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Magnetic field levels generated by electronic and electrical apparatus in the railway environment with respect to human exposure - Measurement procedures

Niveaux de champ magnétique générés par les appareils électriques et électroniques dans l'environnement ferroviaire en regard de l'exposition humaine - Procédures de mesure

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MAGNETIC FIELD LEVELS GENERATED BY ELECTRONIC AND ELECTRICAL APPARATUS IN THE RAILWAY ENVIRONMENT WITH RESPECT TO HUMAN EXPOSURE – MEASUREMENT PROCEDURES

FOREWORD

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International Standard IEC 62597 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This first edition cancels and replaces IEC TS 62597 published in 2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the Technical Specification:

– Annex A test plan has been converted to normative text
– New Annex B (informative) for measurement technique for lower frequency has been added
– New Annex C (informative) about consistency to IEC 62110 in some countries has been added

The text of this International Standard is based on the following documents:

FDIS	Report on voting
9/2505/FDIS	9/2517/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

The intention of this document is to establish a suitable measuring/calculation method for determining the magnetic fields in the space around the equipment mentioned in the scope, to standardize operating conditions and to fix measuring/calculation distances.

MAGNETIC FIELD LEVELS GENERATED BY ELECTRONIC AND ELECTRICAL APPARATUS IN THE RAILWAY ENVIRONMENT WITH RESPECT TO HUMAN EXPOSURE – MEASUREMENT PROCEDURES

1 Scope

The scope of this document 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 specified 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.

The object of this document is to provide 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.

The regulations regarding the protection of human beings during exposure to non-ionizing electromagnetic fields in the railway environment are different within the countries worldwide. This document offers a procedure regarding measurement, simulation/calculation and evaluation.

The measurement procedures and points of measurement cover also the aspect of persons bearing active implantable medical devices.

This document does not apply to the risk assessment for persons bearing active implants in magnetic field generated by electronic and electrical apparatus in the railway environment.

This document does not apply to personal electronic devices (e.g. mobile phones, laptop computers, wireless communication systems, etc.) of passengers and workers.

This document does not apply to intentional transmitters with frequencies higher than 20 kHz.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62311, *Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz – 300 GHz)*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
worker
driver, train-staff and all people working in the railway environment

3.1.2
fixed installation
infrastructure of railway environment without rolling stock

3.1.3
electric traction system
railway electric distribution network used to provide energy for rolling stock

Note 1 to entry: This system includes:

- contact line systems,
- return circuit of electric traction systems,
- running rails of non-electric traction systems, which are in the vicinity of, and conductively connected to the running rails of an electric traction system,
- electrical installations, which are supplied from contact lines either directly or via a transformer,
- electrical installations in power plants and substations, which are utilized solely for generation and distribution of power directly to the contact line,
- electric installations of switching stations.

[SOURCE: IEC 60050-811:2017, 811-36-21]

3.1.4
main line
railway line for passenger and freight trains in regional and long-distances operation

3.1.5
urban transport
railway line for underground trainsets, trams, LRV (Light Rail Vehicles), trolleybuses to operate within the boundary of a city

3.1.6
rolling stock
smallest unit which can be operated covering all vehicles with or without motors

[SOURCE: IEC 60050-811:2017, 811-02-01, modified – "smallest unit which can be operated covering" has been added.]"

3.1.7
level crossing
crossing of railway and a road at the same level

[SOURCE: IEC 60050-811: 2017, 811-07-01]

3.2 Abbreviated terms

AC	Alternating Current
DC	Direct Current
EMF	Electromagnetic fields
FFT	Fast Fourier transform
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEEE	Institute of Electrical and Electronics Engineers
LIM	Linear Induction Motor

4 Measurement procedure

4.1 General

In railways three electromagnetic sources can affect human beings: rolling stock, fixed power supply installation and signalling equipment.

According to generic EMF standard IEC 62311, there are two separate summation regimes for simultaneous exposure to fields of different frequencies. They depend on the effects of the exposure. In the frequency range from 1 Hz to 10 MHz the electrical stimulation is relevant and the underlying basic restriction is induced current density. In the frequency range from 100 kHz to 300 GHz, thermal effects are relevant.

As the detectable emission of rolling stock, fixed power supply installation and signalling equipment is in the frequency range from DC 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 signalling equipment is low in comparison with other sources of EMF in the railway environment, its contribution can be neglected.

The measurement procedure of the whole railway system is divided into two cases.

Case 1: Rolling stock (see 4.2)

– measurements inside rolling stock, and
– measurements outside rolling stock (on platform or alternative).

Case 2: Fixed installation (see 4.3)

– measurement of existing railway infrastructure,
– simulation/calculation of worst case situation (e.g. bridges, level crossing, maximum possible current in overhead contact line or catenary, third rails).

NOTE 1 Compliance of rolling stock can be demonstrated with the first explained case. Compliance of infrastructure can be demonstrated with the second explained case.

For the apparatus, systems and fixed installations in railway environment there are basic restrictions for general public and workers specified in ICNIRP, IEEE and other country-specific documents (see Bibliography).

With compliance of both cases, it can be assumed that the whole railway system is in compliance with the regulations referenced in this document.

NOTE 2 The process defined in this subclause applies also to demonstrate the compliance of railway equipment with active implantable medical devices.

Subclause 4.2 defines the measurement points in established areas inside and outside rolling stock.

Subclause 4.3 defines the measurement points in established areas in fixed installation and gives details regarding simulation/calculation.

Subclause 4.4 defines the test conditions during the measurement of the magnetic field.

Subclause 4.5 is related to the test environment.

A test plan for rolling stock and infrastructure is given in Annex A.

4.2 Rolling stock

4.2.1 General

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

4.2.2 Accessible areas for workers inside rolling stock

The measurements indicate the emissions of the train equipment in standstill and dynamic condition (see 4.4.1).

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.

4.2.3 Public areas inside rolling stock

The measurements indicate the emissions of the train equipment in standstill and dynamic condition (see 4.4.1).

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.

4.2.4 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.

4.3 Fixed installation

4.3.1 General

Demonstration of compliance of the existing infrastructure shall include fixed electric traction system of railway environment.

Positions where compliance has to be demonstrated are given in 4.3.2 to 4.3.4.

Simulation/calculation can give worst case figures (see 4.3.5).

NOTE Country specific measurement procedures can be found in Annex C.

4.3.2 Open railway route (public and worker)

Measurements and/or simulation/calculation regarding public shall be carried out in the distances from the centre of the nearest track of regarded system as given below in Table 1 or in higher distances within the nearest accessible area for public, 1,5 m above ground level (standing area) where people can be at the detected location.

Table 1 – Location and distances

Location	Horizontal distance from centre of track m	Remark
Main line	10 (for public)	If not regulated by legislative requirements. Main line without access to the rails for public.
Urban transport	3 (for public)	If not regulated by legislative requirements. Urban transport without access to the rails for public.
Trams, trolley buses	0	
Level crossings	0	
Bridges	0	
Underpass	0	
NOTE 1 Combined systems (main line and urban line close together) have to be regarded individually which may lead to other distances. NOTE 2 There are some cases where the location of maximum field strength is different from the centre of the track. In these cases the place with the maximum field strength has to be considered.		

Measurements for workers on open railway routes shall be carried out at the closest possible (not restricted) position to the sources of emission where workers can be.

Short circuit conditions are excluded.

4.3.3 Areas close to fixed power supply installations (public and workers)

Measurements and/or simulation/calculation shall be carried out at the closest possible (not restricted) position to the sources of emission from fixed power supply installations where public and workers can be (e.g. as marked on the floor or given by fences). In this case then the consideration of all the public areas shall be at heights of 0,3 m, 0,9 m and 1,5 m and of all the worker areas shall be at heights of 0,9 m and 1,5 m. The horizontal measuring distance to the walls or fences is 0,3 m or at the minimum distance (> 0,3 m) where public and workers can be.

4.3.4 Platform (public and worker)

Measurements and/or simulation/calculation on the platform shall be carried out at heights of 0,9 m and 1,5 m above the platform level and with 0,3 m horizontal distance from the edge of the platform.

4.3.5 Simulation/calculation

If measurements cannot cover the worst case conditions, simulation/calculation with maximum expected current values (to be set by the infrastructure manager) shall be carried out. Harmonics known to be lower than a threshold value of 10 % of the limit value can be neglected.

Validation of the simulation/ calculation shall be performed by comparison between calculated/ simulated results and measured values for known conditions.

4.4 Test conditions

4.4.1 Test of rolling stock

Tests are to be done under normal operating conditions, only.

The condition of the rolling stock during the magnetic field measurements is described below:

– Stand still condition (S)

  The rolling stock is not moving.

  The traction circuits shall be energized 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).

– 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 energized and operating. The auxiliary circuits shall operate and all the appliances shall be active (e.g. air conditioning/heating, lights, window heater, electric generators).

There may be rolling stock (e.g. urban transport) which cannot accelerate with maximum line current under test condition, or supply systems that cannot be deliberately set such that the rolling stock will draw the maximum line current for the purposes of the test. In these cases the maximum emission shall be calculated based on the measurement results and monitored line current using an appropriate method (e.g. extrapolation).

NOTE 1 The emissions of onboard equipment, the third rail or catenary influence the measurement results of rolling stock respectively. While individual fields from onboard equipment will vary as a function of the current in the device, catenary or third rail field will vary as a function of number of cars and current.

The test has, as far as possible, to be done without the influence of other rolling stock.

Electrical brake systems utilizing other circuits than the electrical propulsion systems tested during acceleration need to be tested separately.

NOTE 2 There are some test conditions (interface between rolling stock and power supply) where this separation is not possible.

4.4.2 Test of infrastructure

– Open railway route and platform

  The actual line current of the open railway route/platform as the significant source of emission shall be noted during emission tests.

  Maximum emission shall be calculated based on the measurement results and monitored line current using an appropriate method (e.g. extrapolation).

– Fixed power supply installations

  The actual load of the fixed power supply installations shall be noted during emission tests.

  Maximum emission shall be calculated based on the measurement results and monitored line current using an appropriate method (e.g. extrapolation).

  The load can change widely in short time. Emission is related to load.

4.5 Test environment

Any magnetic induction sources outside the rolling stock and along trackside 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.

5 Measurement technique

5.1 General

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

5.2 Frequency range

Measurements and/or calculation and simulation shall be performed at DC up to 1 Hz and in the frequency range from 5 Hz to 20 kHz.

NOTE 1 In railway environment measurement of the magnetic field-strength respectively the magnetic induction is sufficient in this frequency range.

NOTE 2 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 to 5 Hz are not expected.

NOTE 3 Measurements are necessary for frequencies up to 20 kHz because no relevant field strengths are expected above.

NOTE 4 For systems which contain considerable magnetic sources with frequency ranges from DC to 5 Hz, see also Annex B for additional information.

5.3 Measurement equipment

5.3.1 General

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 document.

NOTE See also Annex B for country specific additional information for systems which contain considerable magnetic sources with time-varying magnetic field with frequencies up to 5 Hz.

5.3.2 Field probes

The following field probes shall be used for measurement:

- measurement of the DC magnetic field: tri-axial isotropic probe;
- measurement of AC magnetic field: tri-axial probe with three orthogonal loops, loop with 100 cm^2 area, minimum frequency range 5 Hz to 20 kHz.

NOTE For measurements in the railway environment the magnetic flux density B is the magnitude of a field vector that is equal to the magnetic field strength H multiplied by the permeability of vacuum μ_0.

$$B = \mu_0 H$$

5.3.3 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 resultant H-field would be given by the following formula:

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

For AC 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.

NOTE The formula for H will give worst case values for summation in the frequency domain as the phase relation between the components is lost. More accurate methods may be used.

5.3.4 Data logging

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

5.3.5 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.

5.3.6 Isotropy

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

5.3.7 Linearity

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

5.3.8 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.