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Edition 3.0 2018-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway applications – Electromagnetic compatibility – Part 2: Emission of the whole railway system to the outside world

Applications ferroviaires – Compatibilité électromagnétique – Partie 2: Émission du système ferroviaire dans son ensemble vers le monde extérieur

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FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 62236-2 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This third edition cancels and replaces the second edition published in 2008. It constitutes a technical revision and has been developed on the basis of EN 50121-2:2015.

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

a) clarification of scope (Clause 1);
b) combination of former Clause 5 and Annex A related to method of measurement for moving trains and traction substations (5.1);
c) moving emission values for radiated H-fields in the frequency range 9 kHz to 150 kHz to new Annex C due to the fact that:
   – there are very few outside world victims;

– there is low reproducibility.

d) clarification of acquisition method (5.2).

This International Standard is to be read in conjunction with IEC 62236-1.

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

FDIS	Report on voting
9/2336/FDIS	9/2366/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.

A list of all parts in the IEC 62236, published under the general title *Railway applications – Electromagnetic compatibility*, can be found on the IEC website.

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.

RAILWAY APPLICATIONS – ELECTROMAGNETIC COMPATIBILITY –

Part 2: Emission of the whole railway system to the outside world

1 Scope

This part of IEC 62236 is intended to define the electromagnetic environment of the whole railway system including urban mass transit and light rail system. It describes the measurement method to verify the emissions, and gives the cartography values of the fields most frequently encountered.

This document specifies the emission limits of the whole railway system to the outside world.

The emission parameters refer to the particular measuring points defined in Clause 5. These emissions are assumed to exist at all points in the vertical planes which are 10 m from the centre lines of the outer electrified railway tracks, or 10 m from the fence of the substations.

Also, the zones above and below the railway system may be affected by electromagnetic emissions and particular cases are considered individually.

These specific provisions are used in conjunction with the general provisions in IEC 62236-1.

For existing railway lines, it is assumed that compliance with the emission requirements of IEC 62236-3-1, IEC 62236-3-2, IEC 62236-4 and IEC 62236-5 will ensure the compliance with the emission values given in this document.

For newly built railway systems, it is best practice to provide compliance to the emission limits given in this document (to be defined in the EMC plan according to IEC 62236-1).

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 62236-1:2018, *Railway applications – Electromagnetic compatibility – Part 1: General*

CISPR 16-1-1:2015, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-4:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements*
CISPR 16-1-4:2010/AMD1:2012
CISPR 16-1-4:2010/AMD2:2017

3 Terms, definitions and abbreviated terms

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 Terms and definitions

3.1.1
apparatus
device or assembly of devices which can be used as an independent unit for specific functions

[SOURCE: IEC 60050-151:2001, 151-11-22]

3.1.2
environment
surroundings in which a product or system exists, including air, water, land, natural resources, flora, fauna, humans and their interrelation

[SOURCE: IEC Guide 109:2012, 3.3]

[SOURCE: IEC 60050-901:2013, 901-07-01]

3.1.3
traction substation, <in electric traction>
substation, <in electric traction>
substation the main function of which is to supply an electric traction system

Note 1 to entry: The synonym substation is used only when the context is clear.

[SOURCE: IEC 60050-811:2017, 811-36-02]

3.1.4
rolling stock
all vehicles with or without motors

Note 1 to entry: Examples of vehicles include a locomotive, a coach and a wagon.

[SOURCE: IEC 60050-811:2017, 811-02-01]

3.2 Abbreviated terms

AC	Alternating current
BW	Band width
DC	Direct current
E	Electric (field)
EMC	Electromagnetic Compatibility
FFT	Fast Fourier transform
H	Magnetic (field)
HV	High voltage
ITU	International Telecommunication Union
r.m.s.	root mean square

4 Emission limits

4.1 Emission from the open railway system during train operation

The emission limits in the frequency range 150 kHz to 1 GHz are given in Figure 1 and the measurement method is defined in Clause 5.

Annex B gives guidance values for typical maximum field values at fundamental frequency of different traction power systems which can occur. They depend on numerous geometrical and operational parameters which can be obtained from the infrastructure manager.

It is not possible to undertake complete tests with quasi-peak detection due to the reasons stated in Annex A.

There may be cases in which radio or other railway external services with working frequencies below 150 kHz are in operation close to the railway system. The EMC management plan covers these cases and an adequate level of emission from the railway system on these working frequencies may be found in the values given in informative Annex C, hence no guarantee can be given for an undisturbed operation.

4.2 Radio frequency emission from traction substations

Radio frequency emission from the traction substation to the outside environment measured according to the method defined in Clause 5 shall not exceed the limits in Figure 2.

The limits are defined as quasi-peak values and the bandwidths are those used in CISPR 16-1-1:

	Bandwidth
Frequencies from 150 kHz to 30 MHz	9 kHz (BW 1)
Frequencies above 30 MHz	120 kHz (BW 2)

The distance of 10 m defined in Clause 5 shall be measured from the fence of the substation. If no fence exists, the measurements shall be taken at 10 m from the apparatus or from the outer surface of the enclosure if it is enclosed.

For other kinds of fixed installations like auto-transformers, the same limit and measuring distance shall be applied.

There may be cases in which radio or other railway external services with working frequencies below 150 kHz are in operation close to the traction substation. The EMC management plan covers these cases and an adequate level of emission from traction substation on these working frequencies may be found in the values given in informative Annex C, hence no guarantee can be given for an undisturbed operation.

5 Method of measurement of emission from moving rolling stock and substations

5.1 General and specific measurement parameters

NOTE The method of measurement is adapted from CISPR 16-2-3 to a railway system with moving rolling stock and substations. The background to the method of measurement of moving rolling stock is given in Annex A.

5.1.1 General measurement parameters

5.1.1.1 Frequency bands

Frequency bands and bandwidths at –6 dB used for measurements are in accordance with CISPR 16-1-1.

These are:

Frequency bands:	0,15 MHz to 30 MHz	30 MHz to 300 MHz	300 MHz to 1 GHz
Bandwidth:	9 kHz (BW 1)	120 kHz (BW 2)	120 kHz (BW 2)

Other bandwidth for peak measurement can be chosen according to CISPR 16-1-1. Data measured with the reference bandwidth shall take precedence.

5.1.1.2 Measurement uncertainty

The measurement uncertainty of the measuring equipment shall comply with the requirements in CISPR 16-1-1 and CISPR 16-1-4.

Due to the measurement method, the normalized site attenuation may not be considered in the measurement uncertainty.

5.1.1.3 Types of antennas

To cover the full frequency range, antennas of different design are required. Typical equipment is described below:

– for 150 kHz to 30 MHz, a loop or frame antenna is used to measure H field (see Figure 3);
– for 30 MHz to 300 MHz, a biconical dipole is used to measure E field (see Figure 4);
– for 300 MHz to 1,0 GHz, a log-periodic antenna is used to measure E field (see Figure 5).

For measurements in the frequency range of 30 MHz to 1 GHz a combined antenna may be used.

Calibrated antenna factors are used to convert the terminal voltage of the antenna to field strength.

5.1.1.4 Measurement distance and height

The preferred distance of the measuring antenna from the centreline of the track on which the vehicle is moving (Test track) is 10 m. In the case of the log-periodic antenna, the 10 m distance is measured to the mechanical centre of the array.

The preferred distance of the measuring antenna while measuring the emission of the substation is 10 m from the outer fence of the substation, at the midpoints of the three sides, excluding the side which faces the railway system, unless this side is more than 30 m from the centre of the nearest electrified railway track. In this case all four sides shall be measured. If the length of the side of the substation is more than 30 m, measurements shall be taken additionally at the corners.

Where the antennas are not at 10 m, the results can be converted to an equivalent 10 m value by using the following formula:

$$E_{10} = E_x + n \times 20 \times \log_{10} (D/10)$$

where

E_{10} is the value at 10 m;

E_x is the measured value at D m;

n is a factor taken from Table 1 below.

Table 1 – Conversion factor *n*

Frequency range	*n*
0,15 MHz to 0,4 MHz	1,8
0,4 MHz to 1,6 MHz	1,65
1,6 MHz to 110 MHz	1,2
110 MHz to 1 000 MHz	1,0

The measured values (at the equivalent 10 m distance) shall not exceed the limits given in Figure 1 for the appropriate system voltage.

No measurements are necessary for total underground railway systems with no surface operation (no victim outside this railway system can be affected).

The height above reference level of the antenna centre shall be within the range 1,0 m to 2,0 m for the loop antenna, and within 2,5 m to 3,5 m to the centre of measuring antenna above 30 MHz. One measuring height within the given range is sufficient and it is not required to do measurements with several antenna heights within this range. The selected height shall be noted in the test report.

The reference level for the substation is the ground.

The reference level for moving trains is the top of the rail.

If the actual level of the ground at the antenna differs from the top of the rail by more than 0,5 m, the actual value shall be noted in the test report.

It is accepted that the fixed antenna position may result in values being less than the absolute maximum at some frequencies.

5.1.1.5 Values of measurement

The values measured are expressed as:

– dBµA/m for magnetic fields,

– dBµV/m for electric fields.

These are obtained by using the appropriate antenna factors and conversions.

5.1.1.6 Antenna position and orientation

The plane of the loop antenna shall be positioned to measure the horizontal component of the magnetic field perpendicular to the track respectively to the wall of the substation. The biconical dipole shall be placed in the vertical and horizontal axis. The log periodic antenna shall be arranged to measure the vertical and horizontal polarization signal, with the antenna directed towards the track respectively to the wall of the substation.

The test locations should whenever possible avoid objects with changing of field characteristic like turnouts, walls and under bridges.

Figures 3, 4 and 5 show the positions and vertical alignments of the antennas as an example for measurements at the track.

5.1.1.7 Ambient noise

At the beginning and at the end of the test series the ambient noise shall be recorded.

If at specific frequencies or in specific frequency ranges the ambient noise is higher than the limit values less 6 dB (ambient noise > (emission limit – 6 dB)), the measurements at these frequencies need not be considered. These frequencies shall be noted in the test report.

5.1.2 Measurement parameter for moving trains

This subclause summarizes the specific conditions for the measurement of moving rolling stock.

- It is not considered necessary to carry out two tests to examine both sides of the rolling stock, even if it contains different apparatus on the two sides, as in the majority of cases the level of fields is due to the radiation of catenary and not to the direct radiation from the train. For systems with a third rail, measurements have to be performed at the same side of it.
- The peak measurement method is used. The duration at selected frequency shall be sufficient to obtain an accurate reading. This is a function of the measuring set and the recommended value is 50 ms.
- The noise may not attain its maximum value as the traction vehicle passes the measuring point, but may occur when the vehicle is a long distance away. Therefore, the measuring set shall be active for a sufficient duration before and after the vehicle passes by to ensure that the maximum noise level is recorded.
- In the case of elevated railway systems, if the antenna heights specified above cannot be achieved, the height of the antenna centre can be referenced to the level of the ground instead of to the top of the rail. The conversion formula in 5.1.1.4 shall be employed where D is the slant distance between the train and the antenna. The train shall be visible from the location of the antenna and the axis of the antenna shall be elevated to point directly at the train. A measurement distance of 30 m from the track centreline is preferred for highly elevated railway systems. Full details of the test configuration shall be noted in the test report.
- If tests are being carried out on a railway system with overhead electrified supply, the measuring point shall be at midspan between the support masts of the overhead contact line and not at a discontinuity of the contact wire. It is recognized that resonance can exist in an overhead system at radio frequencies and this may require changes in the values of frequency chosen for measurement. If resonance exists, this shall be noted in the test report.

  The radio frequency emission will be affected by the state of the railway system supply system. Switching of feeder stations and temporary works will influence the response of the system. It is therefore necessary to note the condition of the system in the test record and, if possible, all similar tests should be carried out within the same working day. Where the railway system has a track-side conductor rail power supply, the test location should be at least 100 m from gaps in the rail, to avoid inclusion of the transient fields associated with the make and break of collector contact. The conductor rail and the antennas shall be on the same side of the track.
- The test sites do not correspond to the definition of a completely clear site because they are influenced by overhead structures, rails and the catenary. However, wherever possible, antennas shall be installed well away from reflecting objects. If HV power lines are nearby, other than those which are part of the railway network, they should be no closer than 100 m to the test site.

5.1.3 Measurement parameter for traction substations

This subclause summarizes the specific conditions for the measurement of substations.

– Test configurations: In view of the special geometry of a railway system traction supply system, it is necessary to perform the measurement of emission of electromagnetic fields under normal feeding configuration of the traction supply system.
– Substation load: A feature of traction substations is that the load can change widely in short times. Since emission can be related to load, the actual loading of the substation shall be noted during emission tests.
– Each measurement shall be started with a peak max hold sweep. If the limits are exceeded due to the substation then it is required to take a measurement from a quasi-peak over the specific frequency range where these limits have been overrun. It is known that the load condition cannot be reproduced exactly during quasi-peak measurement, hence these load conditions should be at least comparable.

5.2 Acquisition methods

5.2.1 General

The electromagnetic disturbances generated by railway network including operating rolling stock are measured by the two following methods:

a) the fixed frequency method;
b) the frequency sweeping method.

The measurement method shall be chosen according to the rolling stock operating modes (see 5.4.2) depending on the train speed.

– For test at high speed the following has to be taken into account:

The fixed frequency method can be used, because it allows continuous monitoring at each frequency.

Alternative methods are allowed if the equivalent scan rate is at least that defined in Table 2 which is sufficiently short for such a moving source.

This ensures that the frequency results are measured at least every 5 m of train movement.

At higher speeds a spectrum analysis swept frequency method is unlikely to be practical, but FFT techniques may be feasible. The measurement equipment shall comply with CISPR 16-1-1.

Table 2 – Scan rate

Speed of train km/h	Speed of train m/s	Time for an observation width of 5 m (scan rate) s
60	16,67	0,300
100	27,78	0,180
200	55,56	0,090
300	83,33	0,060
320	88,89	0,056
NOTE Observation width is the part of rolling stock to be observed in given time.		

– When the rolling stock will be moving at a slower speed with the maximum rated power (see 5.4.2), the frequency sweeping method shall be used.

5.2.2 Fixed frequency method

The fixed frequency method consists of measuring the radiated emissions at only some frequencies (it is recommended to take at least 3 frequencies per decade) using the zero span mode of the spectrum analyser or setting the measuring receiver at the frequency to be checked.

The fixed frequencies shall be chosen according to the ambient noise, i.e. in the areas where the ambient field is the lowest.

The measurement of the field level shall be performed for each frequency during a complete passage of the train.

5.2.3 Frequency sweeping method

For the frequency sweeping method, the frequency range shall be divided into several sub-ranges according to the train speed in order to have a relevant sweep time in comparison with the train speed.

The measurement of the field level shall be performed in each sub-range during a complete passage of the train. The max-hold function of the spectrum analyser shall be used.

5.3 Transients

During the test, transients due to switching may be detected, such as those caused by operation of power circuit breakers. These shall be disregarded when selecting the maximum signal level found for the test.

5.4 Measuring conditions

5.4.1 Weather conditions

To minimize the possible effect of weather on the measured values, measurements should be carried out in dry weather, (after 24 h during which not more than 0,1 mm rain has fallen), with a minimum temperature of 5 °C, and a wind velocity of less than 10 m/s.

Humidity should be low enough to prevent condensation on the power supply conductors.

Since it is necessary to plan the tests before the weather conditions can be known, tests will be carried out in the weather conditions found. In these circumstances, the actual weather conditions shall be recorded with the test results.

5.4.2 Railway system operating modes

Two test conditions are specified for the traction mode and are:

a) measurement at a speed of more than 90 % of the maximum service speed, (to ensure that the dynamics of current collection are involved in the noise level) and at the maximum power which can be delivered at that speed;

b) at the maximum rated power and at a selected speed.

If the vehicle is capable of electric braking, tests are required at a brake power of at least 80 % of the rated maximum brake power.

5.4.3 Multiple sources from remote trains

For the purpose of limits, the presence of “physically-remote but electrically-near” vehicles out of the test zone is regarded as insignificant when considering radio noise.