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Železniške naprave – Elektromagnetna združljivost – 2. del: Sevanje celotnega železniškega sistema v okolje

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

Bahnanwendungen - Elektromagnetische Verträglichkeit -- Teil 2: Störaussendungen des gesamten Bahnsystems in die Außenwelt

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

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

This European standard was prepared the Technical Committee CENELEC TC 9X, Electrical and electronic applications for railways.

The text of the draft was submitted to the formal vote and was approved by CENELEC as EN 50121-2 on 2000-04-01.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2001-04-01
- latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2003-04-01

This European Standard is to be read in conjunction with EN 50121-1:2000.

This standard forms part 2 of the European Standard series EN 50121, published under the general title "Railway applications - Electromagnetic compatibility". The series consists of:

- Part 1 : General
- Part 2 : Emission of the whole railway system to the outside world
- Part 3-1 : Rolling stock - Train and complete vehicle
- Part 3-2 : Rolling stock - Apparatus
- Part 4 : Emission and immunity of the signalling and telecommunications apparatus
- Part 5 : Emission and immunity of fixed power supply installations and apparatus

Annexes designated “normative” are part of the body of the standard.
Annexes designated “informative” are given only for information.
In this standard, annex A is normative and annexes B and C are informative.

Contents

1 Scope

This European Standard sets the emission limits from the whole railway system including urban vehicles for use in city streets, it describes the measurement method to verify the emissions, and gives the cartography values of the fields most frequently encountered.

These specific provisions are to be used in conjunction with the general provisions in EN 50121-1.

The limits refer to the particular measuring points defined in clause 5 and annex A. These emissions should be 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 3 m from the fence of the substations.

The zones above and below the railway will experience emission and particular cases shall be considered individually.

Excluded from the limits is apparatus which complies with the generic industrial emission standard EN 50081-2.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate place in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 50121-1	Railway applications - Electromagnetic compatibility - Part 1: General
EN 50121-3-1	Part 3-1: Rolling stock - Train and complete vehicle
EN 50121-5	Part 5: Emission and immunity of fixed power supply installations and apparatus
EN 55013	Limits and methods of measurement of radio disturbance characteristics of broadcast receivers and associated equipment
EN 55022	Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement
CISPR 16-1	Specification for radio disturbance and immunity measuring apparatus and methods -- Part 1: Radio disturbance and immunity measuring apparatus
CISPR 18	Radio interference characteristics of overhead power lines and high voltage equipment

3 Definitions

For the purpose of this part 2 of the European Standard the following definitions apply.

3.1
apparatus
an electric or electronic product with an intrinsic function intended for implementation into a fixed railway installation, which can be placed on the market as a single unit

3.2
environment
the surrounding objects or region which may influence the behaviour of the system and or may be influenced by the system.

3.3
external interface
the boundary where a system interacts with any other or where a system interacts with its environment

3.4
railway substation
an installation the main function of which is to supply a contact line system at which the voltage of a primary supply system, and in some cases the frequency, is transformed to the voltage and frequency of the contact line

3.5
railway supply lines
conductors running within the boundary of the railway which supply power to only the railway but are not energised at railway system voltage

4 Emission limits

4.1 Emission from the open railway route

The emission limits in the frequency range 9 kHz to 1 GHz are given in Figure 1 and the measurement method is defined in clause 5. For non-electrified lines, the limits are as those given for 750 V d.c.

For urban vehicles city street transport, the emission limits given in Figure 1 for 750 V d.c. conductor rail shall not be exceeded.

NOTE 1 The emission limits for urban vehicles city street transport are under consideration.

NOTE 2 The emission limits in the frequency range d.c. to 9 kHz are under consideration.

The emission values in Figure 1 with peak detection are specified on the basis that the quasi-peak detection values are at least 20 dB below the peak values.

NOTE 3 Test results on the open electric railway mainline with moving trains have demonstrated that the emission field strength with quasi-peak detection, is at least 20 dB below the values measured in peak detection.

NOTE 4 It shall be recognised however that it is not possible to undertake complete tests with quasi-peak detection due to the reasons stated in annex B.

NOTE 5 Values of electric field are for vertical polarisation. Measurements at 80 MHz showed that the horizontal polarisation field is smaller by about 6 dB.

Since parts of the railway system may be at distances greater than 10 m (for example substations) it is necessary to take this into account. For example Figure 2 shows a typical substation and indicates the boundaries at which the Figure 1 limit applies and at which the substation limit applies.

4.2 Emission from railway substations

Radio frequency noise emission from the railway substation to the outside environment measured according to the method defined in annex A shall not exceed the levels shown as the 25 kV line in Figure 1.

If the measurements are taken at power values below the rated continuous power, the results shall be converted in accordance with the rules in annex A.

The bandwidths used for measurement are those used in CISPR 16-1 and are :

	Bandwidth
Frequencies up to 150 kHz	200 Hz
Frequencies from 150 kHz to 30 MHz	9 kHz
Frequencies above 30 MHz	120 kHz

The distance of 3 m defined in annex A shall be measured from the fence of the substation. If no fence exists, the measurements shall be taken at 10 m from the apparatus if not in an enclosure or from the outer surface of the enclosure if it is enclosed.

Emission of trains shall not enter into the measurement.

4.3 Emission at radio frequencies from railway supply lines

Railway supply lines which are not at railway system voltage and are within the railway boundary shall comply with the requirements of CISPR 18.

NOTE Part 1 of CISPR 18 covers general information, part 2 introduces the concept of protection distance, and part 3 gives information concerning mitigation of emission.

4.4 Emission from the substation at power frequencies and harmonics up to 9 kHz

Magnetic fields which enter the outside environment need to be controlled and the limits below shall apply. When measured at 3 m from the fence of the substation, at a height of 1 m above ground level, the r.m.s. value of the magnetic field gradient in any axis, including any effects of harmonic currents, shall not exceed 50 A/m. This value applies to rated load operation. If tests are made at less than rated load, the readings shall be linearly scaled to full load for assessment purposes. Under overload and fault conditions, the limit value shall be 500 A/m.

NOTE 1 The operation of power supply apparatus produces magnetic and electric fields which both enter the environment and enter railway apparatus. Limits are required to control this emission. There is great variety in the geometry used for the power conductors in apparatus and it is not considered possible to set limits for magnetic fields within the substation boundary. Measurements have been made inside typical existing installations and show that the field is unlikely to exceed 1 000 A/m at distances of more than 1 m from d.c. apparatus, or 500 A/m from a.c. apparatus. Under fault conditions these values may be 10 times greater. It is intended to review this subclause and it may be possible to establish railway-specific limits for fields inside the boundary.

NOTE 2 Magnetic fields within the boundary are such that cathode ray display tubes are usually unable to work properly.

5 Method of measurement of emission from moving trains

The method of measurement is adapted from CISPR 16-1 to a railway system with moving vehicle. The background to the method of measurement is given in annex B.

The electromagnetic fields generated by rail vehicles when operating on a railway network are measured by means of field strength meters with several different set frequencies. The horizontal component of the magnetic field perpendicular to the track and the vertical component of the radiated field are measured.

5.1 Measurement parameters

5.1.1 Peak measurement method is used. 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.

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

These are:

Frequency bands:	9-150 kHz	0,15-30 MHz	30-300 MHz	300 MHz -1 GHz
Bandwidth:	200 Hz	9 kHz	120 kHz	120 kHz

5.1.3 When connected to the antenna the error of measurement of the strength of a uniform sine-wave field shall not differ more than ± 4,0 dB from CISPR 16-1 equipment.

5.1.4 Since 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, the measuring set shall be continuously active during the test and not triggered as the train approaches the test site.

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

- for 9 kHz - 30 MHz, a loop or frame antenna is used to measure H field (see Figure 3);
- for 30 MHz - 300 MHz, a biconical dipole is used to measure E field (see Figure 4);
- for 300 MHz - 1,0 GHz, a log-periodic antenna is used to measure E field (see Figure 5).

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

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

It is not considered necessary to carry out two tests to examine both sides of the vehicle, even if it contains different apparatus on the two sides, since the majority of the emission is produced by the sliding contact if the train is moving.

Where the tests are carried out at a site which meets all the recommended criteria except that the antennas are not 10 m from the track centreline, the results can be converted to an equivalent 10 m value by using the following formula:

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

where E_{10} is the value at 10 m
E_x is the measured value at D m
n is a factor taken from the table below.

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.

Where the physical layout of the railway totally prevents the use of reference distances, a method shall be agreed to suit the particular circumstances. For example if the railway is in tunnel, miniature antennas can be used on the wall of the tunnel. In such a case, the limits selected shall take into account the method of measurement.

5.1.7 The height above rail 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 dipole or log-periodic antennas. If the level of the ground at the antenna differs from the rail level by more than 0,5 m, the actual value shall be noted in the test report.

5.1.8 The plane of the loop antenna shall be vertical and parallel to the line of the track. The dipole shall be placed in the vertical axis. The log periodic antenna shall be arranged to measure the vertical polarisation signal, with the antenna directed towards the track.

These alignments are chosen to give standard conditions and may not detect the absolute maxima at a given site. If tests for horizontal polarisation or other alignments are required, these shall be specifically requested. Figures 3, 4 and 5 show the positions and alignments of the antennas.

5.1.9 If tests are being done on a railway with overhead electrified supply, the measuring point shall be at the mid-point between the support masts of the overhead line and not at a discontinuity of the contact wire. It is recognised 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 exist, this should be noted in the test report.

The radio frequency emission will be affected by the state of the railway 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 all similar tests should if possible be carried out within the same working day. Where the railway 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.

5.1.10 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 placed well away from reflecting objects. If overhead 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.

5.1.11 The values measured are expressed as:

-dBµA/m for magnetic fields,
-dBµV/m for electrical fields.

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

5.1.12 Background noise shall be measured at the test site in the absence of train effects. This will give the noise values from the energised power supply conductors. If this is significant, it is advisable to measure also at 100 m from the test site, to identify any high non-railway sources of noise.

5.1.13 Statistical treatment of measurements from moving source

This process allows the noise to be expressed for example as the value which would not be exceeded on 80 % of train passages, with a certainty of 80 %.

Since in general only a small number of tests can be carried out, the non-central t-distribution method mentioned in EN 55013 shall be used to find the required exceedance and certainty values. This method states that

$$N[L,M] \text{ (dB scale)} = \text{Mean value from tests (dB scale)} + k \cdot S_n \text{ (dB scale)}$$

where L is the proportion of values of the total population which will be below the limit value **N**.
M is the probability that this proportion will be achieved.
k is a function of the number of results n and has values given in the table below, taken from [1] with $\overline{X}$ being the mean value and X_n being the nth result.

$$S_n = \sqrt{\frac{\sum (X_n - \overline{X})^2}{n-1}}$$

Values of k versus number of test for L = 80 % and M = 80 %

n	3	4	6	8	10
k	2,04	1,68	1,42	1,30	1,24

[1] Resinkoff, G.J. and Liebermann: Tables of non-central t-Distribution, Stanford University Press, USA, 1957.

This recognises that tests are difficult to arrange and allows a relatively small number of tests to be used. This treatment assumes a normal distribution of the results and should be reviewed if evidence is found of skew or other distributions. The setting of limit values shall take into account the need to use small numbers of tests and the use of statistical techniques.

5.2 Frequency selection

5.2.1 Selected frequencies

The selection of the actual frequencies to be measured will depend on the circumstances of the test site.

If high signals exist, for example from public broadcasting stations, the selection of test frequencies shall take this into account.

It is recommended that test frequencies are selected so that there are at least three frequencies per decade.

5.2.2 Sweep frequency

In view of the short time available for measurement in one train passage, the use of a sweep frequency measuring technique, in which the peak noise is measured with a peak-hold circuit as the frequency is changed, may offer adequate information concerning generation of noise. There will still remain problems of time because the rate of change of frequency is a function of the bandwidth, due to considerations of accuracy. A sweep analyser will usually set its own sweep rate to meet this requirement. If this method is used, sweep rate as well as bandwidth shall be noted.

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 minimise the possible effect of weather on the measured values, measurements should be carried out in dry weather, (after 24 hours during which not more than 0,1 mm rain has fallen), with a temperature of at least 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 but otherwise no limits are set since there is no evidence that the range of values found in Europe has any significant effect on noise.

Since it is necessary to plan the tests before the weather conditions can be known, tests will have to be made in weather conditions which do not meet the target conditions. In these circumstances the actual weather conditions shall be recorded with the test results.

5.4.2 Railway standard conditions

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. This may then not allow the maximum power to be delivered.