

Rollingstock Emission Compatibility with Axle Counter Test for High Speed Train set (B28)

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1 Introduction

Magnetic fields emitted by the rolling stock could interfere with the axle counter detectors. These magnetic fields must be measured at the position of the axle counter sensor in all relevant configurations of the vehicle. In this document the required measurement procedure and the evaluation of the measurement results are described.

This document is based on the normative documents EN 50592 [R01] and CLC/TS 50238-3 [R02].

1.1 Objective and Scope of the Test

In this document the EMC test procedure to demonstrate compatibility of the rolling stock and axle counter is described. The measurement and evaluation methods of rolling stock emissions to demonstrate compatibility are explained.

To ensure the compatibility of the vehicle with the axle counter detector, which is a vital component of the signaling system, it is essential that the rolling stock complies with the defined limits.

The limits for compatibility are defined as magnetic field strength that can disturb the axle counter detector, as part of the axle counter system. In the relevant frequency range of the axle counter detector the magnetic field is dominant and only this type of field is considered. The effects of electric fields are insignificant and are therefore not considered. 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 test procedure.

1.2 Introduction to the system

Train should be designed as per ICF specification ICF/MD/SPEC-447.

1.2.1 System Overview

One basic unit of 4-car unit is the building block for Train Set rake formation. Each basic unit consists of one Driving Trailer Coach (DTC) at the end, two Motor Coaches (MC) and one Trailer Coach (TC).

Two such basic units can be coupled together to form one rake of 8 coaches. Formation of basic unit is shown below:

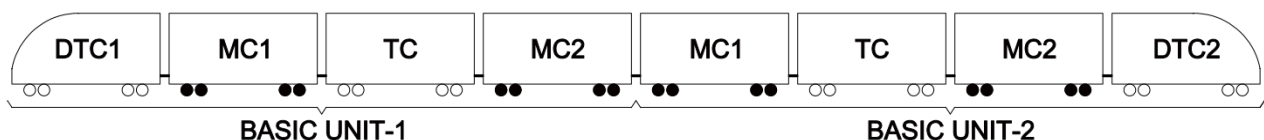


Figure 1: Train Formation

Driving Trailer Coach (DTC) is a non-powered vehicle with a Driver cab at one end. The Driver cab is furnished with a pre-fabricated Driver Desk. All driving operations are possible from Driver

Desk. Feedback from all systems in all the coaches / basic units is available for viewing on the Driver Desk and certain functionalities can be controlled from the Driver Desk. In this regard a 10.4" Touch Based TFT display is provided on driver desk for showing combined status. Various gauges and indications are also provided on driver desk for knowing MR, BC and parking brake pressure. The driver will also be able to control/operate the Passenger Information System, Train Radio from the Driver Desk. It also consists of LVPS with battery charger & battery and main air compressor which are mounted underslung. Rest of the DTC apart from the Driver cab is Passenger saloon area and vestibules. Two electrical cabinets are placed in rear wall of driver cab and one more electrical cabinet at non driving end. All passenger comfort related loads can be controlled by driver from driver cab.

Motor Coach (MC) is a powered vehicle with one Traction Motor driving each axle. The Motor Coach contains a line and traction converter unit (LTC) for each bogie mounted underslung. Transformer secondary cable for both LTC units comes from power transformer mounted in Trailer Coach through underslung mounted IV Coupler. It also consists of 2 no's electrical cabinets.

Trailer Coach (TC) contains a pantograph, vacuum circuit breaker, surge arrestors and isolator on roof. It also consists of auxiliary converter units and power transformer mounted underslung. Power to LTC units of both motor coaches is distributed from same power Transformer through Power Coupler. It also consists of 2 no's electrical cabinets.

In trailer coach there are 2 variants i.e TC coach in basic unit 2 is for executive class and the TC coach in basic unit 1 is for standard class.

All the passenger saloon areas are provided with air condition, controlled using HVAC(2no's) units mounted in each coach. All electrical cabinets, driver cab and passenger saloon areas are provided with fire detection equipment.

All the coaches are provided 4no's of airtight plug type exterior doors for passenger entry/exit. In addition all coaches are provided with automatic internal doors duly segregating passenger saloon area and door way vestibule area.

All the coaches including driver cab are provided with CCTV cameras and passenger information system.

1.3 List of Abbreviations used

Acronym	Description
AC	Alternating Current
DTC	Driving trailer coach
ICF	Integral Coach Factory (Coach Builder)
EN	European standard
MAHSR	Mumbai Ahmedabad High Speed Rail
MC	Motor Coach
ATP	Automatic Train Protection
NHSRCL	National High Speed Rail Corporation Limited
TC	Trailer Coach
TCMS	Train Control and Management System
ACM	Axle Counter Module
OCBU	On-Board Control Unit
EMC	Electro Magnetic Compatibility
Axle counter detector	detector consisting of the axle counter sensor and of the detection circuit, which includes in general filters and rectifiers
Axle counter sensor	sensor head mounted in the track

Table 1: List of Abbreviations

1.4 Applicable Documents and Standards

1.4.1 Customer Specification

1.4.1.1 ICF specification ICF/MD/SPEC-447

SPECIFICATIONS AND STANDARDS FOR DEVELOPMENT OF NEW GENERATION ENERGY EFFICIENT TRAIN WITH DISTRIBUTED POWER SYSTEM (LIGHT WEIGHT STAINLESS STEEL BODIES CARS)” and its subsequent Statement of Deviations accepted by ICF/NHSRCL.

1.4.1.2 ERTS – Employer’s Requirements Technical Specifications of Project for Construction of Mumbai-Ahmedabad High Speed Rail

1.4.2 Other Standards

Standard	Description	Contains
EN 50592: 2016-10 [R01]	Railway applications - Testing of rolling stock for electromagnetic compatibility with axle counters	specified measurement antennas

Standard	Description	Contains
CLC/TS 50238-3: 2022-01 [R02]	Railway applications – Compatibility between rolling stock and train detection systems: Compatibility with Axle Counters	evaluation and limits

Table 2: Applicable standards

2 EMC Test Procedure

The measurements shall be performed with specified measurement antennas as per EN 50592 described in section 2.1. The rolling stock is normally tested under conditions at which maximum emissions are expected in the frequency range considered for compatibility. Specific requirements are described in section 2.2.

Emissions from the rolling stock are measured as magnetic fields in X, Y and Z directions which are defined as shown in Figure 2.

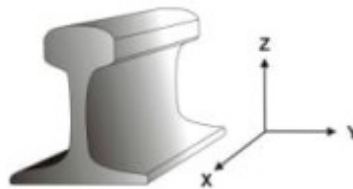


Figure 2: Orientation of the coordinates

Ambient noise measurements shall be conducted before the tests.

2.1 Measurement Antenna

As described in EN 50592 a rectangular 3-dimensional magnetic loop antenna with a common center point and the following geometrical dimensions shall be used:

- 5 cm x 5 cm (25 cm²) (loop for measurement of field along x-axis), named X-coil;
- 5 cm x 15 cm (75 cm²) (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.

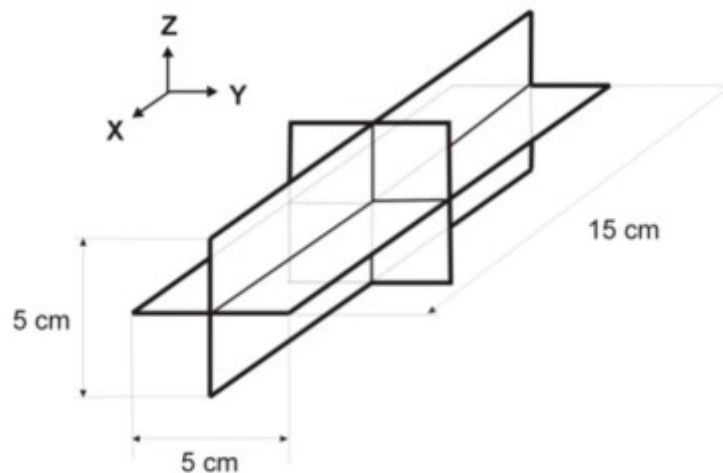


Figure 3: Measurement antenna

The antenna shall have cross polarization rejection higher than 30 dB without a rail being present. For further construction details please refer to EN 50592.

2.2 Vehicle Test Conditions

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 (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 axle counter disturbance, at lower speeds rolling stock will in general use a fast switching (PWM) approximation of an ideal three phase sinus 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 the earthing, 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.

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-condition, restaurant power are known interference sources.

When authorization for double or multiple traction units is sought, it is sufficient to test single traction unit only, provided there are in comparison single / multiple traction units no differences concerning the electrical behavior (e.g. change of converter frequencies) and the individual 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.

Components of signaling systems on board the RST, especially transmitting antennas under the vehicle e.g. tele-powering for balises, shall be switched on during tests.

The number of tests 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 identical.

2.2.1 Operational test conditions for electric and diesel/electric vehicles

The following requirements are derived for locomotives and electrical multiple units (any type, incl. 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 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.

The following operational conditions shall be covered:

- speed v_1 : very low speed of approximately 5 km/h to 10 km/h;
- speed v_2 : approximately 70 % to 90 % of the speed reached at the transition from asynchronous to synchronous switching (maximum pulse repetition rate);
- speed v_3 : approximately 70 % to 90 % of the speed reached at the transition to the power hyperbola (maximum DC-link voltage);

Test runs shall cover the speeds as written before and distinguished in Figure 4. When passing the antenna, the vehicle shall accelerate from the minimum speed v_1 until the maximum speed v_3 is achieved. When decelerating using electrical braking and brake chopper, if present, the vehicle shall cover all three ranges from v_3 to v_1 . 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.

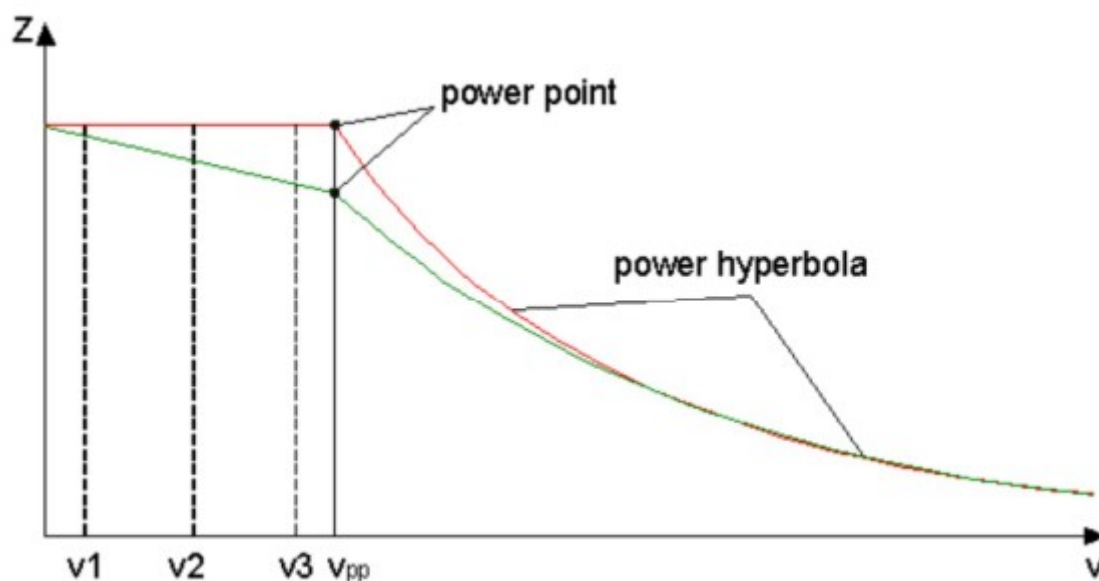


Figure 4: Examples of speed ranges, traction force (Z), velocity (v), speed power point (V_{pp})

2.2.2 Degraded modes

On 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.

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.

2.3 Infrastructural conditions

Measurements shall be done on a railway line where double rail traction return exists, to represent realistic conditions. 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). Where possible, tests need to be done close to an AC substation, if relevant.

2.4 Measurement set-up

Two three-axis-coils are placed on the rail. To minimize influence from earth currents and any other parasitic effects the measurement antennas shall be placed between two sleepers as shown in Figure 5 and Figure 6.

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

The measured signals are recorded by a data recorder. In the interlocking the evaluation unit should be observed to notice the indication of a malfunction of the axle counter. The laptop attached to the data recorder must have sufficient hard disc capacity and hard disc speed.

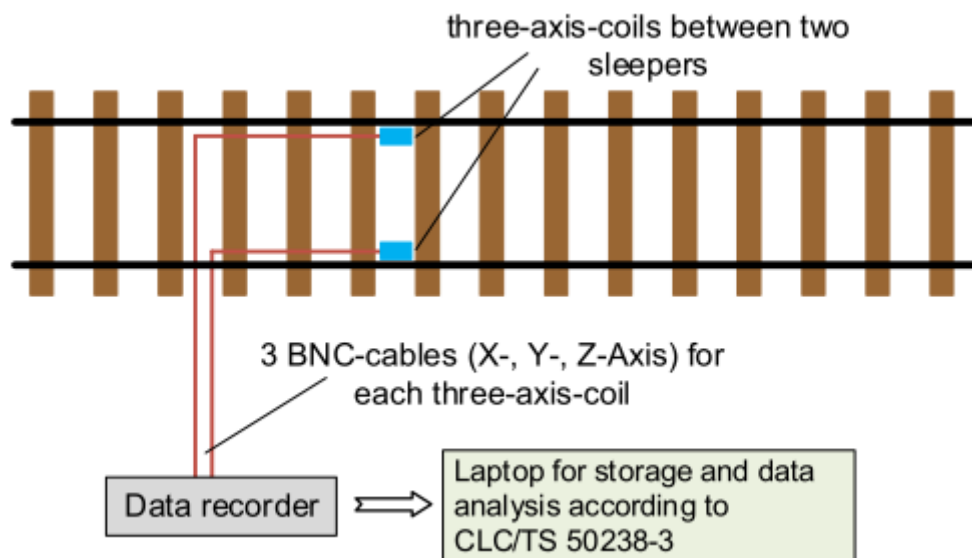


Figure 5: Principle sketch of the measurement set-up



Figure 6: Three-axis-coils mounted on the rail

The center 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 rail heads for Z1. See Figure 7.

- $Y1 = 96 \text{ mm} \pm 3 \text{ mm}$
- $Z1 = 73 \text{ mm} \pm 5 \text{ mm}$

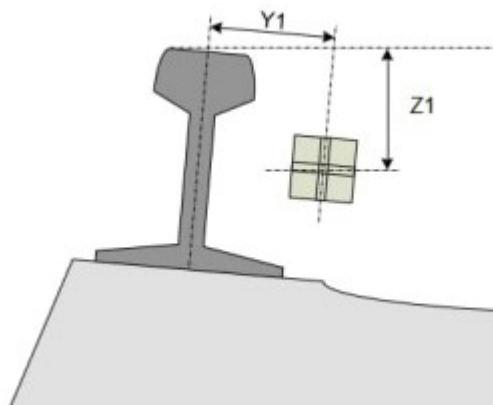


Figure 7: Positioning of the measurement antenna

2.4.1 Evaluation

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 method dedicated to the individual axle counter. The evaluation and limits for the axle counters for narrow band, according

to CLC/TS 50238-3 [R02], are listed in Table 3.

Type of axle counter detector	Centre frequency, tolerance range kHz	Filter curve 3 dB / 20 dB bandwidth kHz	Filter order using for evaluation	Magnetic field in X direction rms dBμA/m	Magnetic field in Y direction rms dBμA/m	Magnetic field in Z direction rms dBμA/m	Integration time ms
ZP D 43	43.0 ± 1.7	± 0.02 / ± 0.3	2	100	85	98	2

Table 3: Emission limits and evaluation parameters (narrow band), according to [R02]

Note: Axle counter type along with center frequency and limit shall be defined

Emissions shall be recorded in X, Y and Z directions using a sampling frequency of 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 measurement data is bandpass-filtered (butterworth) in time domain and then RMS-evaluated with 1 ms integration time with 75 % time overlapping.

The band-pass filter bandwidth for evaluation shall be determined by taking into consideration the tolerance range of the center frequency and the bandwidth of the defined filter curve.

Narrowband evaluation:

The center frequency of the narrowband filters (as defined in Table 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.

Weighting of short duration interference:

In case the limits specified in Table 4 are exceeded and the minimum time interval between two successive exceedances is bigger than the integration time defined, further evaluation for short duration interference shall be conducted for reduced integration times. For the axle counter detectors addressed in this document, the emission limits and maximum time durations of exceedances for short-term interferences are listed in Table 4.

	Increasing of magnetic field of Table 3 / Maximum time interval of exceedances	Increasing of magnetic field of Table 3 / Maximum time interval of exceedances
ZP D 43	6 dB / 0.5 x T _{int}	12 dB / 0.25 x T _{int}

Table 4: Weighting of short duration interference (T_{int} according to Table 3)

Weighting of short duration interference is used in the following cases:

- short single discontinuous interference (transients):
 - the duration of the disturbance shall be less than the defined integration time of 1.8 ms and, in case of using higher emission limits, less than the reduced integration time;
- repetitive short duration interference:
 - the repetition interval shall be greater than the integration time;
 - the duration of the disturbance shall be less than the product specific integration time and, in case of using higher emission limits, less than the reduced integration time.