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Railway applications - Compatibility between rolling stock and train detection systems - Part 3: Compatibility with axle counters

Bahnanwendungen - Kompatibilität zwischen Fahrzeugen und Gleisfreimeldesystemen -- Teil 3: Kompatibilitat mit Achszähler

Applications ferroviaires - Compatibilité entre le matériel roulant et les systèmes de détection des trains - Partie 3: Compatibilité avec les compteurs d'essieux

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Railway applications - Compatibility between rolling stock and train detection systems - Part 3: Compatibility with axle counters

Applications ferroviaires - Compatibilité entre le matériel roulant et les systèmes de détection des trains - Partie 3: Compatibilité avec les compteurs d'essieux

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CENELEC
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

This Technical Specification was prepared by SC 9XA, Communication, signalling and processing systems, of Technical Committee CENELEC TC 9X, Electrical and electronic applications for railways.

It was circulated for voting in accordance with the Internal Regulations, Part 2, Subclause 11.3.3.3 and was approved by CENELEC as CLC/TS 50238-3 on 2010-07-07.

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

The following date was fixed:

latest date by which the existence of the CLC/TS has to be announced at national level (doa) 2011-01-07

This Technical Specification is intended to become Part 3 of the series EN/TS 50238 published under the title '*Railway applications - Compatibility between rolling stock and train detection systems*'. The series consists of:

- Part 1: General [1)]
- Part 2: Compatibility with track circuits
- Part 3: Compatibility with axle counters (this document).

1) Existing EN 50238:2003 was renumbered EN 50238-1 once the voting procedure on Parts 2 & 3 was closed.

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Introduction

This Technical Specification is being developed to permit compliance with the interoperability Directives (High Speed and Conventional). It is recommended that the vehicle test methodology presented in this Technical Specification is also applied to establish compatibility with all types of axle counters, incl. those not covered by this Technical Specification.

This Part 3 of the series defines:

- a set of interference limits for magnetic fields generated by both rail current and equipment on the vehicles.
- measurement and evaluation methods to verify rolling stock emissions and demonstrate compatibility with the interference limits.
- traceability of requirements (type of axle counters considered for the limits).

In the relevant frequency range of the axle counters 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.

Annex C is informative and describes a test procedure for the determination of the magnetic field limits of axle counters by laboratory tests. This test procedure has already been used by axle counter manufacturers for the determination of the given limits in this Technical Specification and is recommended to be used to determine compatibility limits for non-preferred axle counters not covered by this Technical Specification and also for future developments of axle counters.

It is intended that the test specification for immunity tests of axle counters (Annex C) will be published in a separate standard.

1 Scope

This Technical Specification defines, for the purpose of ensuring compatibility between rolling stock and axle counters, the electromagnetic interference limits for rolling stock and the measurement and evaluation methods to verify rolling stock emissions and demonstrate compatibility with the interference limits.

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

The interference limits have been defined for application to interoperable rolling stock. They are for a set of preferred types of axle counters which are defined by Railway Infrastructure Managers for use on new signalling projects on interoperable lines. If the interoperable line over which the rolling stock is intended to run is equipped with an older version or non-listed axle counters then National Notified Technical Rules apply. It is not the intention of this Technical Specification to mandate any particular type of train detection but it is expected that because the list of selected types and their limits for compatibility are drawn on the basis of established performance criteria, the trend will be that newly signalled interoperable lines are fitted with types which meet the compatibility limits published in the Technical Specification and measured in accordance with the test specification in Annex C.

To ensure an adequate operational availability, a margin of 9 dB between the measured axle counter limit and the limit for rolling stock has been applied. If rolling stock does not comply with the defined limits, the availability of the axle counters may be reduced. The measurement condition for railway vehicles with voltage DC-link are provided as an example.

NOTE 1 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 the Technical Specification. Compatibility is established through individual testing according to EN 50238-1 or National Notified Technical Rules.

NOTE 2 Wheel sensors and crossing loops are not part of this Technical Specification.

As the electromagnetic interference coupling between rolling stock and axle counters is multidimensional and difficult to handle, a proposal is made in this Technical Specification for frequency management with fixed frequency ranges (and limits) in Annex B informative, to allow for future developments of rolling stock and axle counters with the aim to decrease the development risk and to minimize the homologation effort for both, rolling stock and axle counters.

2 Normative references

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

EN 50238, Railway applications – Compatibility between rolling stock and train detection systems

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 and the following apply.

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

3.1.2
inflection point
the transition between the static (continuous wave) and the dynamic immunity (short duration) behaviour of the axle counter detector. On the left side of the inflection point the duration is less then the integration time. The inflection point is the transition of 105 % of the steady state threshold concluded from sinusoidal bursts by lab tests. The corresponding burst duration is equivalent to the integration time used for evaluation

3.1.3
integration time
a 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

3.1.4
measurement antenna
a magnetic field antenna mounted in the track to capture magnetic field. The measurement covers the axes X, Y and Z

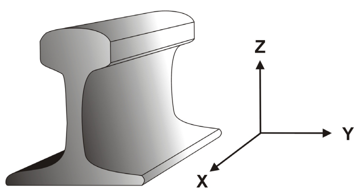

Figure 1 – Orientation of the coordinates

3.2 Abbreviations

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

4QC	Four Quadrant Converter
A/D	Analogue to Digital converter
ACD	Axle Counter Detector
ACS	Axle Counter Sensor
DC	Direct Current
EUT	Equipment Under Test
FGA	Field Generation Antenna
HFR	Higher Frequency Range
LFR	Lower Frequency Range
MA	Measurement Antenna
RBW	Resolution BandWidth
RMS	Root Mean Square
SSS	Small Size Sensor
TEU	Trackside Electronic Unit
Tint	Integration time

4 General aspects

4.1 Interference mechanism

Axle counters can be influenced in different ways, e.g. by magnetic fields or metallic parts in the vicinity of wheels and bogies and thus close to the sensors. The influence of magnetic fields in the range of the working frequency of the individual axle counters is dominant. In addition, the duration and/or repetition rate of interference and the magnetic field strength are also relevant.

4.1.1 Axle counter detector

The compatibility limits in this Technical Specification are based on the immunity of axle counters and are specified only for the axle counter detector – comprising the sensor on the rail and the detection circuits in the trackside equipment as shown in Figure 2.

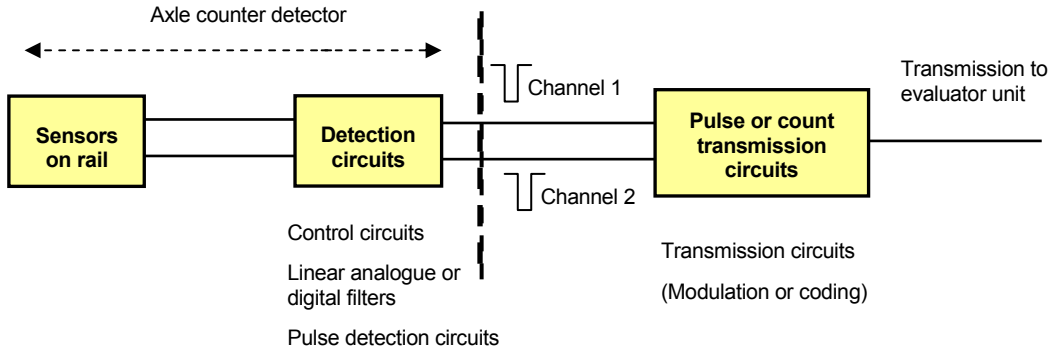

Figure 2 – Axle counter detector, schematic

Axle counters use various additional filter techniques and algorithms which reject interference pulses in order to maximize reliability while maintaining safety.

Examples of these are:

- non-linear pulse duration filters which reject wheel pulses of a duration less than the minimum wheel pulse from a vehicle;
- rejection of wheel pulses in one channel if the axle counter is already in an occupied status.

4.1.2 Susceptibility of the detector on the rail

The precise area of susceptibility is product specific, and defined by manufacturers of individual products. The position of the measurement antenna has been chosen to take the relevant sensors into account.

The immunity (susceptibility limit) is defined as the magnetic field which can generate interference pulses or corrupt the wheel pulses of one or more channels of the axle counter detector.

The magnetic coupling between the transmission and reception units of the axle counter sensor depends among other things on the rail type. Large rail profiles like UIC 60, which provide higher attenuation of the receiver voltage, are therefore more critical with respect to the susceptibility.

4.1.3 Sources of interference fields

The following sources of interference shall be considered:

- electrical equipment on the vehicle and magnetically coupled to the axle counters through the air gap (hence referred to as magnetic fields);
- rail currents in the susceptibility range of operation of the axle counters (hence referred to as rail current fields).

The interference fields from the two sources defined above are superimposed on the axle counter sensor whereby the vector of rail current fields has a predictable direction and the vector of magnetic fields has an unpredictable direction, because it is dependent on the source on the vehicle and on the type of rail.

4.2 Reliability margin

Axle counters are assumed to fail right side if excessive interference leads to a miscount. A safety margin is therefore not required, but a margin is required to meet the performance requirements with regard to reliability of counting.

An acceptable value for the probability of miscounts on interoperable lines is 10^{-7}.

If the interference limit of the axle counter detector is exceeded and a resulting spurious wheel pulse is generated, this may or may not lead to a failure of the axle counter.

Figure 3 shows the duration dependant limits in principle for rolling stock with 9 dB margin already incorporated in. The 9 dB margin accounts for the following factors:

- 6 dB signal to noise ratio to meet the probability requirements for miscount within the established equipment operating tolerances.
- 3 dB accounting for
  - uncertainty of measuring chain,
  - antenna positioning,
  - overlapping effects (analysing methods),
  - other environmental effects affecting interference (rain, temperature, etc.).

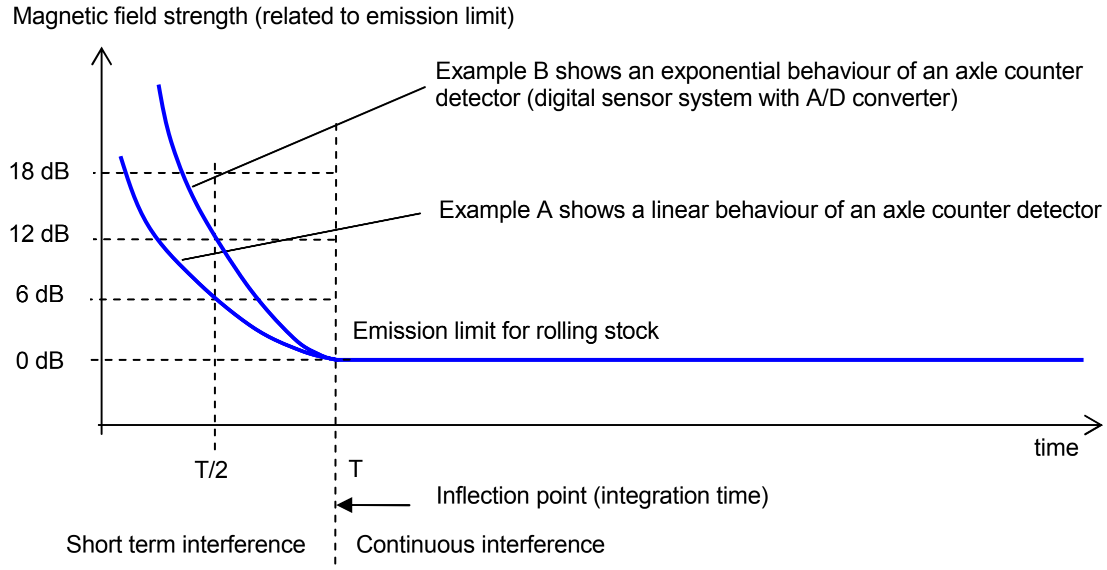

Figure 3 – Duration dependent limits

4.3 Specific axle counter parameters

The interference susceptibility of axle counter detectors depends, among other things, on the amplitude and the duration, for which the interference magnetic field is present. For continuous interference the limits are lower than for short duration (transient) interference.

The analyses of short duration interference susceptibility of axle counter detectors show the following:

- the inflection point (typical values between 1 ms and 2,5 ms) defines the integration time window for evaluation of rolling stock. The integration time (T_{int}) and its corresponding limits are product specific and listed in Table A.1;
- for the evaluation of shorter durations (left side from the inflection point on Figure 3) the integration time window can be reduced and higher emission limits can be applied (see Table A.3). If the product specific axle counter detector has a linear behaviour (analogue sensor principle), the immunity limits typically increase linearly and the time window can be reduced accordingly. Digital filters may not have a linear behaviour and shall be considered on an individual basis.

5 Measurement specification for vehicle emissions

5.1 Rolling stock emission limits

5.1.1 Emission limits (based on existing axle counters)

Table A.1 in Annex A defines emission limits for rolling stock and frequency ranges at which they apply. The limits encompass the worst case influence of UIC 60 rail and are valid for the compatibility testing on any other rail type. The limits are defined for existing selected as preferred types of axle counters and established in accordance with the test specification in Annex C.

5.1.2 Frequency management

For future developments of rolling stock and axle counters with the aim to decrease the development risk and to minimize the homologation effort for both - rolling stock and axle counters - it would be helpful to have a frequency management with clearly defined interference limits based on the measurement specification of this Technical Specification.

While a mandatory European frequency management for rolling stock and axle counters has to be defined by TSI, this Technical Specification would propose - for single frequency ranges - a frequency management based on preferred types of axle counters (see Annex B, informative).

5.2 Methodology for the demonstration of vehicle compatibility

5.2.1 General approach

To establish compatibility between rolling stock and axle counters, magnetic field emissions from rolling stock shall be verified against the emission limits defined in this Technical Specification. For this purpose, measurements shall be performed under specified operational conditions of rolling stock running over specified measurement antennas. The measured data shall be evaluated and compared with the defined emission limits in Annex A.

Compatibility tests with vehicles can be executed with any rail type. Limits established for UIC 60 profile shall be fulfilled.

Emissions from vehicles are measured as magnetic fields in X, Y and Z directions. If interference is exceeding the relevant vehicle emission limit it is necessary to identify any specific source of interference exceeding the limits and consider mitigating arguments.

Rail current interference can be independent of the position of the vehicle between the axles and may occur at positions of sensitivity under the wheels. Magnetic fields will normally occur at a predetermined position along the vehicle or train.

The maximum emission of rolling stock with respect to the compatibility of axle counters can normally be measured at speeds selected by the rolling stock manufacturer at which maximum emissions are expected in the frequency range considered for compatibility. 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. For high performance locomotives the resulting repetition rate normally exceeds a few hundreds of Hertz.

Specific cases exist where the relevant emission source can only be activated at higher speeds or degraded conditions. These cases shall be considered separately, and more measurement runs at higher speeds shall be carried out or additional measurement antennas may be considered, so that it can be guaranteed that relevant interference effects are detected by the measurement antennas.

5.2.2 Measurement antenna

5.2.2.1 Frequency range

Due to the fact that the range of operating frequencies of the axle counters used in Europe is from tens of kilohertz up to 1,3 MHz it is not possible to achieve an acceptably low measurement uncertainty with only one measurement antenna. Therefore two antennas with following ranges are proposed to capture the following frequency ranges:

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

5.2.2.2 Electrical surface

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

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