

Rake Level Pacemaker Interference Test for High Speed Train set (B28)

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1 Introduction

This document is intended to Pacemaker Interference Test of Train set rake as per the specification ICF/MD/SPEC-447, this shall include test to verify that any emissions from the equipment of Train do not adversely affect the pacemakers/hearing aids that may be used by the passengers. Test shall be conducted as per EN 45502 and EN 50500.

2 Objective and Scope of the Test

The scope is limited to apparatus, systems and fixed installations which are intended for use in the railway environment. The frequency range covered is 0 Hz to 300 GHz.

Technical considerations and measurements are necessary for frequencies up to 20 kHz because no relevant field strengths are expected above due to the physical nature of EMF-sources in the railway environment.

Not covered are personal electronic devices (e.g. mobile phones, notebooks, wireless communication systems etc.) of passengers and workers. Not covered are intentional transmitters with frequencies higher than 20 kHz.

The test shall be conducted in accordance with BS EN 50500:2008+A1:2015.

3 Introduction to the system

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

3.1 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:

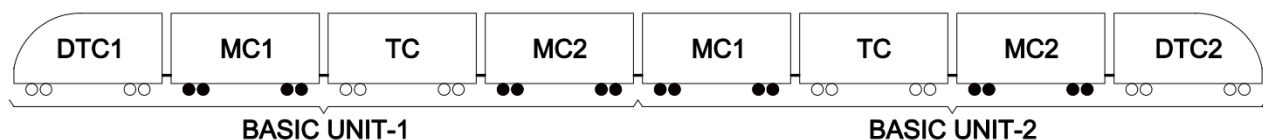


Figure 1: Train Formation

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.

4 List of Abbreviations used

Acronym	Description
AC	Alternating Current
DTC	Driving trailer coach
IEC	International Electro technical Commission
MAHSR	Mumbai Ahmedabad High Speed Rail
MC	Motor Coach
NDTC	Non Driving Trailer Coach
NHSRCL	National High Speed Rail Corporation Limited
TC	Trailer Coach
TCMS	Train Control and Management System
VCB	Vacuum Circuit Breaker
ICNIRP	International Commission on Non-Ionizing Radiation Protection

Table 1: List of Abbreviations

5 Applicable Documents and Standards

5.1 Customer Specification

5.1.1 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.

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

5.2 Other Standards

Standard	Description	Contains
EN 50500:2008+A1:2015	Measurement procedures of magnetic field levels generated by electronic and electrical apparatus in the railway environment with respect to human exposure	measurement and calculation procedures of electric and magnetic field levels generated by electronic and electrical apparatus in the railway environment with respect to human exposure
EN 45502-2-1	Active implantable medical devices - Part 2-1: Particular requirements for active implantable medical devices intended to treat bradyarrhythmia (cardiac pacemakers)	Measuring limits
ICNIRP Guidelines	For limiting exposure to time-varying	Measuring limits

Standard	Description	Contains
2010	Electric and magnetic fields (1 Hz – 100 kHz)	
EN ISO/IEC 17025	General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025)	Guidelines to the report can be found in EN ISO/IEC 17025

Table 2: Applicable standards

6 Description of Test

6.1 Test Pre - Requisites

- The pacemaker test shall be carried out on a fully equipped 8-car high speed train set
- All system and subsystem shall be energized which could contribute to electromagnetic interference. Before starting the test, permission shall be received from NHSRCL regarding the test.
- No other vehicles shall be present on test track.
- No maintenance work or unnecessary switching of power supply which can create noise.
- Other requisites related to site are covered in test site requirements.

6.2 Measurement procedure

As the detectable emission of rolling stock, traction power supply and signalling equipment is in the frequency range from d.c. up to 20 kHz, measurements, simulation and calculation are restricted to this range. Accordingly only one summation regime is applied. In this frequency range the magnetic field is dominant and the electric field can be neglected. As power of signaling equipment is low in comparison with other sources of EMF in the railway environment, its contribution can be neglected.

For the apparatus, systems and fixed installations in railway environment there are basic restrictions for general public and workers specified in 1999/519/EC, 2004/40/EC, ICNIRP Guidelines to static magnetic fields, ICNIRP guidelines to time-varying electric, magnetic and electromagnetic fields.

The measurement procedure of the Rolling stock is defined as

- measurements inside rolling stock and
- measurements outside rolling stock (on platform or alternative

The following measurement points are specified inside and outside rolling stock:

6.2.1 Accessible areas for workers inside rolling stock

The measurements indicate the emissions of the train equipment in standstill and dynamic condition.

Measurements shall be carried out close to the sources of emission of the train (e.g. power converters, power cables and power inductors) where workers usually can be in normal operating conditions of train and appliance and at the driver seat. The measurement heights above the floor shall be 0,9 m and 1,5 m. The horizontal measuring distance to the walls is 0,3 m or at the

minimum distance ($> 0,3$ m) where workers can be. Working areas are described in the scope of 2004/40/EC.

6.2.2 Public areas inside rolling stock

The measurements indicate the emissions of the train equipment in standstill and dynamic condition.

Measurements shall be carried out at the closest possible position of the sources of emission of the train (e.g. power converters, power cables and power inductors), where public can be. In this case then the measurement heights above the floor of all the public areas shall be 0,3 m, 0,9 m and 1,5 m. The horizontal measuring distance to the walls is 0,3 m or at the minimum distance ($> 0,3$ m) where public can be.

6.2.3 Areas outside rolling stock (public and workers)

The measurements close to rolling stock indicate the emissions of the train equipment in standstill condition (see 4.4.1) in 0,3 m horizontal distance to the train enclosure at the closest possible position of the sources of emission of the train (e.g. power converters, power cables and power inductors) at 0,5 m, 1,5 m and 2,5 m height from the top of the running rails. Measurements for public shall not be carried out at the same side of the third rail with respect to the tracks.

6.3 Test conditions

Tests are to be done under normal operating conditions, only. The condition of the rolling stock during the magnetic field measurements is described below:

6.3.1 Stand still condition (S)

The rolling stock is not moving. The traction circuits shall be under voltage but not operating. The auxiliary circuits shall operate and all the relevant appliances shall be active (e.g. air conditioning/heating, lights, window heater, electric generators).

6.3.2 Dynamic condition (D)

The rolling stock starts from the standstill with maximum acceleration to maximum speed, coasting and maximum electrical brake to stop. The traction circuits shall be under voltage and operating. The auxiliary circuits shall operate and all the appliances shall be active (e.g. air conditioning/heating, lights, window heater, electric generators).

The test has, as far as possible, to be done without the influence of other rolling stock. If there are different electrical brake systems they have to be tested separately.

6.4 Reference levels

For d. c. magnetic field a single reference level applies to both occupational exposure and exposure to the general public. The reference level for d. c. magnetic field is 1.0 mT.

For a. c. magnetic field, different reference levels should be considered for occupational exposure and exposure to the general public. The reference levels for occupational exposure and exposure of the general public for a. c. magnetic field are as given in Table 3 and Table 4 respectively.

S. No.	Frequency Range	Magnetic flux density B(T)
1.	5 Hz to 8 Hz	$0.2 / f^2$

2.	8 Hz to 25 Hz	$2.5 \times 10^{-2}/f$
3.	25 Hz to 300 Hz	1×10^{-3}
4.	300 Hz to 3 kHz	$0.3/f$
5.	3 kHz to 20 kHz	1×10^{-4}

Table 3: Reference levels for occupational exposure to time –varying magnetic fields(Unperturbed rms values)

S. No.	Frequency Range	Magnetic flux density B(T)
1.	5 Hz to 8 Hz	$4 \times 10^{-2}/f^2$
2.	8 Hz to 25 Hz	$5 \times 10^{-3}/f$
3.	25 Hz to 50 Hz	2×10^{-4}
4.	50 Hz to 400 Hz	2×10^{-4}
5.	400 Hz to 3 kHz	$8 \times 10^{-2}/f$
6.	3 kHz to 20 kHz	2.7×10^{-5}

Table 4: Reference levels for general public exposure to time –varying magnetic fields (Unperturbed rms values)

6.5 Measurement Point

6.5.1 Driving Trailer Coach (DTC)

S. No.	Test Condition	Location	Test Limit	Test Point Inside the car		Test Point Outside the car on both side (On Platform)	
1	Stationary	Driver cabin	Worker's area	Driver Seat ac	d. c. field		
		Passenger saloon	Worker's area	Electrical Panel / Pantry Area	a. c. field		
2			Public	Battery Charger Unit	d. c. field	Battery Charger Unit	d.c. field
3				20 kVA/5 kVA Transformer	a.c. field	20 kVA/5kVA Transformer	a.c. field
4				RMPU Control Unit	a. c. field d. c. field	RMPU Control Unit	a.c. field
5				Along the cable route	a. c. field d. c. field	-	
7	Dynamic	Driver cabin	Worker's area	Driver Seat	d. c. field	-	

Table 5: Driving Trailer Coach measuring Points

6.5.2 Motor Coach (MC1/MC2)

S. No.	Test Condition	Location	Test Limit	Test Point Inside the car		Test Point Outside the car on both side On Platform	
1.	Stationary	Passenger saloon	Public	Three Points along Passage	a. c. field d. c. field	Three Points outside	a. c. field d. c. field
2.			Worker's area	Electrical Panel / Pantry Area	a. c. field d. c. field		
3.	Dynamic	Passenger saloon		Traction Converter1	a. c. field		
4.				Traction Converter2	a. c. field		

5.			Public	Traction Motor 1 & 2	a. c. field	
6.				Traction Motor 3 & 4 / 20 kVA Tx	a. c. field	

Table 6: Motor Coach measuring Points

6.5.3 Trailer Coach (TC)

Sr. No.	Test Condition	Location	Test Limit	Test Point Inside the car		Test Point Outside the car on both side On Platform	
1.	Stationary	Passenger saloon	Public	Transformer	a. c. field	Transformer	a. c. field
2.				Auxiliary Converter	a. c. field d. c. field	Auxiliary Converter	a. c. field d. c. field
3.				Under Pantograph	a. c. field	Near Pantograph	a. c. field
4.				At end of coach	a. c. field d. c. field	At end of coach	a. c. field d. c. field
5.	Dynamic	Passenger saloon	Public	Transformer	a. c. field	-	-
6.				Under Pantograph	a. c. field	-	-
7.				End of coach	a. c. field d. c. field	-	-

Table 7: Trailer Coach measuring Points

6.6 Test environment

Any magnetic induction sources outside the rolling stock and along track side can influence the measurements carried out. In order to be able to correlate particular magnetic induction values it is necessary, beforehand and during the measurements, to indicate the positions of any possible external sources on a plan of the line run.

7 Test Equipment and Test Set-up

This clause defines the frequency range and the measurement equipment, evaluation methods and measurement execution.

7.1 Frequency range

Measurements and/or calculation and simulation shall be performed at d.c. up to 1 Hz and in the frequency range from 5 Hz to 20 kHz. In railway environment measurement of the magnetic field-strength respectively the magnetic induction is sufficient in this frequency range. The gap between 1 Hz and 5 Hz is justified by the fact that the limit decreases from 1 Hz to 5 Hz by a factor $1/f^2$. In matching the limit at 5 Hz it is assumed, that the limit is matched at lower frequencies, too. Moreover relevant sources in the frequency range 1 Hz - 5 Hz are not expected. Measurements are necessary for frequencies up to 20 kHz because no relevant field strengths are expected above.

7.2 Measurement equipment

The measurement equipment shall meet the requirements as defined in the basic regulation and shall be in accordance with the following technical requirements as a minimum. The centre of each field probe shall be the reference point for the given measuring distances in this standard.

7.2.1 Field probes

The following field probes shall be used for measurement:

- measurement of the d.c. magnetic field: tri-axial isotropic probe;
- measurement of a.c. magnetic field: tri-axial probe with three orthogonal loops, loop with

100 cm' area, minimum frequency range 5 Hz to 20 kHz.

7.2.2 Summation of spatial components

Three measurements shall be performed at the same time in three orthogonal planes to obtain the different components of the field. The total H-field would be given by the following formula:

$$H = \sqrt{H_x^2 + H_y^2 + H_z^2}$$

For a.c. fields the summation has to be performed either in the time domain after filtering or in the frequency domain after FFT (Fast Fourier Transform) of the measured components of the field.

7.2.3 Data logging

It is recommended to use a data logging equipment to make the measurement data available for further offline evaluation.

7.2.4 Dynamic range

The dynamic range of the measurement chain shall cover the range from 5% of the applicable limit to 200 % of the applicable limit as a minimum.

7.2.5 Isotropy

The isotropy deviation of the complete system shall be 5 % or less.

7.2.6 Linearity

The linearity of the complete system regarding measured field strength values shall be not more than ± 5 % in the required dynamic range

7.2.7 Calibration and accuracy

All relevant measurement equipment shall be calibrated for the used frequency range. The uncertainty of the complete measurement chain from the field probes to the final display unit shall be not more than 20 %.

The complete measurement chain shall be checked to verify its performance and accuracy.

7.3 **Evaluation methods**

The methods used for the evaluation and assessment of measurement data should be in line with the basic regulations.

7.3.1 DC magnetic field

The evaluation of DC magnetic fields shall be done by using the formula of summation of spacial components.

7.3.2 AC magnetic field

For a.c. magnetic fields, two basic methods for data evaluation and assessment are applicable. The method defined by ICNIRP guidelines is FFT. This is the basic method.

As the FFT overestimates magnetic fields in comparison with the results of time domain method

(the railway environment is characterized by pulsed and complex non-sinusoidal waveforms) the application of the second method (as mentioned in ICNIRP statement) may be more realistic in some cases.

In case of exceeding the limit because of transients they should be identified. Transients with a duration of less than 1s, e.g. during switching events, can be disregarded.

7.3.3 FFT

Evaluation in the frequency domain with FFT-analyser, digital signal processor or equivalent equipment (online or offline of recorded data) and followed by spectral weighting and summation of spectral components as required by particular basic requirements/standards and as necessary for conversion of the measured signals to values in terms of magnetic flux density $B(f)$.

Record length of FFT-data (i.e. observation time and bandwidth of spectral signal) and sampling frequency should be in accordance with the basic requirements/standards.

Recommendations/typical parameters:

Time window: hanning (no overlap)

Record length: 0,5 s (realtime FFT)

Sampling frequency: > 40 kHz

Summation of spectral components: linear, spectral lines under a threshold value of 10 % of the limit value are not taken into account.

7.3.4 Time domain

Evaluation in the time domain ($dB(t)/dt$ or $B(t)$) with digital or analogue filters with appropriate filter characteristics in order to perform the spectral weighting and conversion of the measured signals to values in terms of magnetic flux density $B(t)$, if necessary followed by evaluation as required by particular basic requirements/standards (example is given in ICNIRP statement).

Sampling frequency: > 40 kHz

7.4 Test Execution

Measure all 3 axis of the magnetic field with one axis in parallel to the rails.

For each point of every measurement area, magnetic fields are measured in the following way:

7.4.1 Inside rolling stock:

Measuring all 3 axis of the magnetic field in static condition for a duration of (30 — 60) s.

Measuring all 3 axis of the magnetic field in dynamic condition from the standstill with maximum acceleration to maximum speed, coasting for a duration of at least 10 s and maximum electrical break to stop.

For each measuring point and each condition one measurement is sufficient.

7.4.2 Outside rolling stock:

Measuring all 3 axis of the magnetic field in static condition for a duration of (30 — 60) s.

8 Test Report

Guidelines to the report can be found in EN ISO/IEC 17025.

The following information pertaining to the instrumentation and measurements should also be provided in all cases:

- Date of measurements
- Post processing method
- Time of measurements
- Test set-up
- Environmental condition (e.g. weather conditions)
- measurement uncertainty
- ICNIRP value of each performed assessment
- Spectrum analysis for selected places (e.g. with high emission or requested from third party)
- Any deviation from the given test conditions (e.g. measurement duration, maximum currents) with a justification.

The following should be specifically noted during the rolling stock tests:
track and direction of travel;

- train configuration - vehicles of the rolling stock and their relative position;
- the approximate weight of the rolling stock (crush load or tare);
- the position of the active pantograph(s);
- feeding station(s);
- nature of the return circuit (double track/single track) and cables for return current;
- location of booster transformers and feeding stations related to the measuring positions.

9 Pass/Fail Criteria

For active medical implantable devices there is only a susceptibility limit to d.c. magnetic fields given in EN 45502-2-1.

For a.c. magnetic fields, assessment are applicable as per the method defined by ICNIRP guidelines.