Moving Europe towards a sustainable and safe railway system without frontiers.

Application guide of ERA/ERTMS/033281 Version 5.0 “Interfaces between CCS trackside and other subsystems”

In accordance with Article 19(3) of Regulation (EU) 2016/796 of the European Parliament and of the Council of 11 May 2016

Document History

Version date	*Section number*	*Modification description*
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1. Table of Contents

2. INTRODUCTION

2.1. Content of the guide

This Application guide needs to be read and used only in conjunction with the document “Interfaces between control-command and signalling trackside and other subsystems” (ERA/ERTMS/033281 [1]) hereafter the “Interface Document”. It is intended to provide additional information for its application, and it is not a substitute for it.

The general part of the “Guide for the Application of TSIs” must also be considered.

Where the interface document does not require further explanations only the brief explanation is provided.

This document is divided into two main sections:

- Additional information related to the interface document.
- The relation between the TSI version 2023 (CCS TSI [2], Loc&Pas TSI [3], WAG TSI [4], OPE TSI [5]) and the interface document.

2.2. Reference Documents

Table 1 Document reference

DOCUMENT REFERENCE	*TITLE*	*LAST ISSUE*
[1] ERA/ERTMS/033281	Interfaces between control-command and signalling trackside and other subsystems	Version 5.0
[2] CCS TSI 2023	Commission Implementing Regulation (EU) 2023/1695 of 10 August 2023 on the technical specification for interoperability relating to the control-command and signalling subsystems of the rail system in the European Union and repealing Regulation (EU) 2016/919	Reg. 2023/1695
[3] L&P TSI 2023	Commission Regulation (EU) No 1302/2014 of 18 November 2014 concerning a technical specification for interoperability relating to the ‘rolling stock — locomotives and passenger rolling stock’ subsystem of the rail system in the European Union Text with EEA relevance, amended by Reg. 2016/919, amended by Reg. 2018/868, amended by Reg. 2019/776, amended by Reg. 2020/387, amended by 2023/1694.	Reg. 2023/1694
[4] WAG TSI 2023	Commission Regulation (EU) No 321/2013 of 13 March 2013 concerning the technical specification for interoperability relating to the subsystem ‘rolling stock — freight wagons’ of the rail system in the European Union and repealing Decision 2006/861/EC Text with EEA relevance, amended by Reg. 1236/2013, amended by Reg. 2015/924, amended by Reg. 2019/776, amended by Reg. 2020/387, amended by 2023/1694.	Reg. 2023/1694

DOCUMENT REFERENCE	*TITLE*	*LAST ISSUE*
[5] OPE TSI 2023	Commission Implementing Regulation (EU) 2023/1693 of 10 August 2023 amending Implementing Regulation (EU) 2019/773 on the technical specification for interoperability relating to the operation and traffic management subsystem of the rail system within the European Union	Reg. 2023/1693
[6] GUI/LOC&PAS TSI/2023	Loc&Pass TSI application guide	Version 4.0
[7] GUI/WAG/2023	WAG TSI application guide	Version 4.0
[8] GUI/TSI/2023	Guide for the application of the Technical Specifications for Interoperability (TSIs)	Version 1.0

Table 2 Standards reference

DOCUMENT REFERENCE	*TITLE*	*LAST ISSUE*
[9] EN 16452	Railway applications - Braking - Brake blocks	2015/A1:2019
[10]EN 50592	Railway applications - Testing of rolling stock for electromagnetic compatibility with axle counters	2016
[11] EN 50728	Railway applications - Rolling stock - Testing for electromagnetic compatibility with track circuits	2024
[12] EN 50617-1	Railway applications - Technical parameters of train detection systems for the interoperability of the trans-European railway system - Part 1: Track circuits	2024
[13] EN 50617-2	Railway applications - Technical parameters of train detection systems for the interoperability of the trans-European railway system - Part 2: Axle counters	2024
[14] CLC/TS 50238-3	Railway applications - Compatibility between rolling stock and train detection systems - Part 3: Compatibility with axle counters	2022
[15] CLC/TS 50238-2	Railway applications - Compatibility between rolling stock and train detection systems - Part 2: Compatibility with track circuits	2020

2.3. Abbreviations

Table 3: Abbreviations

ABBREVIATION	FULL TEXT
AC	Alternating current
CCS	Control command and signalling
DC	Direct current
EMC	Electromagnetic compatibility
ERA	European agency for railways
ERTMS	European rail traffic management system
EU	European union
IC	Interoperability constituent
IM	Infrastructure manager
NNTR	National notified technical rules
OPE	Operation and traffic management
RDD	Reference document database
RINF	Registers of Infrastructure
TDS	Train detection systems
TSI	Technical specifications for interoperability
WAG	Freight wagons
TSI-TDS	TSI compliant train detection systems
non-TSI-TDS	non TSI compliant train detection systems

3. Interface document: ERA/ERTMS/033281

3.1. Chapter 2. Scope

The Interface Document ERA/ERTMS/033281 [1] defines the parameters of the interface between the train detection systems (TDS) - which are part of the Control-Command and Signalling trackside subsystem - and other subsystems, mainly rolling stock.

The Interface Document defines the fundamental vehicles-side parameters for the evaluation of an Influencing Unit (Influencing Unit covers the complete train composition, see e. g. EN 50728 [11], Figure 2). This means that the evaluation of parameters should be performed carefully in relation to the configuration of a vehicle and/or complete consist of more vehicles.

As a general rule, track-side installed TSI-compliant TDS (TSI TDS) have to operate reliably and safely under the conditions specified for vehicles in this Interface Document.

Notice that the term “axle counter” in this document includes the axle counter and wheel sensors.

Train detection systems that do not impose further requirements on vehicles than defined in the Interface Document can be regarded like TSI-compliant train detection systems (e.g.: crocodiles, simple touching mechanical switching contacts, optical detection systems), although they are not formally assessed against the requirements of the Interface Document. The infrastructure manager is responsible for the corresponding evaluation and appropriate classification of the installed train detection systems. Such information about the existing train detection system could be stored in RINF, so that it facilitates the route compatibility check of a train with an existing route.

The actual version (5.0) of the Interface Document has to be complemented with Specific cases from TSIs and national notified technical rules (NNTR) related to TDS. (RDD database)

The Interface Document includes in almost all points a section named “Explanations” that provided some additional information for clarity. However, complementary information is included here in the aim of better parameter evaluation or comprehension. In future versions, the Interface Document should keep the technical parameters only, and all explanations, notes and complementary information should be compiled in this Application Guide.

3.2. Chapter 3.1. Vehicle design and operation

The main parameters in vehicle design and complete consist of more vehicles are detailed here. This section covers mostly mechanical parameters.

In Chapter 3.1.1 “Definitions”, the following definition applies in Figure 2 (see TSI LOC&PAS [3], point 4.2.3.5.2.1):

S_R = Front-to-front dimension ($A_R + S_{d\_left} + S_{d\_right}$)
A_R = Back-to-back dimension

3.3. Point 3.1.2.1. Maximum distance between following axles

There is the risk that detection zones with a shorter length may be bridged by a vehicle or a consist with a longer distance between following axles. That is why the minimum detection length of a track circuit depends on the maximum distance between two consecutive axles. The aim is to avoid an untimely inoccupation of a section.

In addition, it could also depend on:

- the maximum speed of the line,

- the reaction time of the other parts of the signaling system which uses this detection information.

As example, the time that the track circuit outputs a reliable information about its condition including system delays must be longer than the time to transmit and process this information in the other parts of the signaling system.

All reaction times occurring in the system (intrinsic reaction time of the train detection system, transmission time, processing time in the interlocking system) should not lead to a swapping of the train detection information of successive train detection sections.

3.4. Point 3.1.2.2. Minimum distance between following axles

Axle counter systems should be able to distinguish a wheel by the two detection systems of a counting point with sufficient resolution; otherwise, the counting error will occur.

Axle counter should be able to count the axles of a vehicle up to the maximum line speed, where the axle counter is installed. For example, the worst case for the time between two subsequent axles is 19.4ms for trains with 2160 mm axle distance running with a speed of 400 km/h. The compliance can be demonstrated with a test in the laboratory in combination with simulations and/or calculations.

The maximum detectable speed of the train detection system should be determined and specified in the safety-related application conditions (SACs) for the TDS.

3.5. Point 3.1.2.3. Minimum distance between first and last axle

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

3.6. Point 3.1.2.4. Maximum distance between front/ rear end of train and first/last axle for trains running exclusively on High Speed lines and Point 3.1.2.5. on other lines

Signaling systems may have areas where the distance between a detected first / last axle and the nose / tail of the train is of relevance.

High Speed lines have line speeds equal or higher than 250 km/h (traffic code P1). The infrastructure (including alternative routes) should be designed in such a way that a TSI-compliant vehicle with these dimensions can run safely on the Network (Position and function of the TDS, interlocking functionality, etc.). Further details can be found in RINF.

For railway vehicles running on high-speed lines only, point 3.1.2.4 of interface document applies.

For railway vehicles running on no-high-speed lines (other lines), point 3.1.2.5 of interface document applies.

For railway vehicles running on both high-speed lines and other lines, point 3.1.2.5 of interface document applies.

3.7. Point 3.1.3. Wheel geometry

The minimum values of 3.1.3.1, 3.1.3.2, 3.1.3.3 and 3.1.3.4 parameters in combination are the worst case for axle counters detection.

An alternative test with a virtual wheel combining all worst-case values over all track gauges (diameter= 330 mm, rim width = 126 mm, flange thickness = 21,0 mm, flange height = 27,5 mm) can be used. Then, the compliance can be demonstrated with tests in the laboratory in combination with simulations and/or calculations.

3.8. Point 3.1.3.1. Geometric dimension of the rim width

The detection field of the axle counter is influenced by the wheel passing. The rim width is big enough to influence the field sufficiently in order to ensure appropriate detection.

Notice that the interface document uses the definition of rim width which includes the B_R and B_{urr} dimensions, in some Specific cases those are distinguished.

Also, notice that a wheel can be detected via the recognizable distortion of the electromagnetic field emitted by the axle counter due to the wheel rim (thickness / contour) or the thickness of the wheel flange.

3.9. Point 3.1.3.2. Minimum wheel diameter

The length of the influence of the detection field of the axle counter is related to the wheel diameter. The requirements for hooped and massive wheels are mandatory, the requirements for spoke wheels are informative.

3.10. Point 3.1.3.3. Geometric dimension of flange thickness and Point 3.1.3.4. Geometric dimension of the flange height

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.

This value is in line with what specified for geometrical characteristics of wheels in “Locomotives and Passenger rolling stock” [3] and in the “Freight wagons” [4] TSIs.

Notice that a wheel can be detected via the recognizable distortion of the electromagnetic field emitted by the axle counter due to the wheel rim (thickness / contour) or the thickness of the wheel flange.

3.11. Point 3.1.3.5. Metal and inductive-components-free space between wheels

This requirement is for on-board metallic and inductive components. The principle of axle counters is based on the detectable distortion of an electromagnetic field by a wheel. The detectable distortion should occur only with the passage of the wheel and not with the passage of other parts of rolling stock, like other ferromagnetic components or inductive coils mounted close to a rail, in the detection area of the axle counter.

As no specific requirements on magnetic brakes and eddy current brakes are yet defined in the interface document (see section 3.2.3 in [1]), the assessment of axle counters with regards to the compatibility with these brakes is not part of the IC certification.

3.12. Point 3.1.3.6. Wheel material

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

Laboratory tests or simulations should be done with real wheels or with simulated wheels with comparable properties (e.g. in terms of conductivity, permeability).

3.13. Point 3.1.4.1. Maximum amount of sand and point 3.1.4.2. Sand characteristics

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 *railway vehicles on tracks equipped with track circuits. The use of sand addresses two competing: brake and train detection.*

The composition and the amount of sand (as low as possible) and the location of the sanding devices (as few devices as possible and/or large distances between the devices) are decisive for the risk of non-detection of trains on tracks with track circuits.

On the other side the composition, the amount of sand (as high as possible) and the location of sanding devices (as many locations as possible) are decisive for increasing the braking effect of a vehicle (risk: accident due to collision with obstacles).

Notice that those parameters are not evaluated in the conformity assessment section 4 of the interface document.

3.14. Point 3.1.5. On-board flange lubrication

Similar to the sand parameter, 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. Infrastructure managers might propose the use of certain lubricants for their networks, or they might forbid the use of lubricants in certain areas.

3.15. Point 3.1.6. Use of composite brake blocks

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.

The composite brake blocks suitable for TDS based on track circuits are those listed in Appendix G of Regulation 321/2013 [4] and those fulfilling the chapter 7 of ERA/TD/2013-02/INT. The application of EN 16452:2015+A1:2019 [9] provides presumption of conformity to this requirement.

3.16. Point 3.1.7.1. Vehicle axle load

A minimum axle load will activate pedals and treadles. Also, minimum axle load will have a beneficiary effect on the resistance between wheel and rails, which is important for the operation of track circuits. On the other hand, a higher axle load improves the shunting behavior.

Friction elements acting on the surface of wheels contribute to keep them clean and limit the increase of contact resistance.

3.17. Point 3.1.7.2. Vehicle metal construction

This parameter specifies the requirements on the metal construction of a vehicle ensuring its detection by trackside inductive loops (level crossing protection systems).

On the side of the vehicle, these parameters can be checked on the basis of vehicle design drawings (Annex A.1 on the interface document [1]) and/or by test (Annex A.2 on the interface document [1]).

Inductive loops may be used to detect the presence of vehicles, for example to command the operation of the technical systems of level crossings (closing the barriers, flashing lights, etc.). A typical solution is the installation of a loop on the track like a lying “8”, as shown in the following Figure 1. It is mounted and fixed to the sleepers between the rails.

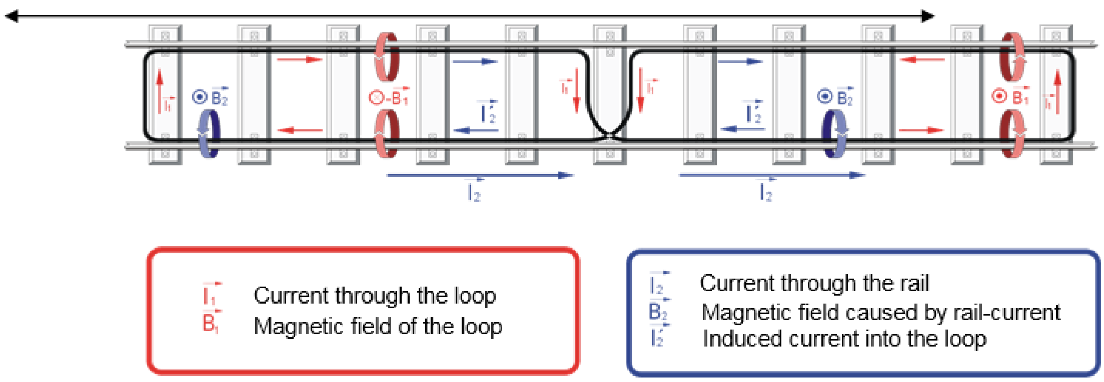


Figure 1 Example of loop installation

The detection of a vehicle is based on the variation of the inductance of the loop which is part of a resonant circuit (see Figure 2 below). This variation can be detected, for example, by changes in the electrical behavior (e.g. resonance frequency) of the resonant circuit.

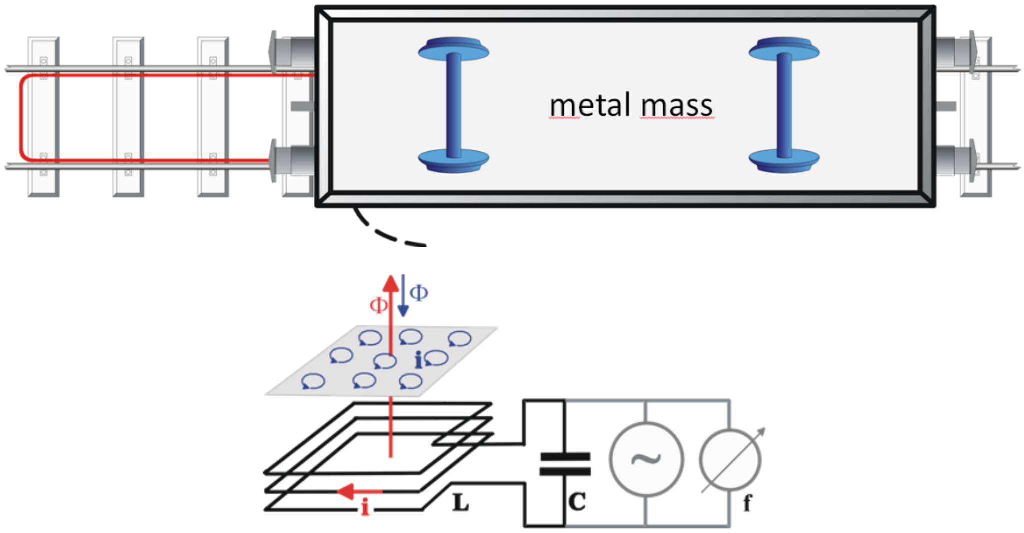
The variation of the loop inductance is caused by generation of eddy currents and mutual induction with conductive elements interacting with the magnetic field of the loop.

Railway vehicles can therefore vary the inductance by the following influencing factors:

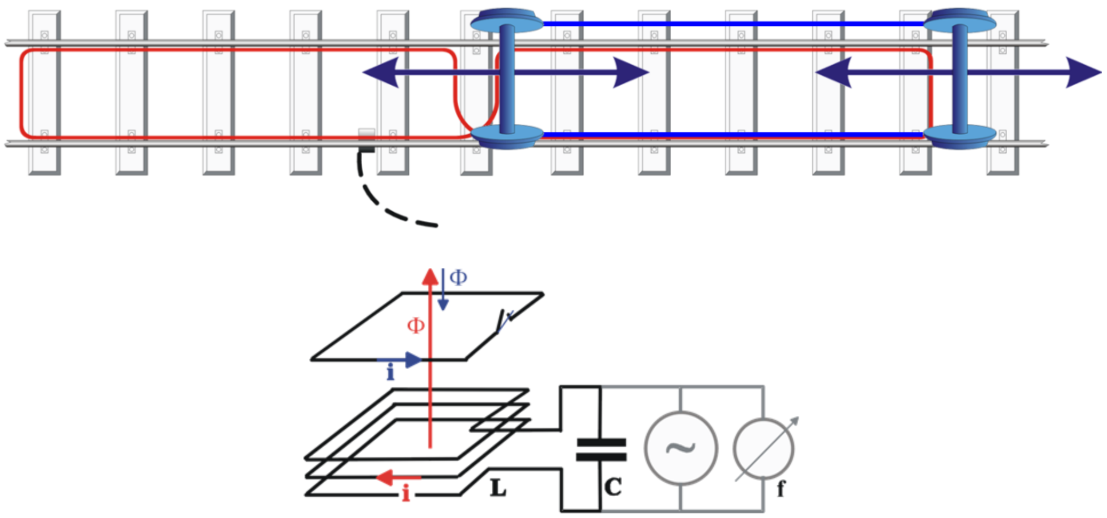
I. Metal construction (bogies, metal parts of the vehicle, metal vehicle floor) above the loop within a defined distance to the rail and within a defined conductivity.
II. Electrical short circuit rings (electrical conducting loops) built by constructive elements of a vehicle e.g. frame beams with cross connections or electrically connected and conducting constructive parts below the vehicles floor within a defined distance to the rail. These parts are electrically connected in a suitable way to form electrically conducting short circuit rings with defined dimensions and defined electrical resistance.
III. Electrical Wheel – rail short circuit rings (electrical conducting loops) built by the path wheel set – rail – wheel set – rail. This is only an additional factor (not further taken into account in the discussion below) because the quality of these short circuit rings depends on the resistance of the train shunt. In case of a high contact resistance between wheel and rail (e.g. caused by rust or particles of dust) the influence of this short circuit ring becomes lower. But in any case, the influence to the loop is improved.

These three factors usually occur in combination. The design of almost all existing vehicles includes constructive solutions, which are sufficient to fulfil the requirements for their detection by loops. (Ensured in the vehicle construction)

Because of its massive mechanical robust construction – several massive beams and conductive connections – a boogie provides a variety of metal parts and short circuit rings which are able to influence a loop sufficiently. Therefore, it is generally assumed that a boogie will be detected by a loop in any case. So, the worst-case situation occurs if only influencing factor I) or II) are affecting the loop, without any influence of bogies.



Variation of inductance by displacing the lines of magnetic flux by metallic mass (influencing mechanisms I) and/or II))



Variation of inductance by short circuit ring formed by the path wheel set – rail – wheel set – rail (influencing mechanism III))

Figure 2 Influencing mechanisms of loops

3.18. Point 3.1.8. Shunting behavior and shunting assisting devices

A track circuit is a section of the railway line, separated by the adjacent sections by means of insulated or electrical joints; a signal is fed at one side of it and, in normal conditions, reaches the receiver at the opposite side.

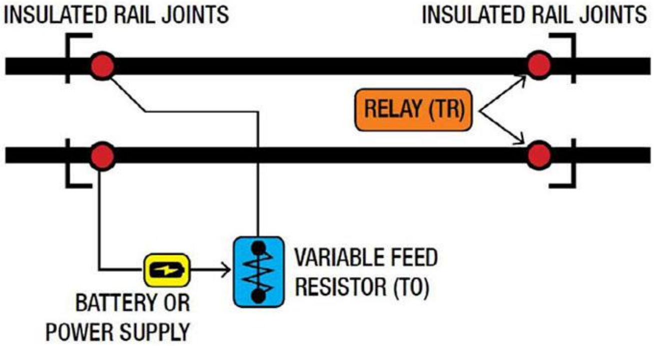


Figure 3 Track circuit example

If an axle of a vehicle “shunts” the rails, the level of the signals at the receiver is lowered below a threshold, indicating that the section is occupied.

To design a track circuit, it is therefore necessary to determine the “shunting impedance”, i.e., the maximum impedance between the rails causing the signal at the receiver become lower than the threshold value.

Such “shunting impedance” is given by: $R_{contact\ rail} + Z_{wheelset} + R_{contact\ rail}$, where $Z_{wheelset}$ includes Z_{axles} and Z_{wheels} (see Figure 4)

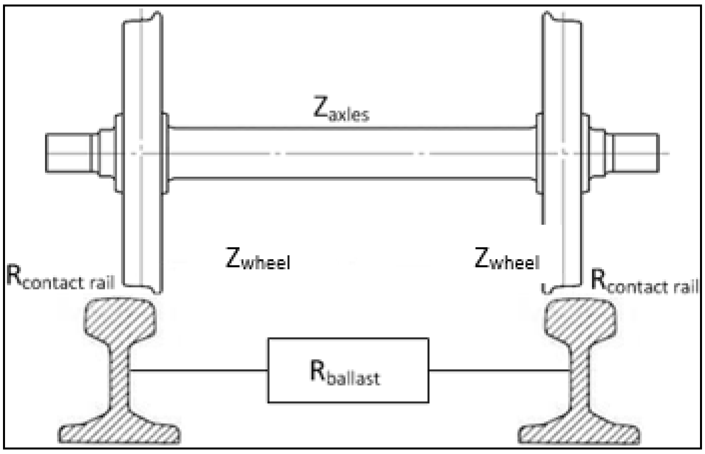


Figure 4 Shunting impedance

Many factors contribute to the shunting impedance (this is not an exhaustive list):

1. Axle load (i.e., the force pressing the wheel surface against the rail surface, influences $R_{contact\ rail}$)
2. Number of axles (i.e. electrical connected together, earthing contacts, driven/no driven axles)
3. Independently rotating wheels (a system in which each of the wheels on an axle, both left and right, can rotate at different speeds)
4. Type of brake (disk brake or brake shoes (iron or composite brakes) have a direct influence on the contamination and the surface of the wheel)
5. Traction current (a current flowing at the contact surface may decrease the impedance between the wheel and the rail)
6. Dimension of the contact surface between wheels and rails furthermore depending on wheel and rail profile, the material and the resulting properties of wheel and rail (e.g. hardness of the

steel), the running behavior/sinusoidal sway and train operation e.g. mono culture or frequency of train operation (influences $R_{contact\ rail}$)

7. Corrosion on the surface of the wheels (influences $R_{contact\ rail}$)
8. Corrosion on the surface of the rails (influences $R_{contact\ rail}$)
9. Pollution on the surface of the wheels (influences $R_{contact\ rail}$)
10. Pollution on the surface of the rails (influences $R_{contact\ rail}$)
11. Sanding / amount of sand (influences $R_{contact\ rail}$)
12. Surface/track conditioning lubricants (influences $R_{contact\ rail}$)
13. The voltage, the working frequency, and the power of the track circuits
14. Number of train runs / axles per time (influences $R_{contact\ rail}$)

Today many different types of track circuits are in service, operating at different frequencies and with different sensitivity for shunting impedance (parameters for track circuits are described in EN 50617-1:2024 [12]).

Shunting assisting devices can improve the shunting behavior between wheel and rail.

In some areas, the use of shunting assisting devices that work according to the electrical principle should be reliably prevented, as their use may lead to the destruction of level crossing safety systems.

There is a conflict here between competing safety objectives - safe/reliable detection of vehicles on track circuits and safe functioning of level crossing safety systems (LX systems) with loops (see interface document [1] section 3.1.7).

3.19. Point 3.1.9. Impedance between wheels

A track circuit is only able to detect rolling stock if the impedance between rails (introduced by the vehicle) 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 specified here on the vehicle side is only related to the electrical resistance between the running surfaces of the opposite wheels of a wheelset.

This impedance includes only the wheelset (Z_{axles} and Z_{wheels}) and not the wheel-rail contact impedance ($R_{contact\ rail}$) nor the ballast impedance ($R_{ballast}$).

3.20. Point 3.2.1. Electromagnetic fields

The frequency management – defined in the interface document section 3.2.1 with respect of the compatibility between rolling stock with axle counters – is based upon the list of known axle counters listed in Annex A of CLC/TS 50238-3:2022 [14](however it does not cover all of them). The rolling stock emission limits and the evaluation parameters have been determined from the known in-band susceptibility threshold limits for axle counters, which includes a 9 dB margin pertinent to the correct bandwidths of operation of the respective axle counter, established from laboratory tests.

The frequency management proposes three distinct frequency bands. These ranges have been established from known technologies and encompass the differences in functional principle, to allow for flexibility and compatibility between axle counters when mounted close to each other on the infrastructure.

For the purposes of the defined frequency management in respect of the compatibility between rolling stock and axle counters, particular attention is drawn to the pulsed switching circuits in operation on modern railway vehicles. These can produce higher levels of harmonics and transients in return currents than previously seen on railway vehicles containing fewer complex technologies. Nevertheless, they can be considered as the main source of interference to axle counters. Critical to this are the short rise-time pulses with high repetition rates.

Pulsed oscillating magnetic fields at or near the axle counter sensor position may be generated by common-mode currents underneath the railway vehicles, flowing in uncontrolled paths. Therefore, the qualification of rolling stock emitted magnetic field levels is highly dependent upon the filter bandwidth used for the qualification for evaluation.

In-band emission limits for the three frequency bands and the corresponding evaluation parameters including frequency range, bandwidth and integration time have been optimized for due consideration of both rolling stock and axle counters. Out of band emission limits are defined because of practical experience with max emissions envelope of magnetic field levels for existing rolling stock and considerations for compatibility with the electromagnetic compatibility (EMC) Directive.

EN 50592:2016 [10] 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 method is based on magnetic field measurements close to the rail. Notice that generated magnetic fields close to the rail depend on on-board electric/electronic equipment, metallic elements, cabling, return current and harmonic currents present in the rail.

Demonstrating the compatibility of magnetic brakes, eddy current brakes or inductively coupled resonant circuits on the vehicle in use with axle counters is still under investigation. Notice that the non-active magnetic brake and eddy current brake in rest position are covered by the requirements of metal free space.

Requirement not only relevant for axle counter but also for wheel sensor. Wheel sensors fulfilling this requirement could also be seen as TSI TDS.

3.21. Point 3.2.2. Conducted interference.

The proposed frequency management principle is based upon the integration of known preferred track circuits immunity levels, coupled with rolling stock emissions, for compatibility purposes, to enable present and future interoperability.

The frequency management – defined in the interface document section 3.2.2 with respect of the compatibility between rolling stock with track circuits - is based upon the list of known preferred track circuits listed in Annex A of CLC/TS 50238-2:2020 [15] (however it does not cover all of them). The rolling stock emission limits and the evaluation parameters have been determined from the known susceptibility threshold limits for these preferred track circuits, which includes safety and availability margins pertinent to the correct bandwidths of operation of the respective preferred track circuits, established from field tests, simulations, and analysis.

Each preferred track circuit is designed for specific infrastructure parameters provided by the manufacturer. It is therefore installed in a certain infrastructure environment (meeting these infrastructure parameters) and gives a certain susceptibility threshold limit. A change of one of these infrastructure parameters influences the susceptibility threshold limits for these preferred track circuits. The fulfilment of the requirements defined indirectly by the frequency management for track circuits must be demonstrated – based on the infrastructure parameter given by the track circuit manufacturer and infrastructure manager and the applied infrastructure parameters within the infrastructure environment – for the authorization of the trackside CCS (train detection system).

The interference current is flowing from the substation through the hot-path (catenary) to the rolling stock and flowing back by the cold-path (rails and earth in some cases, see Figure 5). This current is influenced by the impedance of all the elements in the circuit.

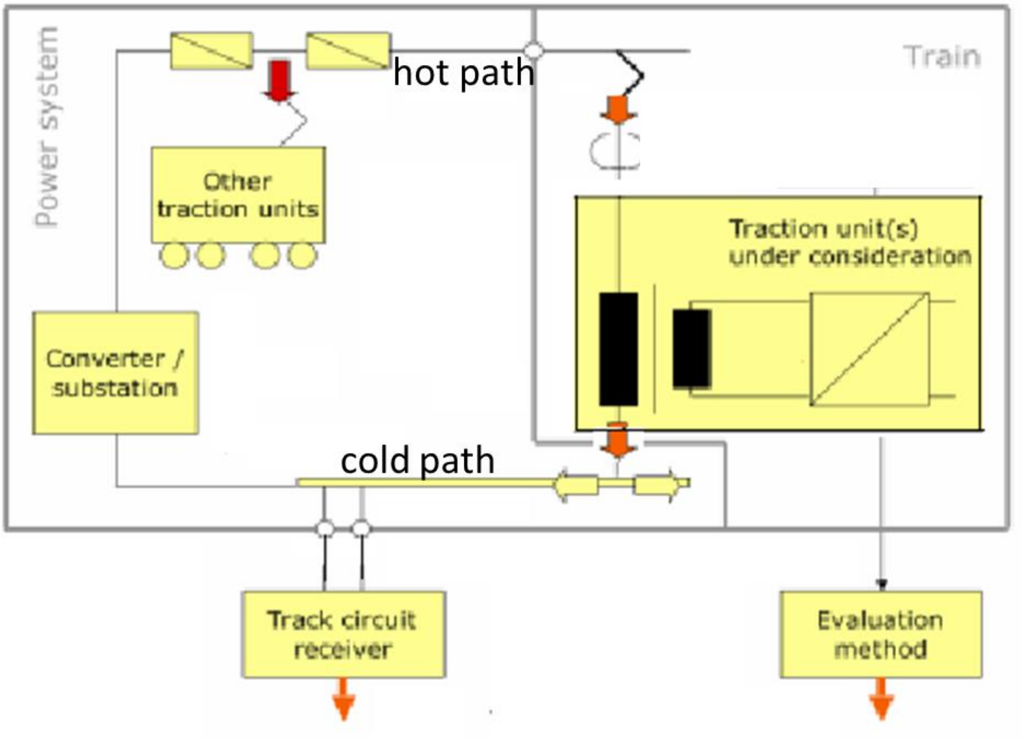


Figure 5 Interference current flow

The Interface document defines the limits and associated parameters for the evaluation of rolling stock emissions. From the point of track circuits, the summation of interference currents from vehicles and other infrastructure sources should be considered.

The test method EN 50728 [11], once it is published, will provide presumption of conformity to this requirement. The application of the Frequency Management (section 3.2.2 of the Interface document) is stated in Table B1.2 of CCS TSI 2023 [2].

3.22. Point 3.2.2.1. Vehicle impedance

Requirement in the minimum impedance of the influencing unit for AC system is defined up to 300Hz. In addition, the maximum input capacitance for AC system is defined for two frequency bands. For all others frequency bands, the AC impedance requirement is not defined at the moment.

Requirement in the minimum impedance of the influencing unit for DC system is defined in the frequency band from 1.5kHz to 3kHz. For all the others frequency bands the requirement is not defined at the moment.

In both cases, AC and DC influencing units, the active control option for increasing the input impedance is allowed if safety is guaranteed.

In TDS, 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.

3.23. Point 3.2.2.4. 25 kV AC, 50 Hz, Point 3.2.2.5. 15kV AC, 16,7Hz and Point 3.2.2.6. DC (3kV, 1.5kV) Electromagnetic interference limits for traction current

The measured current of the influencing unit (usually performed at pantograph level) includes the total harmonic generated by the Rolling Stock in AC and include for DC the rolling stock and the substation contribution (traction current and on-board electrical/electronic equipment harmonics).

To better identify the frequency bands in this section, a new column “Band” was added in the tables. The letter “A” is for 25kVac, “B” for 15kVac and “C” for 3kVdc and 1.5kVdc. This identification can help to classify vehicles and units that are compatible or not to certain frequency bands (please take into consideration the section 3.2.2.8 of the interface document) and supports the IM by defining its interference current limits/frequency bands that will continue to be used or will be used in the future in its network in accordance with Article 13 of the CCS TSI [2]. For the selection of the required bands, the compatibility of the already existing vehicles running on the network should be considered.

The tables 13, 14 and 15 in the interface document cover most of the track circuits in the European network and are known as TSI compliant train detection systems (or TSI-TDS). The Specific cases from CCS TSI and remaining NNTR cover the non TSI compliant train circuits/train detection systems (or non-TSI-TDS), please consider the section 5 of the interface document for the non-TSI-TDS.

3.24. Point 3.2.2.7. Measurement, test and evaluation specification

EN 50728 [11], once it is published, will provide presumption of conformity to interference current emissions from rolling stock. This standard will provide the test and evaluation method for the influencing unit necessary to proof conformity with the frequency management. It may be possible to use other appropriate and adequate procedures.

The application of this standard is in phase with the applicability of the section 3.2.2 of the interface document as referred in the table B1.2 CCS TSI [2] Transition Regime for RST Subsystem. It means, the section 3.2.2 of [1] is not applicable for the next 2 years after entry into force of the CCS TSI [2] for newly developed vehicle design. Please refer to table B1.2 CCS TSI for more details.

3.25. Point 3.2.2.8. Partial Application of the Frequency Management for vehicles

The technical file accompanying the Notified Body dossier will provide the information about the frequency bands to which the Influencing unit is compatible. Indeed, it will include the relevant sub-bands from A, B or C to which the vehicle is compliant including the conditions of use (configurations and restrictions).

Each area of use will provide the Bands that requires be compliant with. If no specific bands are published for the area of use, then the vehicle (depending on the power supply) provides compliance to all bands in Table 13 and/or Table 14 and/or Table 15 of the interface document [1].

When a vehicle is part of the influencing unit and needs to provide partial application of the Frequency management, then the rules of summation and splitting as detailed in EN50728 [11] could be used. As for the influencing unit, conditions of use for the vehicle need to be specified and listed within the vehicle documentation.

In this section, in a future version, the feedback from IM will be included. As for example the list of the A, B and C bands that each IM use (without detail of the type of TDS).

3.26. Point 3.2.3. Use of magnetic / eddy current brakes

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

3.27. Point 3.3.1. Wrong Side Failures

If vehicles meet all requirements as defined in sections 3.1 and 3.2 of the interface document, interoperability of the railway system is assured, which is the aim of this document.

3.28. Point 4. Conformity assessment

For the different kinds of TDS, the list of parameters from Table 16 are assessed either for the IC (Interoperability Constituent) certification or at subsystem level certification.

The table 16 is relevant for Trackside TDS. The actual version of the interface document [1] does not precise the methods or rules in for those certification process. That means that harmonized methods should be applied. Future version of the interface document will include such methods and rules.

3.29. Point 4.1. Interoperability Constituent Axle Counter

The EC declaration of conformity for axle counter products should cover all parameters of the table 16 (column IC) of interface document [1] and applicable for interoperability constituent (IC) certification of axle counters.

It is possible that the architecture of the axle counter product (which can be different from manufacturer to manufacturer) does not allow the declaration of conformity for all parameters from the table 16. In this case the EC declaration for conformity should explicitly mention these parameters.

In practice, the axle counter as IC is in most of the cases a combination of the trackside equipment and the track vacancy evaluation unit (Figure 1 of EN 50617-2:2015 [13]), because otherwise it is difficult to check all the relevant parameters from table 16. The manufacturer of the axle counter defines the system limits of its product with regard to the interoperability requirements (basic parameters defined in 4.2.10 and 4.2.11 of the TSI CCS [2]) for testing by the Notified Body and declares conformity with the IC requirements after the conformity assessment has been carried out by the Notified Body.

As general remark, in future revisions of the interface document [1], it is planned to provide more detailed requirements for the trackside (limits, methods,…) in order to have installed TSI-compliant TDS compatible with TSI-compliant vehicles. This process has already started by specifying requirements for the conformity assessment in chapter 4 of the interface document [1]. On this process, the reference to some sections of the EN 50617 [12][13] series may be included.

For information, the EN 50617-2:2015 [13] specifies parameters for the design and usage of axle counter systems. The standard defines the technical parameters of axle counter systems associated with the magnetic field limits for rolling stock in the context of interoperability. In addition, test methods (e.g. laboratory tests) are defined for establishing the conformity and the performance of axle counter products.

EN 50617-1:2015 [12] (Railway applications - Technical parameters of train detection systems for the interoperability of the trans-European railway system - Part 1: Track circuits) specifies the technical parameters of track circuits associated with the interference current emissions limits for Rolling Stocks in the context of interoperability defined in the form of Frequency Management.

3.30. Point 5.1. Technical characteristics of non TSI compliant train detection systems

The requirements for non-TSI-TDS should be specified in the same way as for TSI-TDS, as far as possible. Member States will transfer the requirements for each of their existing non-TSI-TDS into this interface document by Annex B.1 template and following the Article 13 of the CCS TSI.

3.31. Point 5.2. Compliance with non TSI compliant train detection systems

The technical file of Notified Body will provide the information about the non-TSI-TDS based on technical document produced by Member States as detailed in section 5.1 of the interface document.

3.32. ANNEX B.1 ERA Technical Document for Non TSI compliant train detection systems

The main objective of this template was to provide a structured way to transfer Member States requirements related to the non-TSI-TDS. The collect of those technical documents from all Member State will be the input for a consolidated document with all requirements.

Specific cases and NNTR related to non-TSI-TDS will be evaluated in an efficient way if the following points are considered:

1. The Annex B1 applies to technical parameters related to track circuits, axle counters, loops, or other train detection systems not covered by the interface document,
2. Requirements related on non-TSI-TDS as provided in the Annex B1 document are already part of NNTR published in RDD (Reference Document Database),
3. The Annex B.1 cannot be used to declare and/or publish new NNTR.

All the information compiled from Annex B1 document will be consolidated in a future version of the interface document and the application guide will provide additional information about how to apply them.

4. TSI 2023 and ERA/ERTMS/033281

This section has been included here to provide additional information related to TSIs and the interface document. Please refer to TSI application guide (GUI/TSI/2023) for more global information about TSIs.

4.1. Introduction

This section is divided into four sub-sections:

- Relation between CCS TSI and ERA/ERTMS/033281
- Relation between Loc&Pas TSI and ERA/ERTMS/033281
- Relation between WAG TSI and ERA/ERTMS/033281
- Relation between OPE TSI and ERA/ERTMS/033281

4.2. CCS TSI and ERA/ERTMS/033281

The interface document is mentioned in Table A2 Index [77] of the CCS TSI.

Additional information is available in the CCS TSI application guide.

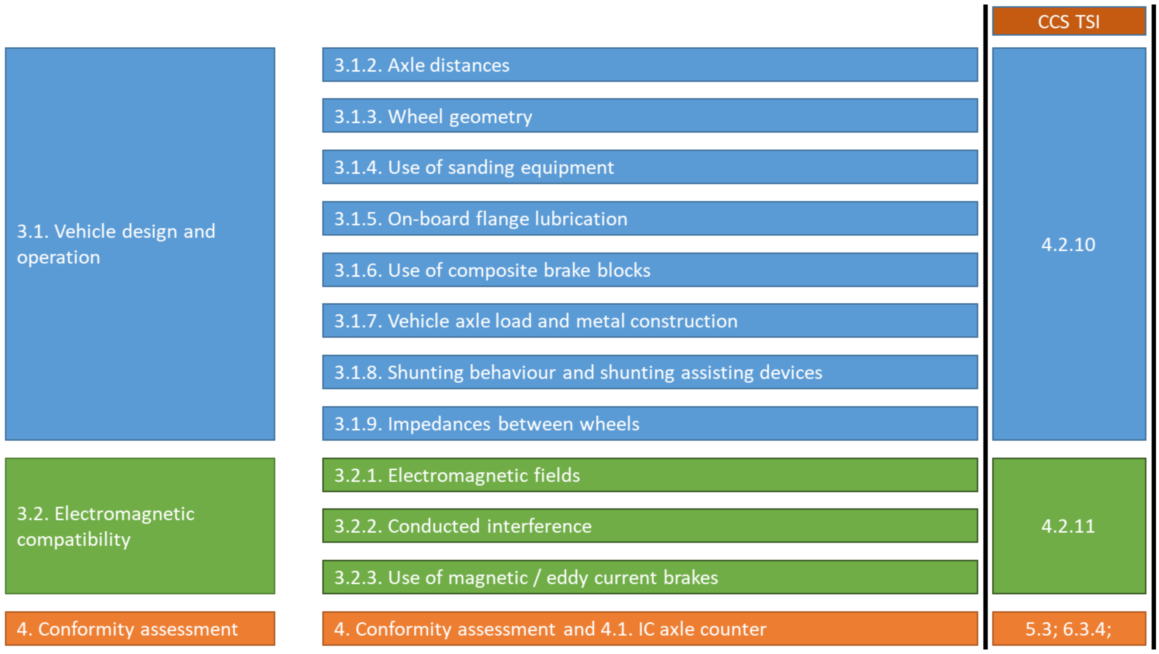


Figure 6 CCS TSI and ERA/ERTMS/033281 cross reference

4.2.1. CCS TSI Point 4.1.1 Basic parameters

The CCS TSI includes two Basic parameters:

- (10) Trackside Train Detection Systems and
- (11) Electromagnetic Compatibility between Rolling Stock and Control-Command and Signalling trackside equipment.

Both are described in the CCS TSI point 4.2.10 and point 4.2.11 respectively.

The point 4.2.10 is mainly the mechanical parameters and point 4.2.11 is mainly the electromagnetic parameters.

4.2.2. CCS TSI Point 4.2.10 Trackside Train Detection Systems

This parameter is related to the “3.1 Vehicle design and operation” section in ERA/ERTMS/033281.

4.2.3. CCS TSI Point 4.2.11 Electromagnetic Compatibility between Rolling Stock and Control-Command and Signalling trackside equipment

This parameter is related to the “3.2 Electromagnetic compatibility” section in the ERA/ERTMS/033281.

4.2.4. CCS TSI Point 5.3 Table 5.2 row 7 Axle counter as Interoperable Constituent

The relevant parameters for axle counters are listed in section “4. Conformity assessment” of the interface document.

4.2.5. CCS TSI Point 6.3.4 Table 6.3 Conformity assessment requirements for a Trackside Subsystem

In order to check and verify that Control-Command and Signaling Trackside Subsystem and the basic parameters are respected, in particular, the row (2d) for Axle counters and the row (7) for Track circuits, Loops and other Train detection systems, section “4. Conformity assessment” of the interface document applies to control-command and signaling trackside subsystem.

4.2.6. CCS TSI Point 7.7 Specific cases

Non-TSI-TDS, not compliant to the interface document, are listed as specific cases in this section and they are assessed following the corresponding NNTR.

The use of Annex B.1 (see point 2.32 in this application guide) as tool to manage non-TSI-TDS will help in the evaluation of additional national rules that could become Specific cases in the following TSI revision.

4.2.7. CCS TSI Table B1.2 – Transition Regime for RST Subsystem

The Table B1.2 from Appendix B of CCS TSI (2023/1695/UE) precises the applicability of the last version of ERA/ERTMS/033281.

Definitions of Design phase, Production phase and Vehicle in operation are used from point 7.2.4.1.1 of CCS TSI in the following diagram. Noted that symbol (ooo) in the figure define a continuous period.

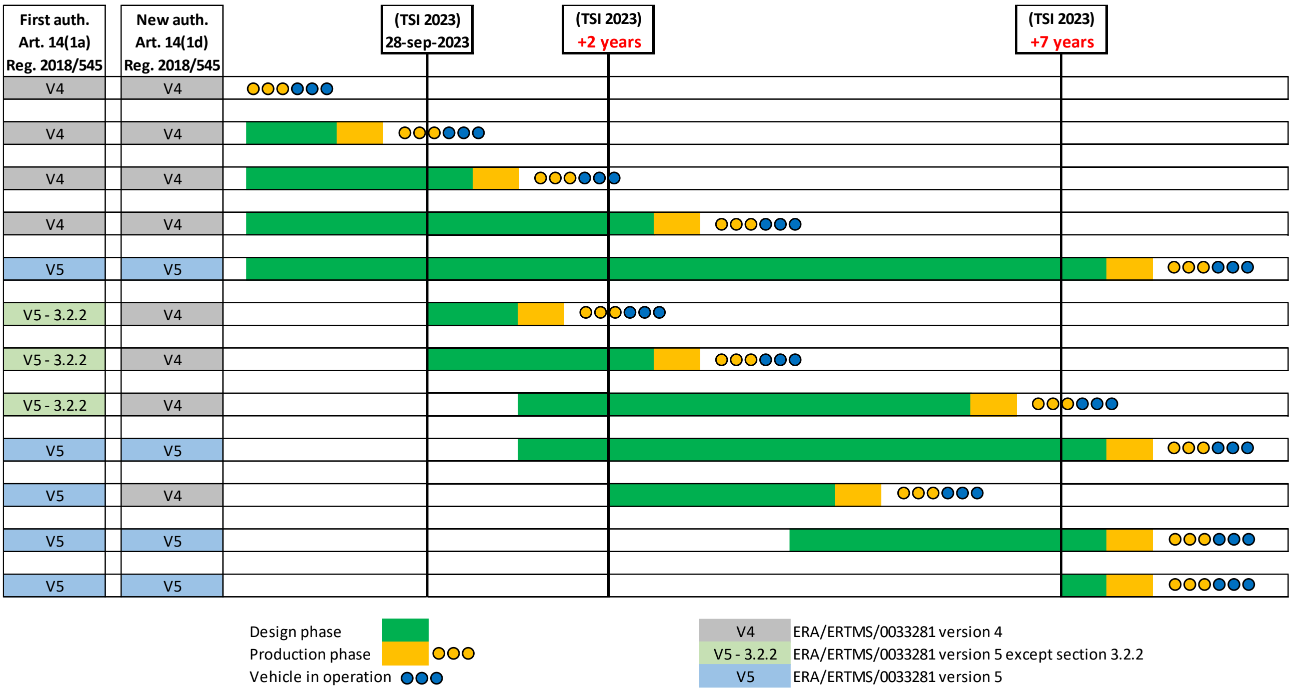


Figure 7 Transition period and application of the interface document version 5

4.3. Loc&Pas TSI and ERA/ERTMS/033281

The interface document is mentioned in Appendix J.2 Index [A] of the TSI Loc&Pas.

Additional information is also available in the L&P TSI application guide (GUI/LOC&PAS TSI/2023).

		Loc&Pas TSI
3.1. Vehicle design and operation	3.1.2. Axle distances	4.2.3.2.1; 4.2.3.3.1.1 (i)(1,2,3); 4.2.3.3.1.2 (i)(1,2,3,4)
	3.1.3. Wheel geometry	4.2.3.3.1.2 (ii)(5) and (iii)(6,7); 4.2.3.5.2.2
	3.1.4. Use of sanding equipment	4.2.3.3.1.1 (iii)(8);
	3.1.5. On-board flange lubrication	4.2.3.3.1.1 (iii)(10);
	3.1.6. Use of composite brake blocks	4.2.3.3.1.1 (iii)(9);
	3.1.7. Vehicle axle load and metal construction	4.2.3.2.1; 4.2.3.3.1.1 (ii)(4); 4.2.3.3.1.3 (1)
	3.1.8. Shunting behaviour and shunting assisting devices	4.2.3.3.1.1 (ii)(7);
	3.1.9. Impedances between wheels	4.2.3.3.1.1 (ii)(5);
3.2. Electromagnetic compatibility	3.2.1. Electromagnetic fields	4.2.3.3.1.2 (iv)(8); 4.2.12.2; 7.1.1.5
	3.2.2. Conducted interference	4.2.3.3.1.1 (ii)(6) and (iv)(11); 4.2.12.2; 7.1.1.5
	3.2.3. Use of magnetic / eddy current brakes	4.2.3.3.1.2 (iv)(9); 4.2.12.2; 7.1.1.5
4. Conformity assessment	4. Conformity assessment and 4.1. IC axle counter	

Figure 8 Loc & Pas TSI and ERA/ERTMS/033281 cross reference

4.3.1. Loc&Pas TSI Point 4.2.3.2.1. Axle load parameter

The axle distance, length of the unit and axle load are parameters included in the ERA/ERTMS/033281 version 5 in the following points:

- 3.1.2. Axle distances and
- 3.1.7.1. Vehicle axle load, minimum load for axles.

4.3.2. Loc&Pas TSI Point 4.2.3.3.1.1. Rolling stock characteristics for compatibility with train detection system based on track circuits

The characteristics to be assessed for the compatibility with track circuits regarding vehicle geometry, vehicle design, isolating emissions and EMC in the interface document are listed here:

(i) Vehicle geometry
   (1) see 3.1.2.1 Maximum distance between following axles (included in Table 16)
   (2) see 3.1.2.4 Maximum distance between front/rear end of train and first/last axle for trains running exclusively on High Speed lines (included in Table 16) or 3.1.2.5 Maximum distance between front/rear end of train and first/last axle for trains running on other lines (included in Table 16)
   (3) see 3.1.2.3 Minimum distance between first and last axle (included in Table 16)

(ii) Vehicle design
   (4) see 3.1.7.1 Vehicle axle load (not included in Table 16)
   (5) see 3.1.9 Impedance between wheels (not included in Table 16)
   (6) see 3.2.2.1 Vehicle impedance (included in Table 16)
   (7) see 3.1.8 Shunting behavior and shunting assisting devices (not included in Table 16)

(iii) Isolating emissions
   (8) see 3.1.4 Use of sanding equipment (not included in Table 16)
   (9) see 3.1.6 Use of composite brake blocks (not included in Table 16)
   (10) see 3.1.5 On-board flange lubrication (not included in Table 16)

(iv) EMC
   (11) see 3.2.2 Conducted emissions (included in Table 16)

4.3.3. Loc&Pas TSI Point 4.2.3.3.1.2 Rolling stock characteristics for compatibility with train detection system based on axle counters

The characteristics to be assessed for the compatibility with axle counters regarding vehicle geometry, wheel geometry, vehicle design and EMC are listed here.

(i) Vehicle geometry
   (1) see 3.1.2.1 Maximum distance between following axles (included in Table 16)
   (2) see 3.1.2.2 Minimum distance between following axles (included in Table 16)
   (3) this parameter is not included in the ERA/ERTMS/033281 version 5, however it refers to the distance b_x from point 3.1.2.4 or point 3.1.2.5. This characteristic “Minimum distance between front/ rear end of train and first/last axle” is equal to half of b_x distance (not included in Table 16)

(4) see 3.1.2.4 Maximum distance between front/rear end of train and first/last axle for trains running exclusively on High-Speed lines (included in Table 16) or in point 3.1.2.5 Maximum distance between front/rear end of train and first/last axle for trains running on other lines (included in Table 16)

(ii) Wheel geometry

(5) see 3.1.3.1 Geometric dimension of the rim width, 3.1.3.2 Minimum wheel diameter, 3.1.3.3 Geometric dimension of flange thickness, and 3.1.3.4 Geometric dimension of the flange height (included in Table 16)

(iii) Vehicle design

(6) see 3.1.3.5 Metal and inductive-component-free space between wheels (included in Table 16)

(7) see 3.1.3.6 Wheel material (included in Table 16)

(iv) EMC

(8) see 3.2.1 Electromagnetic fields (included in Table 16)

(9) see 3.2.3 Use of magnetic/eddy current brakes (not included in Table 16)

4.3.4. Loc&Pas TSI Point 4.2.3.3.1.3. Rolling stock characteristics for compatibility with loop equipment

The characteristics to be assessed for the compatibility with loop equipment regarding vehicle design is listed here.

Vehicle geometry

(1) see 3.1.7.2 Vehicle metal construction (Annex A.1 and A.2) (included in Table 16)

4.3.5. Loc&Pas TSI Point 4.2.3.5.2.2. Mechanical and geometrical characteristics of wheels

(2) Geometrical dimensions of wheels

The Loc&Pas TSI Table 2 “In-service limits of the geometric dimensions of wheel” precises, in principle, dimensions of wheels for 1435mm track gauge. These values are included and complement for others track gauges in the interface document in the following points:

- Point 3.1.3.1. Geometric dimension of the rim width
- Point 3.1.3.2. Minimum wheel diameter
- Point 3.1.3.3. Geometric dimension of flange thickness
- Point 3.1.3.4. Geometric dimension of the flange height

Notice that Loc&Pas TSI has Specific cases in point 7.3.

4.3.6. Loc&Pas TSI Point 4.2.12.2. General documentation

In Loc&Pas TSI Point 4.2.12.2 (26) related to the unique authorization, the required technical information as part of the technical documentation and related to Conditions for having a vehicle type authorisation and/or an authorisation for placing on the market of passenger coaches not limited to a particular area of use are listed. These are the maximum interference current, maximum magnetic field and minimum vehicle impedance. This information is relevant in the analysis of consistent and evaluation of vehicles for train composition.

4.3.7. *Loc&Pas TSI Point 7.1.1.5. Conditions for having a vehicle type authorisation and/or an authorisation for placing on the market of passenger coaches not limited to a particular area of use*

This section uses ERA/ERTMS/003328 version 5 to perform the compatibility of the passenger coaches and other related cars. The interface document in the actual version 5 provides limits for the influencing unit only. The evaluation, other than influencing unit, is subject to discussion for future version of ERA/ERTMS/033281.

For instance, the evaluation of vehicles (ex. Coaches, wagons) should use methods and rules based on standards (ex. prEN50728 for track circuits or EN50592 for axle counters).

The document prEN50728 provides a presumption of compliance in the application of limits and methods:

- (i)Maximum interference current (A), and applicable summation rule,
- (ii)Maximum magnetic field (dBµA/m) both radiated field and field due to the return current, and applicable summation rule,
- (iii)Minimum vehicle impedance (Ohm), and applicable summation rule

4.3.8. *Loc&Pas TSI Appendix L Changes of requirements and transition regimes*

See point 4.2.7 in this application guide.

4.4. WAG TSI and ERA/ERTMS/033281

The interface document is mentioned in Appendix D.2 Index [A] of the TSI WAG.

Additional information is also available in the WAG TSI application guide (GUI/WAG TSI/2023).

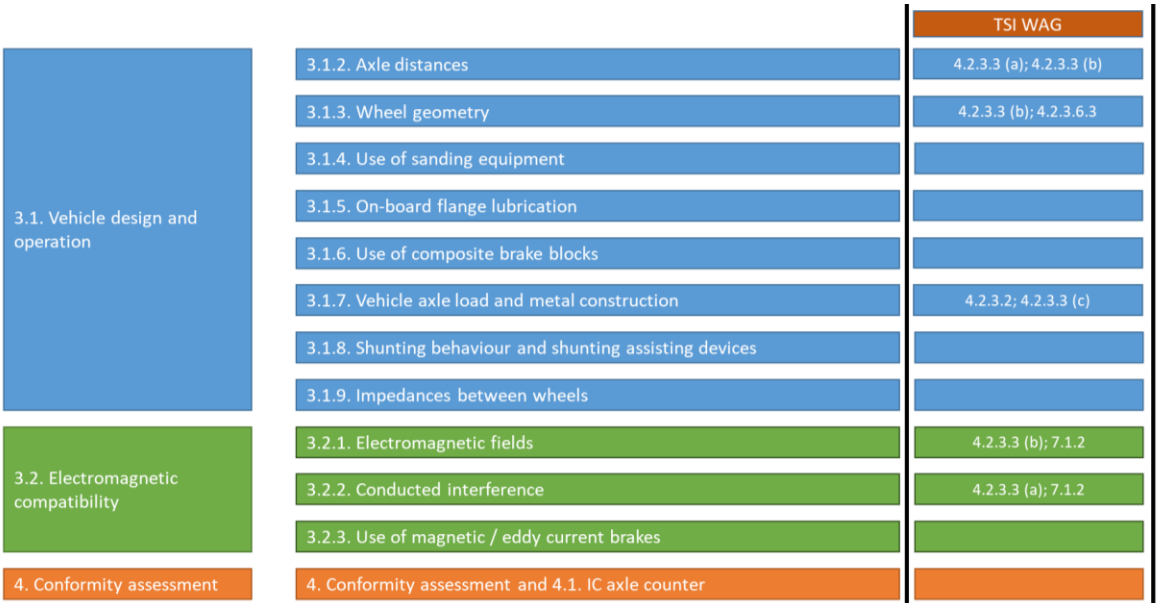


Figure 9 Loc & Pas TSI and ERA/ERTMS/033281 cross reference

Notice that previous versions of WAG TSI only covered mechanical parameters when compatibility with Train Detection Systems was evaluated. However, the use of on-board electrical/electronic equipment requires a complementary evaluation to in include the Electromagnetic compatibility evaluation. This point has been explicitly covered in the last version of WAG TSI.

4.4.1. WAG TSI Point 4.2.3.3 Compatibility with train detection systems

Some of the relevant parameters are listed here but not limited to them.

WAG TSI 4.2.3.3 (a) and WAG TSI Table 7 can be covered by the following parameters in the interface document:

- Point 3.1.2.1. Maximum distance between following axles
- Point 3.1.2.3. Minimum distance between first and last axle
- Point 3.1.2.4. Maximum distance between front/rear end of train and first/last axle for trains running exclusively on High Speed lines
- Point 3.1.2.5. Maximum distance between front/rear end of train and first/last axle for trains running on other lines
- Point 3.2.2 Conducted Interference

WAG TSI 4.2.3.3 (b) and WAG TSI Table 7 can be covered by the following parameters in the interface document:

- Point 3.1.2.1. Maximum distance between following axles
- Point 3.1.2.2. Minimum distance between following axles
- Point 3.1.2.3. Minimum distance between first and last axle
- Point 3.1.2.4. Maximum distance between front/rear end of train and first/last axle for trains running exclusively on High Speed lines
- Point 3.1.2.5. Maximum distance between front/rear end of train and first/last axle for trains running on other lines
- Point 3.1.3.1. Geometric dimension of the rim width
- Point 3.1.3.2. Minimum wheel diameter
- Point 3.1.3.3. Geometric dimension of flange thickness
- Point 3.1.3.4. Geometric dimension of the flange height
- Point 3.1.3.5. Metal and inductive components-free space between wheels
- Point 3.1.3.6. Wheel material
- Point 3.2.1. Electromagnetic fields

WAG TSI 4.2.3.3 (c) and WAG TSI Table 7 can be covered by the following parameters in the interface document:

- Point 3.1.7.2. Vehicle metal construction.

In addition to specific cases in Loc&Pas TSI point 7.3 and TSI CSS point 7.7, and those provided by Article 13 CSS TSI, check if the system does not impose any additional requirements at vehicle side.

4.4.2. WAG TSI Point 4.2.3.6.3. Characteristics of wheels

Reproduced in the point 3.1.3 of the interface document. Some little differences were identified for $B_R + B_{URR}$ in between WAG TSI Table 4 and the interface document for 1524mm and 1600mm. Those in the interface document should be use for compatibility with Train Detection Systems evaluation.

4.4.3. WAG TSI Appendix A Changes of requirements and transition regimes

Detailed information in point 4.2.7 of this application guide

4.5. OPE TSI and ERA/ERTMS/033281

4.5.1. OPE TSI 4.2.2.5. Route compatibility, OPE TSI 4.3.2 and OPE TSI Appendix D Section D1

Route information, available in Register of Infrastructure (RINF) or provided by Infrastructure manager until RINF is complete, are mostly the result of tests performed in accordance with the interface document, Specific cases and NNTR. Basically, if the vehicle has on-board electrical or electronic equipment the verification of compatibility is performed for TSI-TDS and non-TSI-TDS. The information from RINF and vehicle technical document will be used for technical compatibility in the Area of Use.