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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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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- withdrawn,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.

5.4 Evaluation methods

5.4.1 General

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

5.4.2 DC magnetic field

The evaluation of DC magnetic fields shall be done by using the formula stated in 5.3.3.

5.4.3 AC magnetic field

5.4.3.1 General

The methods defined by ICNIRP and IEEE documents (see Bibliography) are frequency domain (such as FFT, see 5.4.3.2) and time domain (see 5.4.3.3). The frequency domain is the basic method.

As the frequency domain method overestimates magnetic field strength 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 time domain method (as mentioned in ICNIRP statement (see Bibliography)) 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 1 s, e.g. during switching events, can be disregarded.

5.4.3.2 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 relevant requirements/standards.

Recommendations/typical parameters (not mandatory):

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.

Evaluation of transients and variables frequencies by FFT analysis may cause wrong results. If peak hold result complies with limit values, a detailed analysis of each time step is not necessary. Changes in load (e.g. change from accelerating to coasting) may cause errors in FFT analysis. Therefore a separate investigation of different operating conditions without the transition is allowed.

5.4.3.3 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 (see Bibliography)).

Sampling frequency: > 40 kHz.

NOTE The two methods:

- will produce identical results for sinusoidal magnetic fields (assuming that the weighting functions are the same for both methods);
- will produce comparable results for periodic magnetic fields;
- may produce different results for impulse shaped magnetic fields (for multi frequency signals the FFT method overestimates the exposure).

5.5 Measurement execution

5.5.1 General

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.

5.5.2 Rolling stock

– Inside rolling stock:

  Measuring all 3 axis of the magnetic field in static condition for a duration of (30 to 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 brake to stop.

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

– Outside rolling stock:

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

5.5.3 Infrastructure

Monitor the current affecting the magnetic field at the same time of magnetic field measurement.

During measurement different railway related and other magnetic field sources may contribute to measuring result.

During measurement on open railway line no electric active rolling stock shall be between the fixed power supply installations and the magnetic field measurement point.

NOTE In some countries where national legislative regulations are in compliance with IEC 62110, see also C.4.2 for additional information.

6 Report

Guidelines to the report can be found in 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;
– relevant results 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);
- position(s) of the active pantograph(s);
- feeding station(s);
- nature of the return circuit(s) (double track/single track) and cables for return current;
- location of booster transformers and feeding stations related to the measuring positions;

It is also recommended as far as possible to record the line current corresponding to the total consumption of the rolling stock, and preferably also the rolling stock speed and catenaries voltage.

Other information which should be provided, when appropriate, includes drawings which describe the area and locations where measurements are performed.

Annex A
(normative)

Test plan

A.1 General

Verification of magnetic field levels in rolling stock and infrastructure can consume large amounts of time. Therefore it is recommended to prepare a test plan.

DC magnetic field measurements are only to be performed if significant DC magnetic field sources are expected (e.g. lines with DC traction/DC power supply, coaches with DC train heating line).

A.2 Rolling stock

A.2.1 General

The process of test plan for rolling stock is:

a) identify electromagnetic sources to be analysed,
b) define relevant frequency range to be considered,
c) define measurement position and dynamic range.

A.2.2 Electromagnetic sources

The measurement plan shall identify the sources of magnetic fields. Primary sources are items that handle large currents such as transformers, inductors, electric motors, converters and associated cabling.

Identification of magnetic field sources shall be done including:

- expected frequency range including DC,
- dependence on operating conditions of the train (current consumption, motor current or other physical quantities),
- external supply (e.g. catenary or third rail).

Only the rolling stock(s) under test should be operated in the supply line section to minimize the influence of infrastructure.

A.2.3 Frequency range of measurement

The frequency range of this document is chosen to include known and in the near future expected working frequencies of electrical equipment.

If it can be verified that the maximum relevant frequency of the sources is below a set frequency then the time of measure and post processing of each measurement position can be reduced.

NOTE Not relevant frequencies are those with magnetic field strength below 10 % of the limit.

The verification can be done before measurement on the rolling stock by measurement of magnetic fields of equipment in laboratory. Other means of verifications can be frequency analysis of currents in equipment.

A.2.4 Measurement positions

A.2.4.1 Stand still conditions

If it can be shown that the maximum magnetic field is local at a given measuring height (see 4.2), the other measuring height(s) can be omitted.

A.2.4.2 Dynamic conditions

In some cases measurement positions from stand still condition (see 4.4.1) can be valid also for the dynamic conditions.

This shall be deduced from the test results of the stand still position measurement together with an analysis of the position of other sources so that the magnetic field will not be increased in that position during dynamic condition measurement.

A.3 Infrastructure

A.3.1 Open line

a) Use a validated tool for simulation/calculation, define worst case situations for each of the typical constellations regarding:
   - conductor geometry,
   - feeding line (with or without),
   - parallel feeding lines,
   - absolute current (I_{max} from fixed power supply installations),
   - return current distribution or impedance of ground.

b) Typical constellations of railway routes to be considered are:
   1) single track line,
   2) double track line,
   3) two double track lines in parallel (e.g. one for high speed, one for local traffic),
   4) multiple track lines are included in 3).

   Simulation can be done either by simulating the current distribution in the conductors or by injecting currents considering worst case assumptions about current distribution.

   NOTE 1 In complex systems the current distribution cannot be measured with sufficient accuracy. The tool is usually based on Biot-Savarts law for the magnetic field of each conductor. Therefore the tool can be validated at a practicable place with simple geometry and a small number of conductors.

c) Compare the worst case results of simulation/calculation with limits.

d) Verification measurement at 2 places of each of the typical constellations.

   Verification measurement can be done by either:
   - a long time measurement (e.g. 24 h including rush hour) in a place apart from fixed power supply installations (5 km for AC lines and 1 km or the maximum available distance for DC lines). Measured magnetic field shall be compared to simulated magnetic field,
   - measuring current in each of the conductors and magnetic field at the same time (practicable only at a single tracked line). The measurement results have to be extrapolated to maximum current values.

   NOTE 2 A verification of open line covers tunnels as well. The magnetic fields caused by railway sources can be lower in tunnels as the current distribution may include return paths via the reinforcement that improves compensation.

A.3.2 Level crossing

Procedure for assessment of level crossing is covered by open line.

A.3.3 Platform

A.3.3.1 General

The procedure is the same as that given for open lines. The worst case model of a platform includes only the two nearest tracks to each side (if existing) in a place apart from fixed power supply installations (5 km for AC lines and 1 km or the maximum available distance for DC lines). The influence of additional tracks can be neglected.

A.3.3.2 Terminal station

Terminal station is covered by platform because of magnetic field compensation due to higher return currents portion in the track of terminal station and low traction current at low speed.

A.3.4 Bridges/underpass

The procedure is the same as that given for open lines. Care has to be taken in modelling the layout of the contact line system (e.g. overhead contact line itself, line feeders, reinforcing feeders).

A.3.5 Fixed power supply installations

Usually no simulation/calculation for fixed power supply installations is made. Nevertheless an extrapolation at least for the magnetic field of cables is possible after measurement.

a) Classify the different types of fixed power supply installations regarding:
   - power classes,
   - transformed voltage level,
   - layout of cabling,
   - type of return current conductor system,
   - ground-plan (distance of sources of magnetic fields to the fence of fixed power supply installation).
b) Measurement shall be carried out only on one fixed power supply installation of each different type. Worst case measuring points shall be chosen close to sources of high magnetic fields. e.g.:
   - switchgear close to the active bus bar;
   - transformer;
   - earth bus bar (where all return currents are collected);
   - cable ducts with high currents;
   - fence of fixed power supply installation (close to emission sources as transformer);
   - cabling or return, current collector.

Annex B
(informative)

Measurement technique for lower frequency

B.1 Lower frequency ranges

Lower time-varying field up to 5 Hz are foreseen in some traction systems.

NOTE An example is linear induction motors (LIM) described in IEC 62520. The maximum RMS value of the resultant magnetic field may appear when the LIM stops acceleration during the operating frequency range up to 5 Hz.

B.2 Field probes for lower frequency

For measurement of the AC magnetic field with lower frequency ranges, a tri-axial isotropic fluxgate sensor probe specified in IEC 61786 with a minimum frequency range from DC to 20 kHz is applicable.

B.3 Dynamic range

The dynamic range of the measurement chain shall cover a range similar to or larger than the expected maximum level of the field strength. Automatic range should not be used for measurement in railway environment.

Annex C
(informative)

Consistency to IEC 62110 in some countries

C.1 General

Following legislative regulations in compliance with IEC 62110, measurement procedures for fixed installations should be coherent with and compatible with the measurement procedures for general electric power systems. In this case IEC 62110 should be referenced if applicable.

IEC 62110 is not applicable to exposure in working area associated with, for example, the operation and/or maintenance of the fixed power supply installations. Therefore, Annex C is applicable in areas where public can be (area except for working area).

C.2 Terms and definitions

For the purpose of this annex, the terms and definitions given in IEC 62110 apply.

C.3 Fundamental measurement procedure

Following fundamental measurement procedures specified in IEC 62110:2009 apply:

– Single-point measurement in 5.2;
– Three-point measurement in 5.3;
– Five-point measurement in 5.4.

C.4 Measurement procedure for fixed installations

C.4.1 General

Positions where compliance has to be demonstrated are given in C.4.2 to C.4.4.

Measurement procedure should be coherent and compatible with IEC 62110.

C.4.2 Open railway route

A single-point measurement should be carried out.

The magnetic field under/above an overhead line is normally considered to be uniform.

If the magnetic field is considered to be non-uniform, a three-point measurement should be carried out.

Measurements and/or simulation/calculation should be carried out in the distances from the centre of the nearest track of regarded system as given in Table C.1 or at higher distances within the nearest accessible area.

Table C.1 – Location and distances

Location	Horizontal distance m	Remark
Main line	0,2 from the closest distance where public can be.	Main line without access to the rails for public. Normally, the boundary is marked by walls or fences.
Urban transport	0,2 from the closest distance where public can be.	Urban transport without access to the rails for public. Normally, the boundary is marked by walls or fences.
Trams, trolley buses	0	At the centre of track.
Level crossings	0	At the centre of track.
Bridges and underpasses	0 (at the centre of track) or the expected maximum point of the magnetic field.	
Inside buildings	0,2 from the closest distance where public can be.	Normally, the boundary is marked by walls or fences.

It is preferred to have measurement arrangements in which the line current and field strength are correlated so that the maximum value of field strength can be identified. Generally, the value of line current depends on the type of feeding system, the distance from substation, the number of parallel tracks, and the number of trainsets. The measurements may be carried out taking into consideration these factors.

The direction of the axis of the field probe should be noted with respect to the track(s) in the test report. There is no requirement for direction of the axis.

NOTE The isotropy of the field probe generally has a deviation which is characterized by an angular between the axis of the probe and the direction of the magnetic field.

C.4.3 Areas close to fixed power supply installations

A three-point measurement should be carried out.

Measurements and/or simulation/calculation should be carried out at the closest possible (not restricted) position to the sources of emission from fixed power supply installations where public can be (e.g. as marked on the floor or given by fences/walls).

The horizontal distance should be 0,2 m or the closest possible horizontal distance (> 0,2 m) where public can be.

A five-point measurement should be performed where the area above a fixed power supply installation is accessible and where it is not unusual that a person may lie on the floor.

In cases where it is unusual that a person lies on the floor, the normal three-point measurement should be performed.

C.4.4 Platforms

A three-point measurement should be performed.

On platforms, the heights of measurement and/or simulation/calculation above the platform level are given: 0,5 m, 1,0 m and 1,5 m applying IEC 62110 correspondingly.

The horizontal distance should be 0,3 m or the closest possible horizontal distance (> 0,3 m) from the edge of the platform where public can be.

The measurement arrangements should be the same as shown in C.4.2.

C.4.5 Procedure to find out the measurement point

Measurement should be carried out at a place/point where the field level would be the maximum or a place/point of interest.

NOTE The place or point of measurement means: the measurement place of an open line and a platform with respect to the track direction, the measurement point of a fixed power supply installation.

The following conditions can be neglected for the selection of the measurement point on an open railway line only if applying Annex C:

– the distance from a fixed power supply installations to the measurement point,
– the locations of electric active rolling stocks with respect to the fixed power supply installations and the measurement point.

However, fixed power supply installations and electric active rolling stocks which may disturb the magnetic field to be measured should be considered during the measurement.

The method to find out the place/point should meet the national specific technical criteria, appropriate standards or other method verified. Simulation or calculation specified in Annex A is a useful method, however it is not mandatory only if applying Annex C.

The following shows example methods:

– Using simulation or calculation (method specified in A.3.1 or another method).
– Method specified in IEC 62110.
– Given by national laws, technical criteria or other stakeholders.

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