of the main traction supply has less impact on the amplitudes of the generated magnetic fields in the working range of the axle counter detector.

For different test runs, the maximum possible number of potential sources of emission shall be considered for the worst case. Justification of the worst case (normal or degraded) conditions shall be prepared as part of the test specification.

The test specification shall include a requirement to measure on both sides of the vehicle passing over the antenna.

All individual interference sources on board the vehicle should be considered for the worst case test conditions. For example, traction converters, auxiliary converters, heating line converters, installed train control/safety equipment, lighting, heating, air-conditioning, restaurant power are known interference sources.

When authorization for double or multiple traction units is sought it is sufficient to test single traction units only, provided there are no differences in comparison between single and multiple traction units regarding the electrical behaviour (e.g. change of converter frequencies), in which case the footprint concerning characteristic emissions remains unchanged.

For DC traction power systems, in case there is more than -6 dB from the limit in the magnetic field values measured before or after the passing of the individual unit, the effect of multiple units shall be considered.

No specific tests are included for transient conditions. Any short-term interference captured during the tests are analyzed and evaluated according to the methodology presented in this standard.

If fitted on the EUT, the components of the ETCS on board the RST shall be switched on during tests. When ETCS components are installed on board of already approved rolling stock, no additional compatibility tests are needed.

If necessary, an additional vehicle (locomotive, load wagon) shall be used to reach the required values for the parameters (e.g. specified traction force, specified braking force) of the tested vehicle. The influence of the additional vehicle on the measured magnetic interference field shall be negligible or at least it shall be possible to exclude it from the assessment. One reference test run (EUT main switch open, pantograph down, 20 km/h to 30 km/h) shall be performed before (direction 1) and after (counter direction to 1) the measurements. The reference test runs can also be used as environment measurements.

The number of test runs under the same operational conditions should be defined to give confidence that the test results are reproducible. For the chosen test scenario(s), confidence can be reached if the measurements of at least two test runs in each direction under the same operational conditions are comparable.

Rolling stock shall be tested under the operational conditions specified in 4.2.3.2.

4.2.3.2 Operational conditions for electric and diesel/electric vehicles

4.2.3.2.1 General

The following requirements are derived for locomotives and electrical multiple units (any type, including high speed trains and light rail vehicles). All test runs shall be performed under continuous electrical power feed. Different requirements may be derived for other vehicles, for example hybrid vehicles. If a vehicle is equipped for electrical braking/ energy regeneration and with brake resistors, then both shall be taken into consideration explicitly. No braking tests are required if no different circuits are used in braking mode compared with acceleration mode.

4.2.3.2.2 Locomotives

For locomotives, the following operational conditions shall be covered:

When passing the antenna, the vehicle shall accelerate and decelerate (using electrical braking and brake chopper if present) with approximately 1/3 of its maximum tractive effort in addition to the following different speeds, as distinguished in Figure 6:

- speed v1: very low speed of approximately 5 km/h to 10 km/h;
- speed v2: approximately 70 % to 90 % of the speed reached at the transition from asynchronous to synchronous switching (maximum pulse repetition rate);
- speed v3: approximately 70 % to 90 % of the speed reached at the transition to the power hyperbola, where max DC link voltage is achieved.

The supplier of the rolling stock shall indicate at which speeds and operational conditions maximum emissions (also return currents, due to the field generated by return currents) may be expected and these shall be taken into consideration for the tests.

NOTE The tractive effort is not a dominant parameter for magnetic fields underneath the vehicles, which are measured.

4.2.3.2.3 Multiple units

For multiple units, the following operational conditions shall be covered:

Test runs shall cover the speeds as written in 4.2.3.2.2 and distinguished in Figure 6. When passing the antenna, the vehicle shall accelerate from the minimum speed v1 until the maximum speed v3 is achieved.

When decelerating using electrical braking and brake chopper, if present, the vehicle shall cover all three ranges from v3 to v1. The vehicle shall accelerate or decelerate with a minimum of 1/3 of its maximum tractive effort.

The starting position for each test should be such that the vehicle is passing over the antenna at the required speed.

Bi-directional test runs shall be performed when passing over the antenna at different speeds.

NOTE The tractive effort is not a dominant parameter for magnetic fields underneath the vehicles, which are measured.

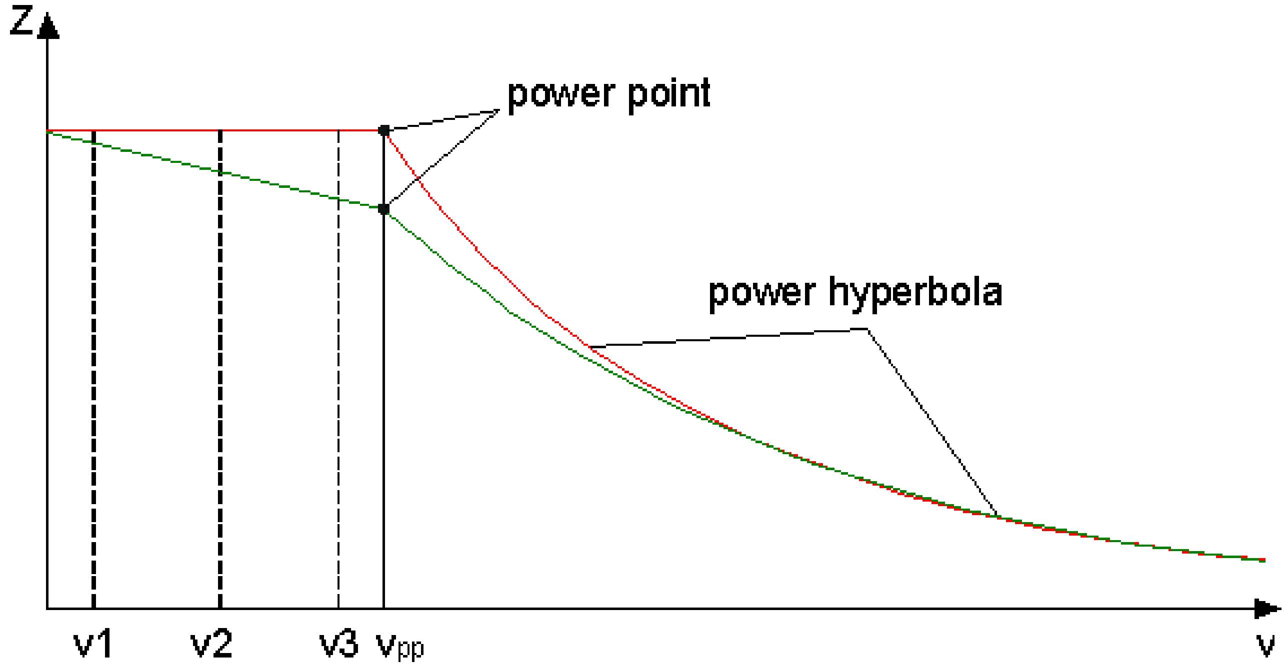


Figure 6 — Speed ranges, tractive effort (force) (Z) – speed (v), speed power point (Vpp), diagram (examples)

4.2.3.3 Other rail vehicles

For other rail vehicles (e.g. diesel hydraulic / diesel mechanical powered locomotives, hybrid vehicles or coaches), the EMC Management plan shall define if testing is necessary, depending on whether there are active electromagnetic interference sources. Slow speed measurements shall be performed at speed between 5 km/h and 20 km/h.

For the test of locomotives with a dedicated heating line supplied by inverters, a resistive load with a minimum power of 80 kW shall be used. The full range of supply frequencies of the heating line shall be tested. The relevant EMC Management plan shall also define whether special test runs (e.g. with wagons or passenger coaches) are needed.

For passenger coaches with heating line supplies it shall be defined which frequencies and signal forms (sinusoidal, rectangle, trapeze) of the heating lines current shall be taken into consideration. The influence of the powering locomotive on the measured magnetic interference field should be negligible or at least it should be possible to exclude it from assessment.

Slow passing at speed between 5 km/h and 20 km/h at each supply frequency of the heating line shall be conducted.

4.2.3.4 Degraded modes

On the basis of analysis and assessments it shall be defined whether tests in degraded modes are necessary, depending on whether there are active electromagnetic interference sources.

For practicable degraded modes which are part of the test specification, the test results shall demonstrate the same level of repeatability as for normal conditions. The vehicle shall be demonstrated as compatible with axle counter limits to be allowed to operate in such degraded modes.

NOTE Examples of degraded conditions to be considered are: switched off traction motors and/or driving units which have consequences to the remaining ones like increase of power and/or traction force, change of pulse frequency, etc. A representative number of degraded modes may be covered in the tests specifications.

The operational conditions for degraded modes shall be limited to changes in the emission's profile from the train.

4.2.4 Infrastructure conditions

Depending on the train impedance, conducted emissions measured close to substations may be higher, especially at Band 1 frequencies.

If the measurements are taken on a dedicated test track, the parameters of the test track which can influence the measurements shall be documented, for example the extent of the metal free area, the type of track bed, type of sleepers.

If the measurements are taken on a railway line, double rail traction return shall be used. If testing needs to be performed in a single rail return section, the measurement antennas shall still be mounted on both rails. The influence of other trains shall be avoided. If it is not possible, background emissions shall be recorded to determine their influence.

The rolling stock tests shall be done close to a DC substation (closer than 100 m).

NOTE Where possible, tests need to be done close to an AC substation, if relevant.

4.2.5 Uncertainty and calibration

The extended uncertainty of the whole measurement chain shall be no more than ± 3 dB (k = 2) of the defined magnetic field limit.

All equipment in the measurement chain shall be calibrated for the relevant frequency range.

The calibration shall be performed in the absence of rail.

NOTE The calibration is usually performed with the MA outputs loaded on an impedance equivalent to the typical impedance used for the tests. To reduce the measurement uncertainty, the antenna factor issued from the calibration is then used to correct the measured value.

If relevant, the reflection coefficients (or the VSWR) from cabling (e.g. long cabling) and from the ports of the different transducers in the measurement chain shall be considered in the uncertainty calculation (see CISPR 16-4-2).

5 Measurement and evaluation methods

5.1 Method based on the frequency management of the TSI CCS interface document

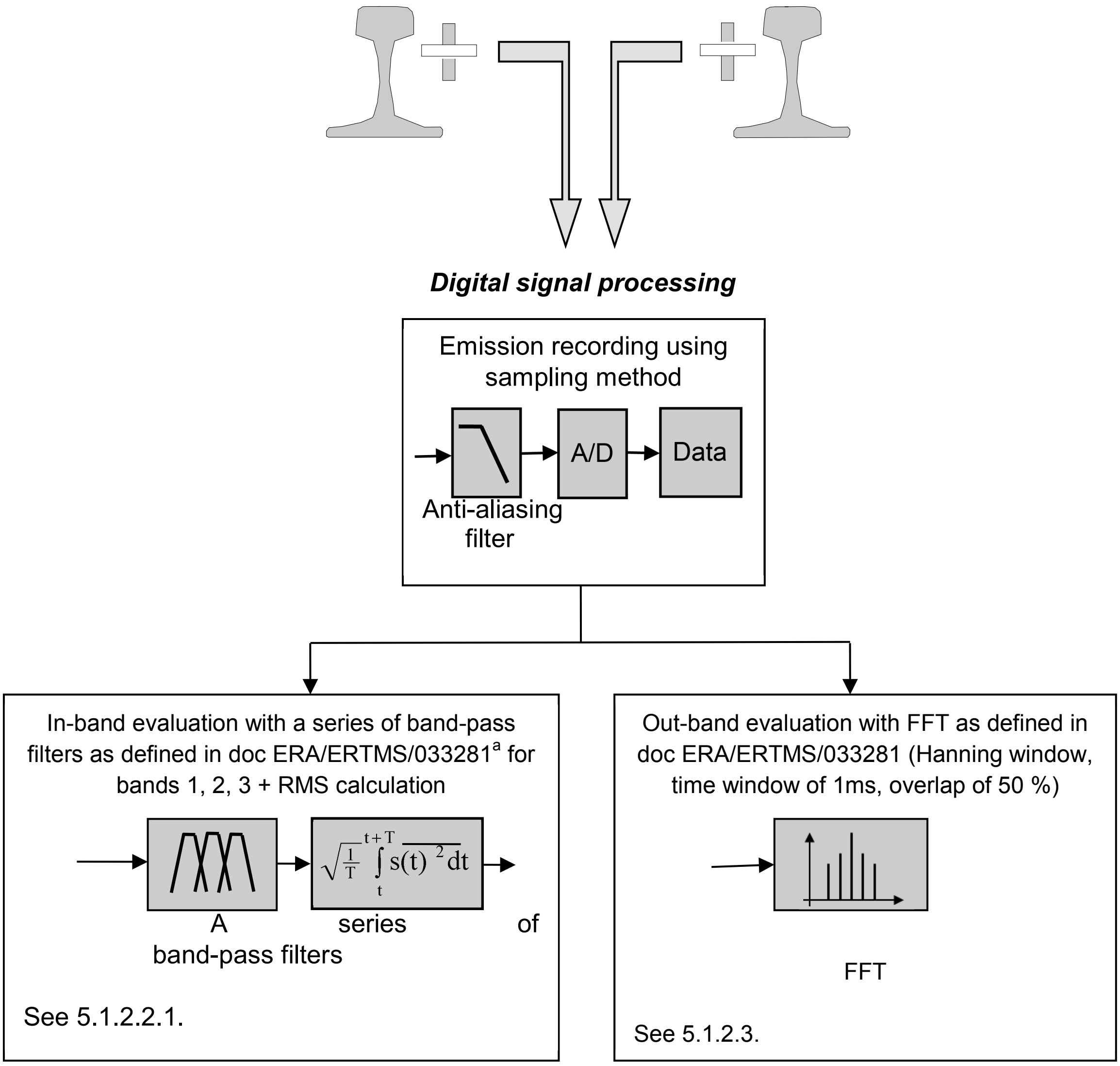
5.1.1 Principle

The measurement is taken using digital instrumentation with an A/D converter and a large data storage system. After recording of data using the sampling method, the evaluation is done in two ways:

— in-band evaluation with a series of band-pass filters as defined in document ERA/ERTMS/033281 for bands 1, 2, 3;

— out-band evaluation with FFT as defined in document ERA/ERTMS/033281.

Figure 7 shows the test method.



[a] Refer to 5.1.2.2.2 for a practical approach.

Figure 7 — Test method based on TSI requirements

5.1.2 Procedure

5.1.2.1 General

Emissions shall be recorded in X, Y and Z directions using a sampling rate of at least 300 kHz for the LFR and at least 3 MHz for the HFR.

5.1.2.2 In band evaluation

5.1.2.2.1 Band-pass evaluation

For in-band evaluation the recorded data files shall be then filtered and analyzed through a series of band-pass filters in X, Y, Z directions and the 3 bands defined in document ERA/ERTMS/033281.

The following parameters shall be considered:

a) 3 dB-bandwidth, type and order of digital band-pass filters are all as defined in document ERA/ERTMS/033281 for bands 1, 2, 3:

1) Band 1:

   i) from 27 kHz to 52 kHz: 300 Hz, Butterworth, 4th order;

   ii) from 41,2 kHz to 44,8 kHz (only for Y direction): 40 Hz, Butterworth, 2nd order;

2) Band 2:

   i) from 234 kHz to 363 kHz: 7500 Hz, Butterworth, 4th order;

   ii) from 287 kHz to 363 kHz (only for Z direction): 4000 Hz, Butterworth, 4th order;

3) Band 3:

   i) from 740 kHz to 1250 kHz: 10 kHz, Butterworth, 4th order;

b) 20 % of frequency overlap (3 dB-points) of the filters in all 3 bands, see Figure 8:

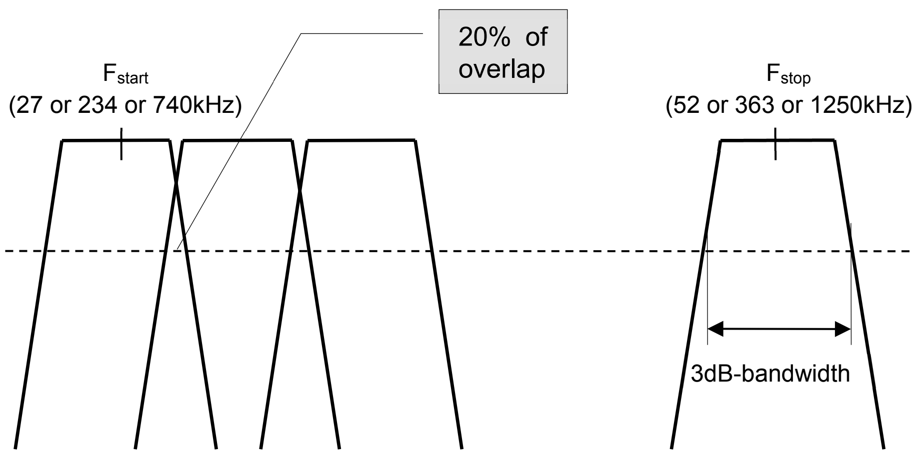


Figure 8 — One series of band-pass filters

For band 1, the evaluation through filters of 300 Hz bandwidth with 20 % of overlap means centre frequency steps of 240 Hz. In order to have a whole number of filters from 27 kHz, the frequency sub-bands to be analyzed should be precisely as follows:

- 27 kHz to 41,4 kHz or 41,16 kHz;
- 41,4 kHz or 41,16 kHz to 44,76 kHz or 45 kHz;
- 44,76 kHz or 45 kHz to 51,92 kHz or 52,2 kHz.

For band 2, the evaluation through filters of 7 500 Hz bandwidth with 20 % of overlap means Δf of 6 kHz. In order to have a whole number of filters from 234 kHz, the frequency sub-bands to be analyzed should be precisely as follows:

- 234 kHz to 288 kHz;
- 288 kHz to 360 kHz or 366 kHz.

For band 3, the evaluation through filters of 10 kHz bandwidth with 20 % of overlap means Δf of 8 kHz. In order to have a total number of filters from 740 kHz, the frequency sub-bands to be analyzed should be precisely as follows:

a) 740 kHz to 1028 kHz;

b) 1 028 kHz to 1 244 kHz or 1 252 kHz;

c) Integration time for rms calculation as defined in document ERA/ERTMS/033281 for bands 1, 2, 3 with a time overlapping of 75 %:

   1) Band 1: 1 ms;

   2) Band 2: 1,5 ms;

   3) Band 3: 1,5 ms.

NOTE Time overlapping of 75 % means that for 1 ms integration time the time interval between successive windows is 0,25 ms.

5.1.2.2.2 FFT Evaluation

In order to reduce the processing time, the in-band evaluation can start by a broadband analysis of each band using FFT with Hanning window, 75 % of time overlapping and time window of:

- 1 ms for band 1;
- 0,5 ms for band 2;
- 0,5 ms for band 3.

If the vehicle satisfies the emission limits in document ERA/ERTMS/033281, the evaluation through moving pass-band filters as defined in 5.1.2.2.1 is not necessary.

5.1.2.3 Out band evaluation

For out-band evaluation, the FFT of the recorded data shall be calculated with the parameters defined in document ERA/ERTMS/033281:

- hanning window;
- time window of 1 ms;
- time overlap of 50 %.

5.1.3 Evaluation of short duration interference

In case there are exceedances of the limits specified in document ERA/ERTMS/033281 shorter than the integration time and the minimum time interval between two exceedances is greater than the integration time, further evaluation can be done using shorter integration time as defined in document ERA/ERTMS/033281.

5.2 Method for RST compatibility with individual axle counter detectors

5.2.1 General

This method can be used in the following cases:

- When a new train needs to run on lines which are not declared as interoperable (including metro and tram lines) or equipped with axle counter detectors listed in CLC/TS 50238-3 or covered by NNTRs.
- When an existing/refurbished train needs to prove compatibility only with individual axle counter detectors listed in CLC/TS 50238-3 or covered by NNTRs.

5.2.2 Principle

As described in 5.1.1, the measurement and the evaluation of rolling stock emissions are realized with a digital measurement technique using an A/D converter with a large data storage system. After recording data using the sampling method, the evaluation is done with a less stringent method dedicated to the individual axle counter which could be a single band filter or a more sophisticated algorithm closer to the real working principle of the axle counter as defined in CLC/TS 50238-3 or in the NNTR (centre frequency, bandwidth, filter order, integration time).

Figure 9 shows the test method.

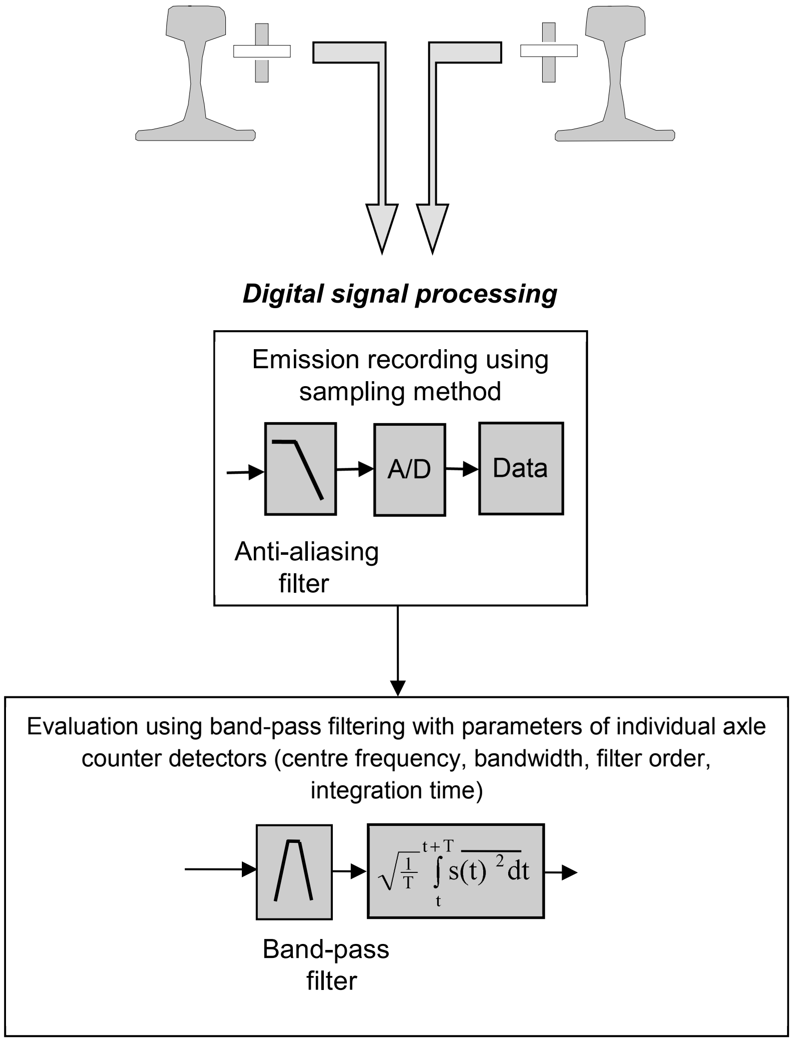


Figure 9 — Test method for compatibility with individual axle counter detectors

5.2.3 Procedure

Emissions shall be recorded in X, Y and Z directions using a sampling frequency of 3 MHz, or at least 3 times the maximum operating frequency of the axle counter detector to be considered.

The frequency response of the integrated anti-aliasing filters shall be considered and corrected if necessary.

The recorded data files shall be then filtered and analyzed in X, Y and Z directions. The following parameters shall be considered:

- digital band-pass filter bandwidth, order, type (Butterworth) as defined in CLC/TS 50238-3 or in the NNTR for each type of axle counter detector;
- integration time for rms calculation as defined in CLC/TS 50238-3 or in the Notified National Technical Rules (NNTR) for each type of axle counter detector with 75% time overlapping.

NOTE Time overlapping of 75 % means e.g. for 1 ms integration time a 0,25 ms time interval between successive windows.

The band-pass filter bandwidth for evaluation shall be determined by taking into consideration the tolerance range of the centre frequency and the bandwidth of the defined filter curve. For the evaluation it is allowed for a quicker evaluation time, first to evaluate the whole frequency range of each axle counter detector (tolerance range of the centre frequency plus half of the 3 dB filter bandwidth of the axle counter detector on both sides, see Figure 10). If there are no exceedances, the evaluation with respect to the axle counter detector is passed successfully.

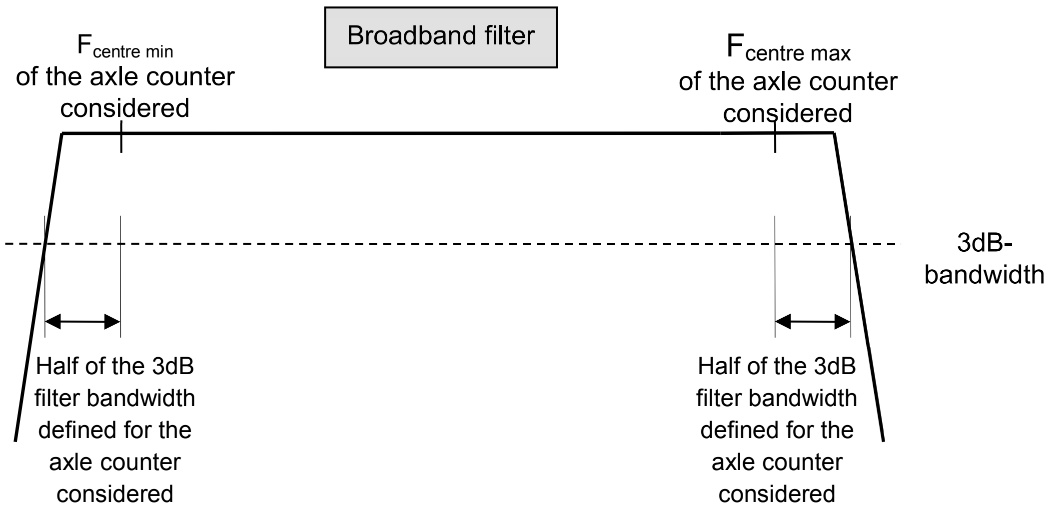


Figure 10 — Broadband evaluation on the tolerance range of centre frequency

If there are exceedances, the centre frequency of the narrowband filters (i.e. with the 3 dB bandwidth as defined in CLC/TS 50238-3) shall be swept through the full working frequency range of the axle counter detector. In this case, an overlap of 20 % (3 dB points) of the filter bandwidth should be implemented.

5.2.4 Evaluation of short duration interference

In case there are exceedances of the limits specified in CLC/TS 50238-3 and the minimum time interval between two exceedances is greater than the integration time $T_{int,}$ further evaluation can be done using shorter integration time according to CLC/TS 50238-3.

The same principles apply for evaluation against relevant National Notified Technical Rules.

Annex A
(informative)

Design guide for rolling stock measurement antennas — Measurement antennas characteristics

The sensitivity of a loop is directly proportional to the loop area and to the number of turns in the loop. It is, in general, inversely proportional to the wavelength of the signal.

The inductance of the loop winding itself makes loop antennas frequency-sensitive. Because of that, it becomes difficult to make such antennas with wide-band characteristics. To increase the sensitivity of a loop, multiple-turn coils are used at the low frequency range. However, the distributed capacitance of the windings acts with the loop's inductance to decrease the antenna's frequency response. That however, is not always a disadvantage. The frequency selectivity of a loop winding is often an advantage in that it can provide for rejection of out-of-band signals.

For the design of the measurement antennas the following recommendations are given:

a) applying the given electrical antenna surface X, Y and Z according to Figure A.1;

b) mounting recommendation:

   1) 30 turns to 100 turns (copper conductor of 0,15 mm to 0,4 mm diameter, isolated) for the lower frequency range;

   2) 8 turns to 30 turns (copper conductor of 0,15 mm to 0,4 mm diameter, isolated) for the higher frequency range (above 100 kHz).

More turns lead to higher electromagnetic coupling between layers. To reduce the capacitance of the turns only two layers are recommended.

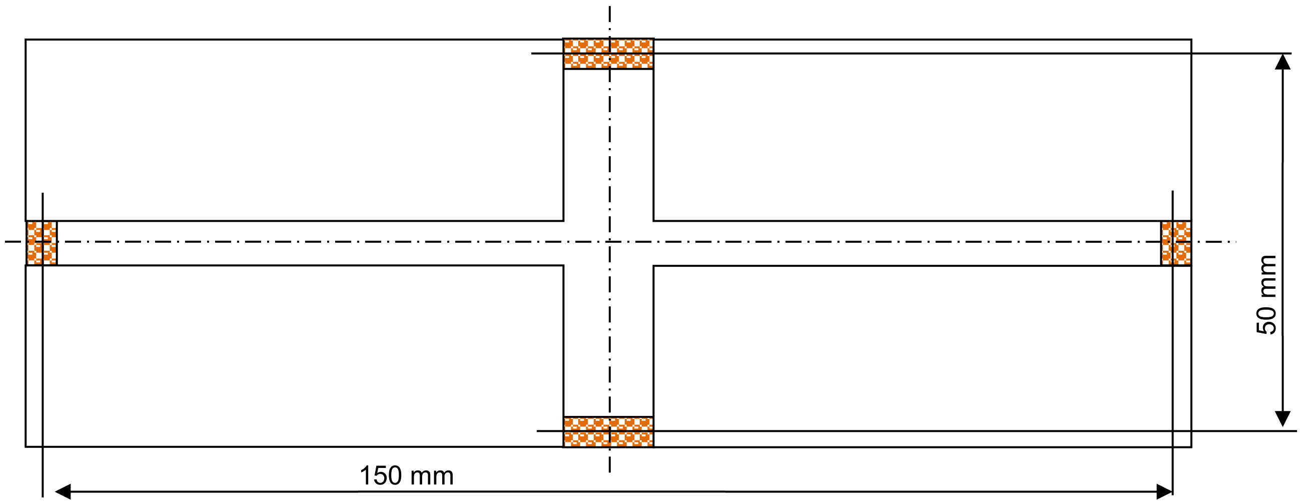


Figure A.1 — Top and side view (Y and Z coils, dimensions 50 mm by 150 mm, X coil dimension 50 mm by 50 mm)

Annex ZZ
(informative)

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

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers all relevant essential requirements as given in Annex III of the EC Directive 2008/57/EC (also named as New Approach Directive 2008/57/EC Rail Systems: Interoperability).

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard given in Table ZZ.1 for “Control, Command and Signalling” and Table ZZ.2 for “Locomotives and Passenger Rolling Stock” confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZZ.1 — Correspondence between this European Standard, the CCS TSI (DECISION 2012/88/EU of 25 January 2012, DECISION 2012/696/EU of 6 November 2012 amending Decision 2012/88/EU, DECISION 2015/14/EU of 5 January 2015 amending Decision 2012/88/EU) and Directive 2008/57/EC

Clauses of this European Standard	Chapter / § / points / of CCS TSI	Essential Requirements (ER) of Directive 2008/57/EC	Comments
The whole standard is applicable, except 5.2.	4.2.11. Electromagnetic Compatibility between Rolling Stock and Control-Command and Signalling track-side equipment ERA/ERTMS/033281 Interfaces between CCS track-side and other Subsystems – version 2.0 Section 3.2.1 Electromagnetic fields	2. Requirements specific to each sub-subsystem 2.3. Control Command and signalling 2.3.2 Technical compatibility	Small differences between the standard and the TSI interface document exist. They should have no relevant impact on interoperability.

Table ZZ.2 — Correspondence between this European Standard, the TSI "Locomotives and Passenger Rolling Stock" (REGULATION (EU) No 1302/2014 of 18 November 2014) and Directive 2008/57/EC

Clauses of this European Standard	Chapter / § / points / of LOC & PAS TSI RST	Essential Requirements (ER) of Directive 2008/57/EC	Comments
The whole standard is applicable, except 5.2.	4.2.3.3.1.2. Rolling stock characteristics for compatibility with train detection system based on axle counters ERA/ERTMS/033281 Interfaces between CCS track-side and other Subsystems – version 2.0 Section 3.2.1 Electromagnetic fields	2. Requirements specific to each sub-subsystem 2.4. Rolling Stock 2.4.3. Technical compatibility	Version 2.0 of ERA/ERTMS/033281 includes: 3.2.3 Use of magnetic / eddy current brakes (open point) Small differences between the standard and the TSI interface document exist. They should have no relevant impact on interoperability.

WARNING: Other Union legislation may be applicable to the products falling within the scope of this standard.

Bibliography

[1] UIC 790, Use of axle counters

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