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REDLINE VERSION

INTERNATIONAL STANDARD

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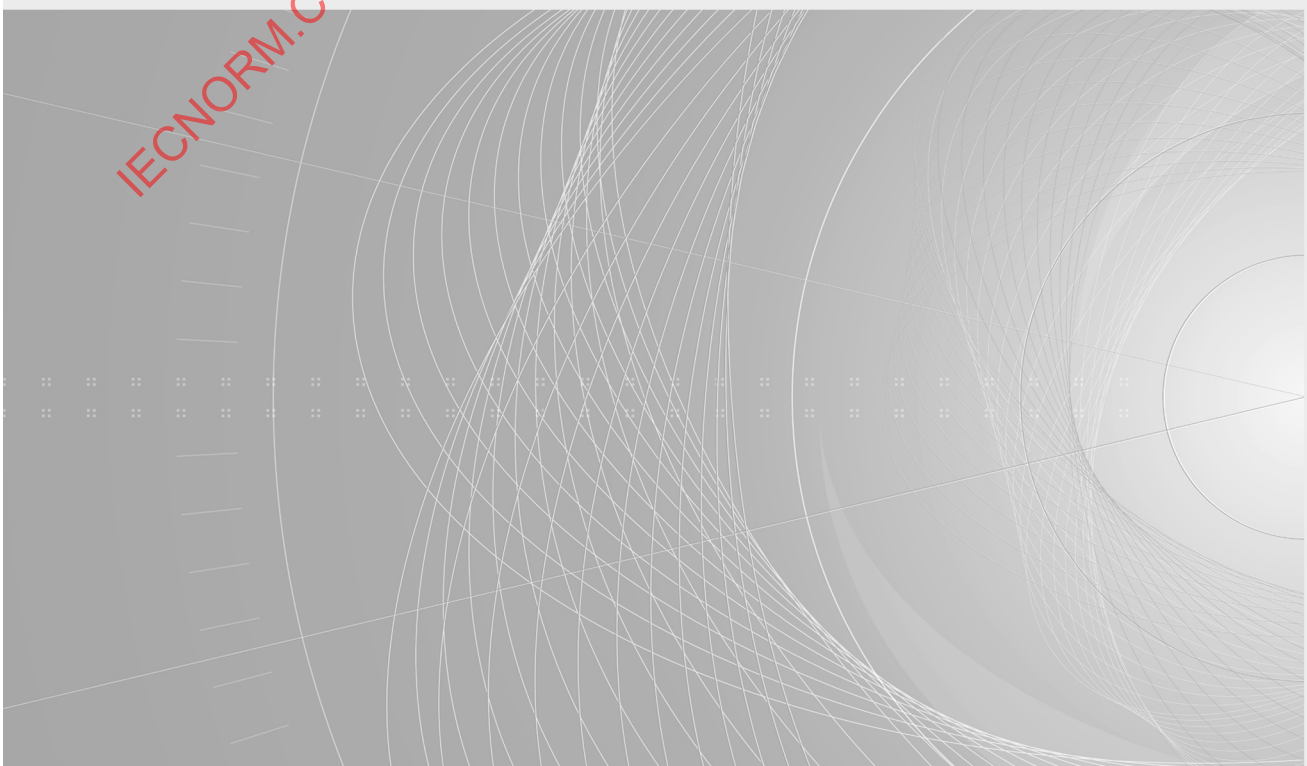
Railway applications – Electromagnetic compatibility – Part 3-1: Rolling stock – Train and complete vehicle



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Railway applications – Electromagnetic compatibility – Part 3-1: Rolling stock – Train and complete vehicle

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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RAILWAY APPLICATIONS – ELECTROMAGNETIC COMPATIBILITY –

Part 3-1: Rolling stock – Train and complete vehicle

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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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 62236-3-1 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 50121-3-1:2015.

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

a) clarification of scope (Clause 1);

b) clarification of definitions (Clause 3);

c) clarification of applicability (Clause 4);

d) clarification of interference on outside party telecommunication lines (6.2), psophometric current (Annex A);

e) moving emission values for radiated H-field in the frequency range 9 kHz to 150 kHz into new Annex C due to the fact that:

   – there are very few outside world victims (e.g. radio services),

   – the radiated emission measured at 10 m is not representative of the compatibility with internal railway apparatus,

   – the EMC with other railway apparatus in this frequency range is covered in other procedures and standards like IEC 62427 series,

   – there is low reproducibility.

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
9/2337/FDIS	9/2367/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.

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

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.

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INTRODUCTION

High powered electronic equipment, together with low power microcontrollers and other electronic devices, is being installed on trains in great numbers. Electromagnetic compatibility has therefore become a critical issue for the design of train-related apparatus as well as of the train as a whole.

This Product Standard for rolling stock sets limits for electromagnetic emission and immunity in order to ensure a well functioning system within its intended environment.

Immunity limits are not given for the complete vehicle. Part 3-2 of this series defines requirements for the apparatus installed in the rolling stock, since it is impractical to test the complete unit. An EMC plan ~~should be established for~~ includes equipment covered by this document.

RAILWAY APPLICATIONS – ELECTROMAGNETIC COMPATIBILITY –

Part 3-1: Rolling stock – Train and complete vehicle

1 Scope

This part of IEC 62236 specifies the emission and immunity requirements for all types of rolling stock. It covers traction stock, hauled stock and trainsets including urban vehicles for use in city streets. This document specifies the emission limits of the rolling stock to the outside world.

The scope of this document ends at the interface of the rolling stock with its respective energy inputs and outputs. In the case of ~~locomotives~~ traction units, trainsets, trams, etc., this is the current collector (pantograph, shoe gear). In the case of hauled stock, this is the AC or DC auxiliary power connector. However, since the current collector is part of the traction stock, it is not entirely possible to exclude the effects of this interface with the power supply line. The slow moving test has been designed to minimize these effects.

~~Basically, all apparatus to be integrated into a vehicle should meet the requirements of Part 3-2 of this standard. In exceptional cases, where apparatus meets another EMC standard, but full compliance with Part 3-2 is not demonstrated, EMC should be assured by adequate integration measures of the apparatus into the vehicle system and/or by an appropriate EMC analysis and test which justifies deviating from Part 3-2.~~

There may be additional compatibility requirements within the railway system identified in the EMC plan (e.g. as specified in IEC 62427).

~~The electromagnetic interference concerning~~ Electromagnetic emissions of the railway system as a whole ~~is~~ are dealt with in IEC 62236-2.

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

The frequency range considered is from 0 Hz (DC) to 400 GHz. No measurements need to be performed at frequencies where no requirement is specified.

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*

IEC 62236-2:2018, *Railway applications – Electromagnetic compatibility – Part 2: Emission of the whole railway system to the outside world*

IEC 62236-3-2:2018, *Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus*

~~IEC 62427, *Railway applications – Compatibility between rolling stock and train detection systems*~~

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*

~~ITU-T, *Directive concerning the protection of telecommunication lines against harmful effects from electrical power and electrified railway lines – Volume VI: Danger and disturbances*~~

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
traction stock
~~electric and diesel locomotives, high speed trainsets, electric and diesel multiple units (no locomotive, each coach has its own traction equipment) for main line vehicles, Light Railway Vehicles (LRV) such as underground trainsets, trams, etc., for urban vehicles~~
electric and diesel traction unit, high speed trainset, elementary fixed combination of traction stock and hauled stock, electric and diesel multiple unit (no traction unit, distributed traction equipment), Light Railway Vehicle (LRV), such as tram, trolley bus or any other electrical vehicle for urban mass transit, underground trainset

3.1.2
hauled stock
~~all~~ independent passenger coaches and freight wagons (if they contain electric apparatus such as freezing equipment) which may be hauled in random combinations by different types of ~~locomotives~~ traction units

3.1.3
main line vehicles
vehicles such as high speed trains, suburban trains, freight trains, mainly designed to operate between cities

3.1.4
urban vehicles
vehicles such as underground trainsets, trams, LRV (Light Rail Vehicles), trolleybuses, mainly designed to operate within the boundary of a city

3.2 Abbreviated terms

AC	Alternating current
BW	Band width
DC	Direct current
E	Electric (field)
EMC	Electromagnetic compatibility
EUT	Equipment under test

H	Magnetic (field)
ISDN	Integrated Services Digital Network
ITU-T	International Telecommunucation Union – Telecommunication Standardization Sector
LRV	Light rail vehicle
PCM	Pulse – code modulation
QC	Quadrant converters
QP	Quasi-Peak
xDSL	All types of **d***igital* **s***ubscriber* **l***ines*

4 Applicability

Generally, it is not possible to test electromagnetic compatibility invoking every function of the stock. The tests shall be made at typical operating modes considered to produce the largest emission.

The typical operating mode shall require all systems to be energised which are normally in continuous operation during service. It is not necessary during the test to exercise systems which operate transiently such as for example operation of internal doors, although they should be energised. It is not necessary to test degraded modes of operation.

The configuration and mode of operation shall be specified in the test plan and the actual conditions during the tests shall be precisely noted in the test report.

5 Immunity ~~tests and limits~~ requirements

No tests are applied to the complete vehicle~~, but the immunity tests and limits in Part 3-2 of this standard were selected in the knowledge that the vehicle can be deemed to be immune to a level of 20 V/m over the frequency range 0,15 MHz to 2 GHz~~. It is expected that the assembly of the apparatus into a complete vehicle will give adequate immunity, provided that an EMC plan has been prepared and implemented, taking into account the ~~limits~~ requirements in IEC 62236-3-2.

In exceptional cases, where apparatus meets another EMC Standard, but full compliance with IEC 62236-3-2 is not demonstrated, EMC shall be ensured by adequate integration measures of the apparatus into the vehicle system and/or by an appropriate EMC analysis and test which justifies deviating from IEC 62236-3-2.

6 Emission tests and limits

6.1 General

The emission tests and limits for rolling stock in this document should ensure as far as possible that the rolling stock does not interfere with typical installations in the vicinity of the railway system.

Measurements shall be performed in well-defined and reproducible conditions. It is not possible to totally separate the effects of the railway system and the stock under test. ~~Therefore, the operator and the manufacturer have to define in the contract the test conditions and the test site for compatibility with signalling and communication systems and for interference on telecommunication lines, (e.g. load conditions, speed and configuration of the units).~~ For radiated emissions, the test conditions are defined in 6.3.1 and 6.3.2. ~~The contributions of other parts of the railway system (e.g. substations, signalling) and of the~~

~~external environment (e.g. power lines, industrial sites, radio and television transmitters) to the measurements must be known and taken into account.~~

~~6.1 Compatibility with signalling and communication systems~~

NOTE 1 Signalling and communication, train radio and other railway systems (axle counters, track circuits, train control systems, etc.) are different in every country in terms of operating frequencies and waveforms. Therefore, ~~emission~~ compatibility requirements ~~shall be~~ are specified according to the type of signalling and communication systems used ~~(see IEC 62427)~~.

NOTE 2 There can be cases in which radio or other railway external services with working frequencies below 150 kHz are in operation close to the railway. The EMC plan covers these cases and an adequate level of emission from railway 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.

~~The requirements need to take into account sources of disturbance other than the rolling stock, including the train radio and signalling systems themselves, and the effects of transients due to bad contact, pantograph bouncing, third rail gaps, etc.~~

6.2 Interference on outside party telecommunication lines

6.2.1 Digital telecommunication lines

Interference with digital systems such as PCM, ISDN, xDSL is not covered in this document.

It should be noted that these systems operate in a higher frequency range using multiple carriers and various automatic error correction protocols.

It is considered unlikely that rolling stock can produce sufficient interference in this frequency range.

6.2.2 Analogue telecommunication lines

~~The harmonics in the traction current of a railway system may induce noise in a conventional analogue telecommunication system. The acceptable level of noise on conventional analogue telephone lines is specified by ITU-T. The value of this noise is measured with a psophometric filter. The relationship between the current absorbed or generated by the traction vehicle and the noise in the telephone line is neither under the total control of the vehicle manufacturer nor of the operator of the network (for details see Clause A.1). Thus it shall be the responsibility of the purchaser of the tractive stock in accordance with the rules of the Infrastructure Controllers to specify a frequency weighted current limit at the vehicle interface.~~

~~One method commonly used is to specify the psophometric current I_{pso} which has a psophometrical frequency weighting. The background and application of this method is described in Annex A. As it is known that the I_{pso} method does not fully represent the noise effect of the harmonics in the kHz range, alternative methods of frequency weighting may be specified by the purchaser.~~

No harmonized limits apply.

Information about interference on telecommunication lines can be found in Annex A.

6.3 Radiated electromagnetic disturbances

6.3.1 Test site

~~The test site shall meet as far as possible the "free space" requirements below within the existing constraints of the railway environment:~~

~~– no trees, walls, bridges, tunnels or vehicles shall be close to the measurement point, minimum separation distance:~~

~~30 m for main line vehicles,~~

~~10 m for urban vehicles;~~

It can be assumed that measurements will not take place in laboratory conditions. Trees, walls, bridges, tunnels or other conductive objects in the vicinity of the measurement antenna could have an impact on the measurement. Other railway vehicles operating in the same feeding section or nearby the measuring point may affect the measurement result. Overhead/third rail discontinuities as well as substations, power lines, buried lines, transformers, neutral sections, section insulators, etc., close to the measuring point may cause additional variations.

These influences shall be reduced as far as practical but in any case no obstacles above rail level which may influence the measurements shall be located between antenna and EUT.

The overhead/third rail should be a continuous line as far as practical on both sides of the measurement point (typically at least 200 m).

Since it is impossible to avoid the support masts of the overhead, the measurement point shall be at the midpoint between masts, on the opposite side of the track (in case of a double track, on the side of the track which is being used). If the railway system is powered by a third rail, the antenna shall be on the same side of the track (worst case).

~~– the overhead/third rail should be an "infinite" line on both sides of the measurement point, the minimum clear length on both sides of the measurement point should be:~~

~~3 km for main line vehicles,~~

~~500 m for urban vehicles~~

~~Overhead/third rail discontinuities as well as substations, transformers, neutral sections, section insulators, etc., should be avoided.~~

Since resonances may occur in the overhead line at radio-frequencies, it may be necessary to change the test site. The exact location of the test site and features of both the site and the overhead system layout shall be noted.

The contribution of the substation may be considered when assessing the emissions from the vehicle. Note that the contribution of a DC substation depends on its load current and will not be measured properly in a no-load condition.

~~– close proximity to power lines including buried lines, substations, etc., should be avoided;~~

~~– no other railway vehicle should be operating in the same feeding section or within a distance of~~

~~20 km for main line vehicles,~~

~~2 km for urban vehicles~~

~~If these conditions are not possible, the ambient noise before and after each emission measurement of the vehicle under test shall be recorded. Otherwise, only two ambient noise measurements at the beginning and the end of the test series are sufficient.~~

At the beginning and at the end of the test series the ambient noise shall be recorded. This measurement shall be done without any influence of the vehicle.

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

NOTE It is helpful to perform this ambient noise measurement also with the vehicle completely powered down in front of the antenna.

6.3.2 Test conditions

The tests shall cover the operation of all systems onboard the rolling stock which may produce radiated emissions.

Hauled stock (a representative version) shall be tested while stationary in an energised mode (auxiliary converters, battery chargers, etc., in operation). The antenna should be sited opposite the equipment expected to produce the greatest emissions at the frequencies under measurement.

Tests for identical coaches or wagons are performed only once.

Traction stock shall be tested while stationary and at slow moving speed. During the stationary test, the auxiliary converters shall operate (it is not inevitably under maximum load conditions that the maximum emission level is produced) and the traction converters shall be under voltage but not operating. The antenna ~~should~~ shall be ~~sited opposite~~ in front of the middle of each vehicle ~~centre line~~ unless an alternative location is expected to produce higher emission levels.

For the slow moving test, the speed shall be low enough to avoid arcing at or bouncing of the sliding contact and high enough to allow for electric braking. The recommended speed range is (20 ± 5) km/h for urban vehicles and (50 ± 10) km/h for main line vehicles. When passing the antenna, the vehicle shall accelerate or decelerate with approximately 1/3 of its maximum tractive effort within the given speed range.

The slow moving test may be replaced by a stationary test with the vehicle operating at 1/3 of its maximum tractive effort against the mechanical brakes, if the following conditions are fulfilled:

– the traction equipment ~~allows for operation whilst~~ can be operated while the vehicle is stationary;

– tests of electric braking are not required, if no different circuits are used in braking.

If the slow moving test is replaced by a stationary test with tractive effort, then the slow moving limits ~~shall be applied~~ apply. ~~The decision for the stationary test with tractive effort has to be justified in the test report.~~

Any vehicles using onboard energy storage for traction shall use the test procedure and limits for slow moving test for the charging process.

NOTE Slow moving test procedure and limits are used for charging process (for traction energy storing devices) because it has a short duration with high energy transfer.

6.3.3 Emission limits

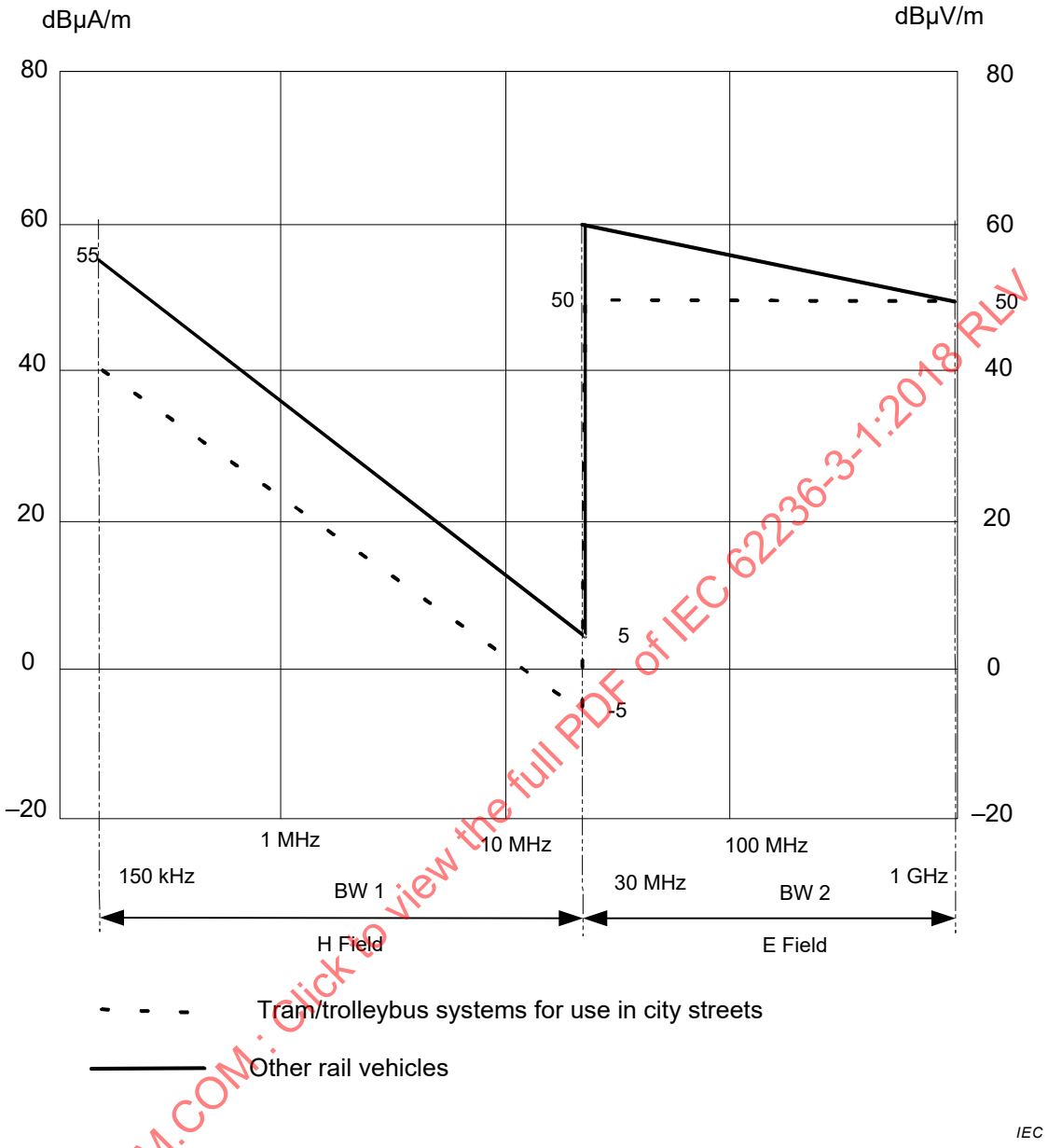


Figure 1 – Limits for stationary test (quasi-peak, 10 m)

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

	Bandwidth
~~Frequencies up to 150 kHz~~	~~200 Hz~~
Frequencies from 150 kHz to 30 MHz	9 kHz (BW 1)
Frequencies ~~above~~ from 30 MHz to 1 GHz	120 kHz (BW 2)

~~NOTE~~ All values are measured at a distance of 10 m from the centre of the track.

The emission limits are specified up to 1 GHz due to the fact that there are no significant sources of interference above 1 GHz and that emissions from microprocessor controlled equipment which may give rise to emissions at frequencies greater than 1 GHz are addressed by compliance with IEC 62236-3-2.

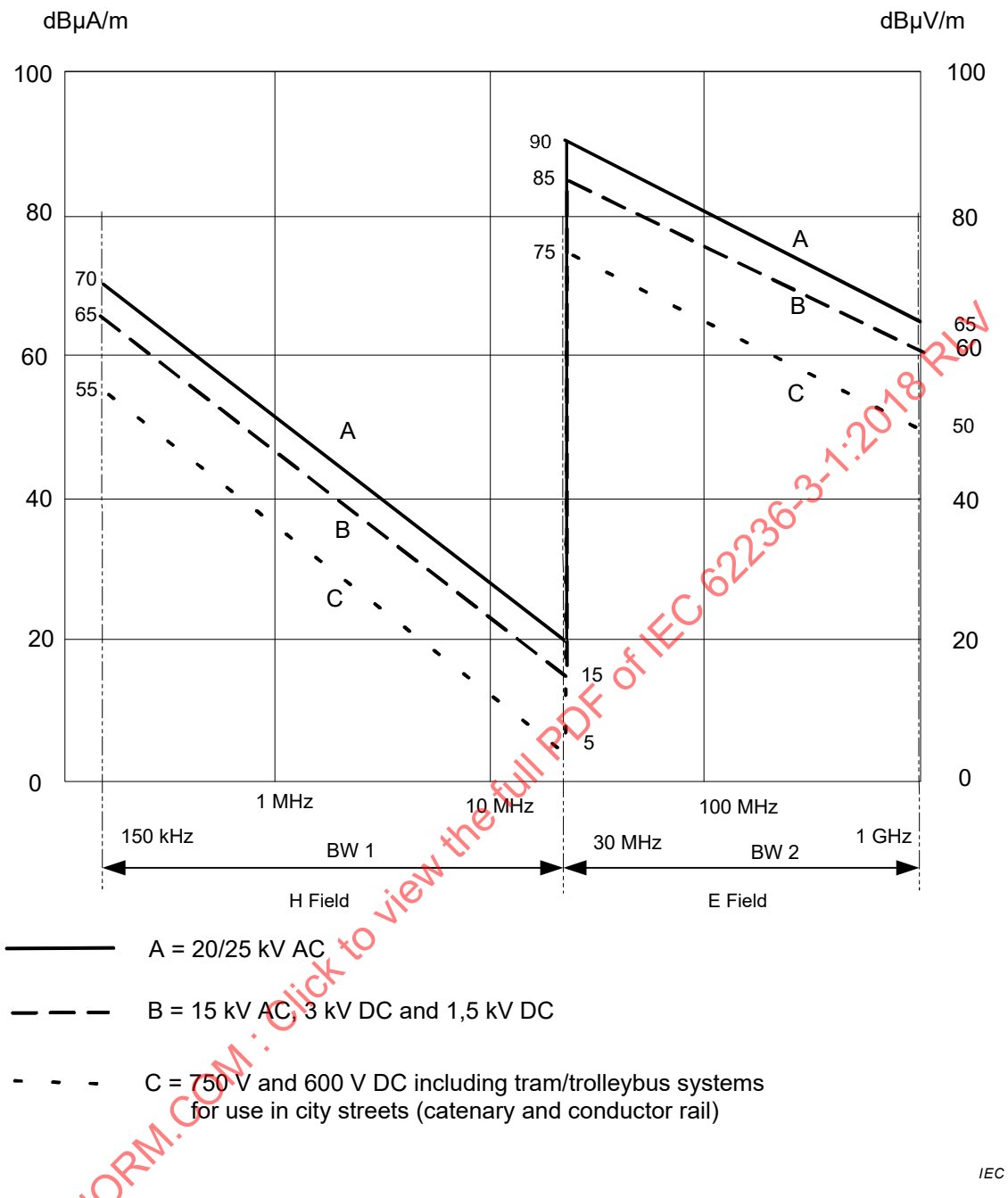


Figure 2 – Limits for slow moving test (peak, 10 m)

~~NOTE~~ For details of test procedure, see Annex B.

~~NOTE~~ All values are measured at a distance of 10 m from the centre of the track in peak values.

~~NOTE~~ For diesel and diesel electric ~~locomotive~~ traction units and multiple units, the emission limits of Figure 1 (“other rail vehicles”) and B in Figure 2 shall apply unless specific measures dictate otherwise (e.g. usage in lower voltage electrified lines).

The emission limits are specified up to 1 GHz due to the fact that there are no significant sources of interference above 1 GHz and that emissions from microprocessor controlled equipment which may give rise to emissions at frequencies greater than 1 GHz are addressed by compliance with IEC 62236-3-2.

~~NOTE There are very few external radio services operating in the range 9 kHz to 150 kHz with which the railway can interfere. If it can be demonstrated that no compatibility problem exists, any emission level exceeding the relevant limits given in figure 1 and 2 may be acceptable.~~

Annex A
(informative)

Interference on telecommunication lines

A.1 Harmonics in the traction current

A.1.1 General

The harmonics in the traction current of a railway system may induce noise in a conventional analogue telecommunication system. The acceptable level of noise on conventional analogue telephone lines is specified by ITU-T. The value of this noise is measured with a psophometric filter. The relationship between the current absorbed or generated by the traction vehicle and the noise in the telephone line is neither under the total control of the vehicle manufacturer nor of the operator of the network. Thus, it is the responsibility of the purchaser of the tractive stock in accordance with the rules of the infrastructure manager to specify a frequency weighted current limit at the vehicle interface.

One method commonly used is to specify the psophometric current I_{pso} which has a psophometrical frequency weighting. The background and application of this method is described in this Annex. As it is known that the I_{pso} method does not fully represent the noise effect of the harmonics in the kHz range, alternative methods of frequency weighting may be specified by the purchaser.

A.1.2 Relationship between currents in railway system and noise on telecommunication lines

Conventional telecom copper cables in the vicinity of electrified railway lines are subject to electromagnetic disturbances caused by the currents in the railway system.

These disturbances result in induced longitudinal voltages ranging from the frequency of the fundamental wave to higher frequency harmonics. Sources of the harmonics are converters applied within the traction equipment of the traction stock and/or in the power supply station. Due to imbalances in the cable itself, these longitudinal voltages translate to transverse voltages or noise.

The acceptable level of noise on conventional analogue telephone lines is specified by the ITU-T. The value of this noise is measured with a psophometric filter.

The relationship between the current absorbed by the traction vehicle and the noise on the telecom line is neither under the total control of the vehicle manufacturer nor of the railway and telecommunication network operators.

This relationship depends on:

a) the structure of the telecom cables
   1) shielding, isolation to ground, balance of the cable;
b) the characteristics of the telecom terminals
   1) susceptibility, input balance;
c) the topology of the telecom network
   1) length of parallel sections of the telecom line to the tracks;
   2) the distance between tracks and telecom lines;
   3) the earth-resistivity;
d) the topology of the railway network

1) single/double track;

e) the type of power supply of the catenary

1) AC / DC;

2) substation ripple (DC rectifiers or AC 16,7 Hz static converters in some cases);

3) type of catenary and feeder system (e.g. 1 × 25 kV or 2 × 25 kV);

4) application of return conductors;

5) single-end or double-end supply of the section under consideration;

f) the density of train circulation;

g) the current absorption and generation of harmonics of the tractive stock;

h) the kind of harmonics superposition from a number of converters.

A.2 Psophometric current definition

The psophometric current is an equivalent disturbance current, which represents the effective disturbance of a current spectrum in a power circuit to a telephone line. It is defined by the formula:

$$I_{\mathrm{pso}} = \frac{1}{p_{800}} \sqrt{\sum (p_{\mathrm{f}} I_{\mathrm{f}})^2}$$

where:

I_{f} is the current component at frequency f in the contact line current;

p_{f} is the psophometric weighting.

The values of p_{f} may be found in the ITU-T ~~Directive „Protection of telecommunications lines against harmful effects from electrical power and electrified railway lines“ (ITU-T O.41)~~ Directives ITU-T O.41 and ITU-T K.68.

For measurement purposes, voltage and ampere meters which automatically calculate the signal according to these values of p_{f} by means of a psophometric filter are available.

A.3 Limits and test conditions

It ~~shall be~~ is the responsibility of the purchaser to specify the maximum value of the psophometric current, and the conditions under which it is defined, including duration.

The following conditions ~~shall be~~ are covered:

a) Limits of I_{pso} under normal and under reduced performance conditions (one or more traction converters temporarily out of service).

b) In the case of DC supply:

DC railways are normally fed by diode rectifiers from the 3-phase mains supply. Ideally, a single bridge rectifier produces a 6-pulse shape of voltage (i.e. first harmonic at 300 Hz in a 50 Hz mains) or two bridges produce a 12-pulse shape (i.e. 600 Hz). Due to imbalances in the rectifier and due to induction, a fundamental component at 50 Hz is commonly found.

The presence of filters in the substation greatly reduces the effect of the substation.

Nevertheless, in DC systems, the substation is the main source of perturbation.

Thus, to qualify a traction vehicle, the contribution of the rectifier unit and filters of the fixed installation ~~shall be taken into account~~ are relevant.

It ~~shall~~ is also ~~be~~ necessary to take into account the distance between the traction vehicle and the substation which affects the line inductance.

b) In the case of AC supply:

If the line voltage distortion has to be taken into consideration, the essential harmonics ~~shall~~ have to be specified. If special resonance conditions in the ~~catenary~~ power supply line system ~~shall be taken into account~~ are relevant, it ~~shall be~~ is necessary to specify the relevant data. Otherwise, the situation of the vehicle nearest to the supply station is assumed to give the highest value I_{pso}.

A.4 Measurement of the psophometric current

During acceptance tests or investigation tests, the disturbance current I_{pso} ~~shall be~~ is measured on board the traction vehicle. Existing current sensors of the vehicle may be used, if their frequency response is sufficient (at least up to 5 kHz). ~~In the case of an a.c. system, the current shall be picked up on the high voltage side of the transformer primary winding, and not on the ground side, as the transformer may have a resonant frequency below 10 kHz.~~ The current is measured at the high voltage input of the vehicle and not on the ground side.

The psophometric current ~~shall be~~ is measured by means of a psophometer or another adequate system which uses filtering according to the psophometric weighting factor p_f.

To obtain additional information about the composition of the spectrum and the sources of disturbance, the use of a dual channel spectrum analyser, applied to vehicle input current and input voltage, is strongly recommended.

The psophometric current ~~should be~~ is measured in normal and in reduced operation mode (not all converters operating). The interpretation of the measurement results ~~should~~ takes into consideration the influence of operating conditions as well as changes in line inductance and supply voltage.

Effects due to transients (switching in the power circuits, pantograph bouncing, third rail/fourth rail gaps, etc.) ~~should be kept~~ are out of the evaluation.

A.5 Calculation of the overall psophometric current of a trainset

A.5.1 Current of one tractive unit

A.5.1.1 General

Typically, the total current of a trainset is not available. Instead of installing a special measuring system which can generate an image of the total current from sensors distributed over the whole trainset, it is normally sufficient to pick up the current of one tractive unit of the trainset.

If the psophometric current is being measured at one power terminal of a trainset and this trainset has "n" terminals, the overall current ~~shall be~~ is calculated according to thefollowing rules:

A.5.1.2 DC systems

DC railways are normally fed by diode rectifiers from the three phase supply. If no special filters are applied, the ripple of the rectifier output contributes considerably to the psophometric current absorbed by vehicles in the supply section.

– DC systems with dominating rectifier ripple

(Vehicles with camshaft control; vehicles with chopper or inverter control, substation with 6-pulse rectifier without filtering)

$I_{pso\ (total)} = n$ x $I_{pso\ (one\ unit)}$

– DC systems with converters on the vehicle and low rectifier ripple

$I_{pso\ (total)}$ may be less than $I_{pso\ (one\ unit)}$, for choppers operating in interlaced mode

$I_{pso\ (total)} = \sqrt{n}$ x $I_{pso\ (one\ unit)}$, for choppers operating without synchronisation or for inverters directly connected to the power supply.

A.5.1.3 AC systems

The psophometric current generated by vehicles in the supply section depends mainly on the type of converter used on board the vehicle.

– AC systems with phase controlled converters

$I_{pso\ (total)} = \sqrt{n}$ x $I_{pso\ (one\ unit)}$. This seems to be based on a statistical mix of vehicle types, speeds and actual current consumption. But recent experience with high power trainsets shows that this $\sqrt{n}$-law is not applicable in the case of equal speeds, equal power and equal vehicle types, when $I_{pso\ (total)} = n$ x $I_{pso\ (one\ unit)}$ applies.

– AC systems with 4 quadrant converters (4QC, pulse width modulated line converter)

$I_{pso\ (total)}$ ~~<~~ may be less than $I_{pso\ (one\ unit)}$, if 4QC ~~operate in interlaced~~ depends on the interlacing mode used (normal operating condition)

$I_{pso\ (total)} = n$ x $I_{pso\ (one\ unit)}$, if n equal units operate in non-interlaced mode.

Annex B
(normative)

Radiated electromagnetic disturbances – Test procedure

B.1 Purpose

This annex describes a measurement method for evaluation and qualification of a complete railway vehicle or train concerning the ~~noise~~ disturbance generated in the range ~~9~~ 150 kHz to 1 GHz. It fulfils most of the IEC 62236-2 measurement method recommendations but provides simplified features which significantly reduce the whole test duration.

B.2 Measuring equipment and test method

To reduce test duration, the frequency scanning technique is used. This can be done either by a spectrum analyser or a computer controlled receiver. Each frequency range is divided into several subranges.

Each evaluation of a train or a vehicle consists in doing a test of each subrange.

The apparatus shall scan this subrange continuously and memorize the maximum values reached during the test. This can be achieved by the "peak hold" function or under computer control of the apparatus. This method assumes that the level and characteristics of electromagnetic ~~noise~~ disturbance do not vary significantly during each scan.

The position, location, type and other features concerning the antennas are the same as described in IEC 62236-2:2018, Clause 5.

The measuring apparatus shall be in accordance with the CISPR 16-1-1:2015 requirements described in ~~4.2~~ Clause 5: "Peak measuring receivers for the frequency range 9 kHz to ~~1~~ 18 GHz". ~~However, for the 9 kHz to 150 kHz range (band A), the 200 Hz bandwidth may give the following problems.~~

~~– it is not always available in standard spectrum analysers;~~

~~– the scan duration is excessive for moving sources;~~

~~This would make it necessary to multiply the number of subranges which is contrary to the objective of the method.~~

~~For these reasons, the bandwidth for band A may be higher and 1 kHz is a convenient value. Proper corrections shall be carried out on the measurement results assuming that the noise is a broadband white noise.~~

Table B.1 may be used as a guideline for the test:

Table B.1 – Guideline for test

Band	Subrange Hz	Span [a] Hz	Bandwidth kHz	Sweep time [b] ms
~~A~~	~~9 k - 59 k~~ ~~50 k - 150 k~~	~~50 k~~ ~~100 k~~	~~1~~ ~~1~~	~~300~~ ~~300~~
B	150 k to 1,15 M	1 M	9 or 10	37
	1 M to 11 M	10 M	9 or 10	370
	10 M to 20 M	10 M	9 or 10	370
	20 M to 30 M	10 M	9 or 10	370
C/D	30 M to 230 M	200 M	100 or 120	42
	200 M to 500 M	300 M	100 or 120	63
	500 M to 1 G	500 M	100 or 120	100

[a] For a spectrum analyser.

[b] May be slightly different from one instrument to another.

~~NOTE If using a standard low cost spectrum analyser, care should be taken to always use the apparatus within the manufacturer guaranteed limits (input attenuation, intermediate frequency gains, etc.) and ensure a proper calibration. It also may be necessary to check the accuracy of the instrument over the whole frequency range with a reference signal prior to testing.~~

Annex C
(informative)

Emission values for lower frequency range

In the early 1990s measurements of emission from railways and vehicles on railways were undertaken to get information about the values to be expected in the neighbourhood of railways. It was experienced that in particular the results of magnetic field measurements, at 10 m distance, gave a poor reproducibility for frequencies below 150 kHz due to several reasons.

Due to the large variation in measured value (up to 20 dB) on the same vehicle depending on the location and other circumstances the reproducibility cannot be achieved and the usefulness is in question.

Since these emission values were published in the first editions of IEC 62236-3-1, the graphs are shown in this informative annex without being a requirement to be fulfilled (see Figures C.1 and C.2).

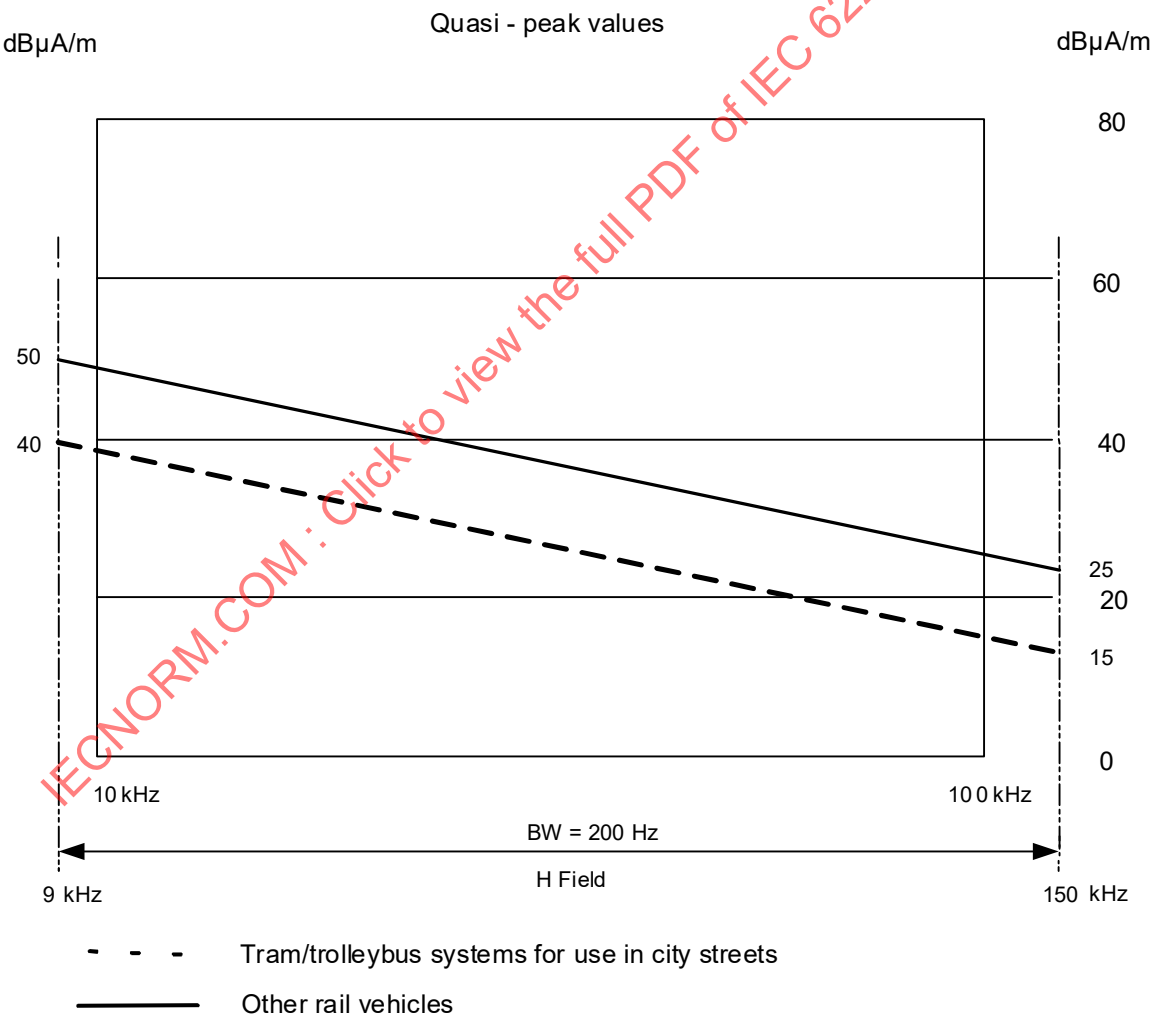


Figure C.1 – Emission values for stationary rolling stock

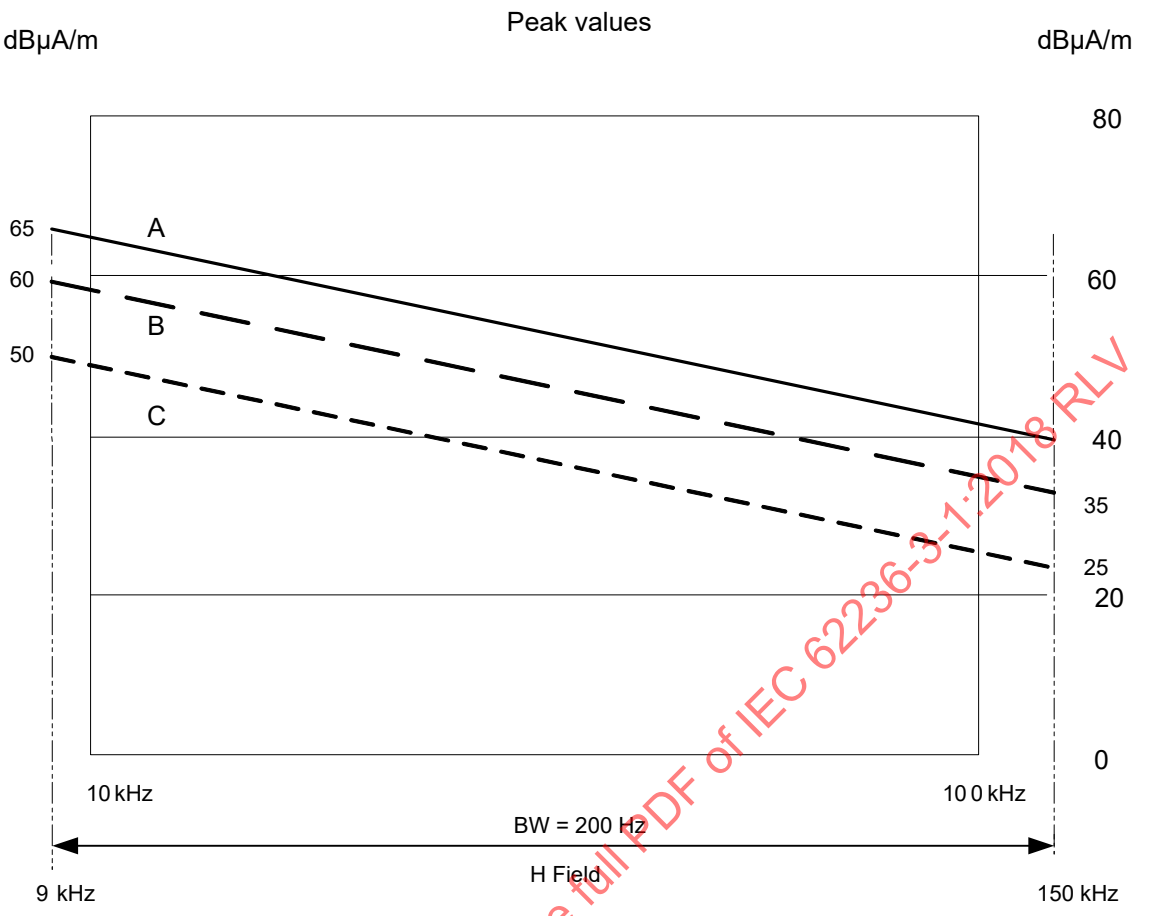


Figure C.2 – Emission values for slow moving rolling stock

Bibliography

IEC 62427:2007, *Railway applications – Compatibility between rolling stock and train detection systems*

ITU-T K.68:2008, *International Telecommunication Union – Telecommunication Standardization Sector of ITU; Series K: Protection against interference; Operator responsibilities in the management of electromagnetic interference by power systems on telecommunication systems*

ITU-T O.41:1994, *International Telecommunication Union – Telecommunication Standardization Sector of ITU; Specifications for measuring equipment – equipment for the measurement of analogue parameters; Psophometer for use on telephone-type circuits*

IEC 62236-3-1

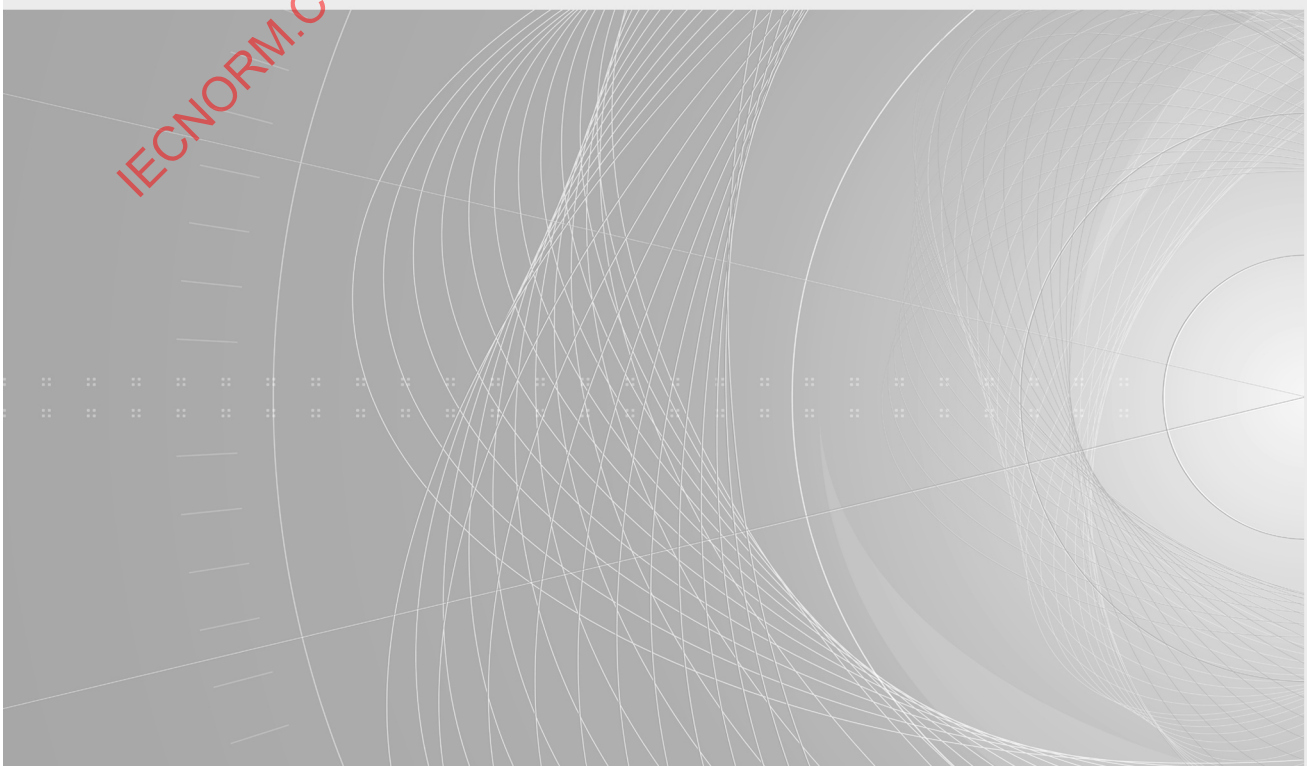
Edition 3.0 2018-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway applications – Electromagnetic compatibility – Part 3-1: Rolling stock – Train and complete vehicle

Applications ferroviaires – Compatibilité électromagnétique – Partie 3-1: Matériel roulant – Trains et véhicules complets



IEC 62236-3-1:2018-02(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

RAILWAY APPLICATIONS – ELECTROMAGNETIC COMPATIBILITY –

Part 3-1: Rolling stock – Train and complete vehicle

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 62236-3-1 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 50121-3-1:2015.

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

a) clarification of scope (Clause 1);
b) clarification of definitions (Clause 3);
c) clarification of applicability (Clause 4);
d) clarification of interference on outside party telecommunication lines (6.2), psophometric current (Annex A);

e) moving emission values for radiated H-field in the frequency range 9 kHz to 150 kHz into new Annex C due to the fact that:
   – there are very few outside world victims (e.g. radio services),
   – the radiated emission measured at 10 m is not representative of the compatibility with internal railway apparatus,
   – the EMC with other railway apparatus in this frequency range is covered in other procedures and standards like IEC 62427 series,
   – there is low reproducibility.

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
9/2337/FDIS	9/2367/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.

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

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.

INTRODUCTION

High powered electronic equipment, together with low power microcontrollers and other electronic devices, is being installed on trains in great numbers. Electromagnetic compatibility has therefore become a critical issue for the design of train-related apparatus as well as of the train as a whole.

This Product Standard for rolling stock sets limits for electromagnetic emission and immunity in order to ensure a well functioning system within its intended environment.

Immunity limits are not given for the complete vehicle. Part 3-2 of this series defines requirements for the apparatus installed in the rolling stock, since it is impractical to test the complete unit. An EMC plan includes equipment covered by this document.

RAILWAY APPLICATIONS – ELECTROMAGNETIC COMPATIBILITY –

Part 3-1: Rolling stock – Train and complete vehicle

1 Scope

This part of IEC 62236 specifies the emission and immunity requirements for all types of rolling stock. It covers traction stock, hauled stock and trainsets including urban vehicles for use in city streets. This document specifies the emission limits of the rolling stock to the outside world.

The scope of this document ends at the interface of the rolling stock with its respective energy inputs and outputs. In the case of traction units, trainsets, trams, etc., this is the current collector (pantograph, shoe gear). In the case of hauled stock, this is the AC or DC auxiliary power connector. However, since the current collector is part of the traction stock, it is not entirely possible to exclude the effects of this interface with the power supply line. The slow moving test has been designed to minimize these effects.

There may be additional compatibility requirements within the railway system identified in the EMC plan (e.g. as specified in IEC 62427).

Electromagnetic emissions of the railway system as a whole are dealt with in IEC 62236-2.

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

The frequency range considered is from 0 Hz (DC) to 400 GHz. No measurements need to be performed at frequencies where no requirement is specified.

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*

IEC 62236-2:2018, *Railway applications – Electromagnetic compatibility – Part 2: Emission of the whole railway system to the outside world*

IEC 62236-3-2:2018, *Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus*

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*

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
traction stock
electric and diesel traction unit, high speed trainset, elementary fixed combination of traction stock and hauled stock, electric and diesel multiple unit (no traction unit, distributed traction equipment), Light Railway Vehicle (LRV), such as tram, trolley bus or any other electrical vehicle for urban mass transit, underground trainset

3.1.2
hauled stock
independent passenger coaches and freight wagons (if they contain electric apparatus such as freezing equipment) which may be hauled in random combinations by different types of traction units

3.1.3
main line vehicles
vehicles such as high speed trains, suburban trains, freight trains, mainly designed to operate between cities

3.1.4
urban vehicles
vehicles such as underground trainsets, trams, LRV (Light Rail Vehicles), trolleybuses, mainly designed to operate within the boundary of a city

3.2 Abbreviated terms

AC	Alternating current
BW	Band width
DC	Direct current
E	Electric (field)
EMC	Electromagnetic compatibility
EUT	Equipment under test
H	Magnetic (field)
ISDN	Integrated Services Digital Network
ITU-T	International Telecommunucation Union – Telecommunication Standardization Sector
LRV	Light rail vehicle
PCM	Pulse – code modulation
QC	Quadrant converters
QP	Quasi-Peak
xDSL	All types of **d***igital* **s***ubscriber* **l***ines*

4 Applicability

Generally, it is not possible to test electromagnetic compatibility invoking every function of the stock. The tests shall be made at typical operating modes considered to produce the largest emission.

The typical operating mode shall require all systems to be energised which are normally in continuous operation during service. It is not necessary during the test to exercise systems which operate transiently such as for example operation of internal doors, although they should be energised. It is not necessary to test degraded modes of operation.

The configuration and mode of operation shall be specified in the test plan and the actual conditions during the tests shall be precisely noted in the test report.

5 Immunity requirements

No tests are applied to the complete vehicle. It is expected that the assembly of the apparatus into a complete vehicle will give adequate immunity, provided that an EMC plan has been prepared and implemented, taking into account the requirements in IEC 62236-3-2.

In exceptional cases, where apparatus meets another EMC Standard, but full compliance with IEC 62236-3-2 is not demonstrated, EMC shall be ensured by adequate integration measures of the apparatus into the vehicle system and/or by an appropriate EMC analysis and test which justifies deviating from IEC 62236-3-2.

6 Emission tests and limits

6.1 General

The emission tests and limits for rolling stock in this document should ensure as far as possible that the rolling stock does not interfere with typical installations in the vicinity of the railway system.

Measurements shall be performed in well-defined and reproducible conditions. It is not possible to totally separate the effects of the railway system and the stock under test. For radiated emissions, the test conditions are defined in 6.3.1 and 6.3.2.

NOTE 1 Signalling and communication, train radio and other railway systems (axle counters, track circuits, train control systems, etc.) are different in every country in terms of operating frequencies and waveforms. Therefore, compatibility requirements are specified according to the type of signalling and communication systems used.

NOTE 2 There can be cases in which radio or other railway external services with working frequencies below 150 kHz are in operation close to the railway. The EMC plan covers these cases and an adequate level of emission from railway 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.

6.2 Interference on outside party telecommunication lines

6.2.1 Digital telecommunication lines

Interference with digital systems such as PCM, ISDN, xDSL is not covered in this document.

It should be noted that these systems operate in a higher frequency range using multiple carriers and various automatic error correction protocols.

It is considered unlikely that rolling stock can produce sufficient interference in this frequency range.

6.2.2 Analogue telecommunication lines

No harmonized limits apply.

Information about interference on telecommunication lines can be found in Annex A.

6.3 Radiated electromagnetic disturbances

6.3.1 Test site

It can be assumed that measurements will not take place in laboratory conditions. Trees, walls, bridges, tunnels or other conductive objects in the vicinity of the measurement antenna could have an impact on the measurement. Other railway vehicles operating in the same feeding section or nearby the measuring point may affect the measurement result. Overhead/third rail discontinuities as well as substations, power lines, buried lines, transformers, neutral sections, section insulators, etc., close to the measuring point may cause additional variations.

These influences shall be reduced as far as practical but in any case no obstacles above rail level which may influence the measurements shall be located between antenna and EUT.

The overhead/third rail should be a continuous line as far as practical on both sides of the measurement point (typically at least 200 m).

Since it is impossible to avoid the support masts of the overhead, the measurement point shall be at the midpoint between masts, on the opposite side of the track (in case of a double track, on the side of the track which is being used). If the railway system is powered by a third rail, the antenna shall be on the same side of the track (worst case).

Since resonances may occur in the overhead line at radio-frequencies, it may be necessary to change the test site. The exact location of the test site and features of both the site and the overhead system layout shall be noted.

The contribution of the substation may be considered when assessing the emissions from the vehicle. Note that the contribution of a DC substation depends on its load current and will not be measured properly in a no-load condition.

At the beginning and at the end of the test series the ambient noise shall be recorded. This measurement shall be done without any influence of the vehicle.

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

NOTE It is helpful to perform this ambient noise measurement also with the vehicle completely powered down in front of the antenna.

6.3.2 Test conditions

The tests shall cover the operation of all systems onboard the rolling stock which may produce radiated emissions.

Hauled stock (a representative version) shall be tested while stationary in an energised mode (auxiliary converters, battery chargers, etc., in operation). The antenna should be sited opposite the equipment expected to produce the greatest emissions at the frequencies under measurement.

Tests for identical coaches or wagons are performed only once.

Traction stock shall be tested while stationary and at slow moving speed. During the stationary test, the auxiliary converters shall operate (it is not inevitably under maximum load conditions that the maximum emission level is produced) and the traction converters shall be under voltage but not operating. The antenna shall be in front of the middle of each vehicle unless an alternative location is expected to produce higher emission levels.

For the slow moving test, the speed shall be low enough to avoid arcing at or bouncing of the sliding contact and high enough to allow for electric braking. The recommended speed range is (20 ± 5) km/h for urban vehicles and (50 ± 10) km/h for main line vehicles. When passing the antenna, the vehicle shall accelerate or decelerate with approximately 1/3 of its maximum tractive effort within the given speed range.

The slow moving test may be replaced by a stationary test with the vehicle operating at 1/3 of its maximum tractive effort against the mechanical brakes, if the following conditions are fulfilled:

– the traction equipment can be operated while the vehicle is stationary;
– tests of electric braking are not required, if no different circuits are used in braking.

If the slow moving test is replaced by a stationary test with tractive effort, then the slow moving limits apply.

Any vehicles using onboard energy storage for traction shall use the test procedure and limits for slow moving test for the charging process.

NOTE Slow moving test procedure and limits are used for charging process (for traction energy storing devices) because it has a short duration with high energy transfer.

6.3.3 Emission limits

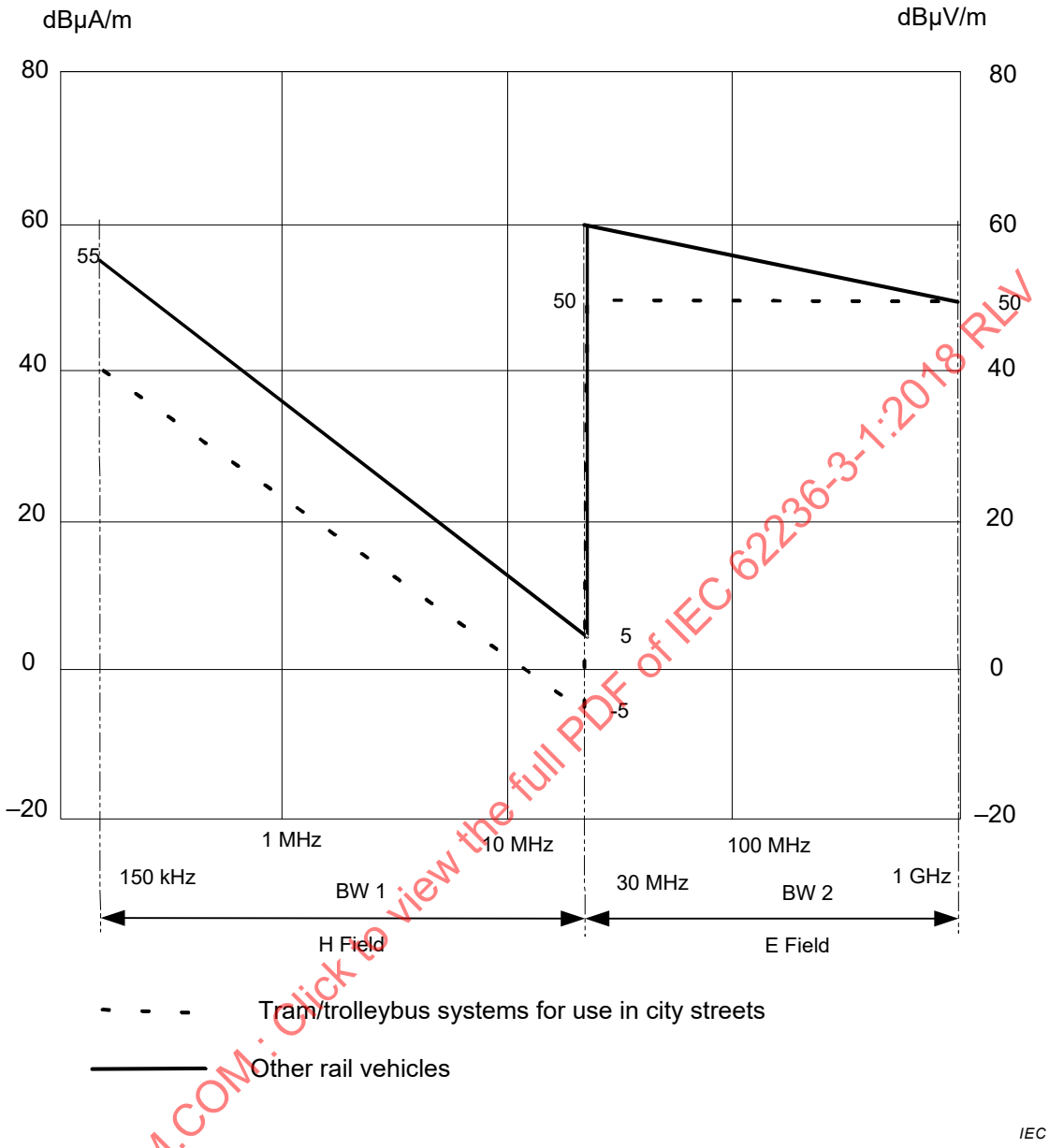

Figure 1 – Limits for stationary test (quasi-peak, 10 m)

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 from 30 MHz to 1 GHz	120 kHz (BW 2)

All values are measured at a distance of 10 m from the centre of the track.

The emission limits are specified up to 1 GHz due to the fact that there are no significant sources of interference above 1 GHz and that emissions from microprocessor controlled equipment which may give rise to emissions at frequencies greater than 1 GHz are addressed by compliance with IEC 62236-3-2.

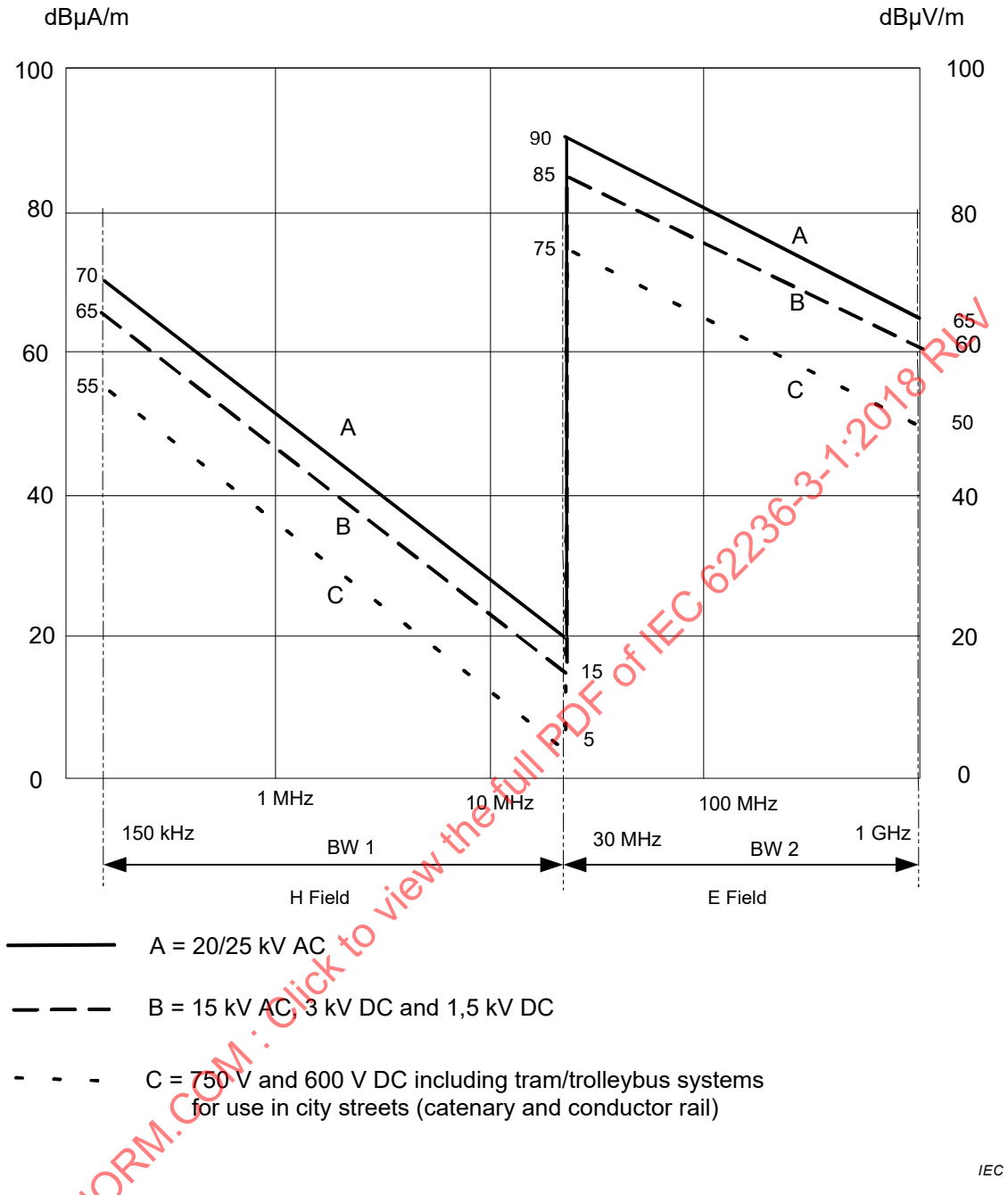

Figure 2 – Limits for slow moving test (peak, 10 m)

For details of test procedure, see Annex B.

All values are measured at a distance of 10 m from the centre of the track in peak values.

For diesel and diesel electric traction units and multiple units, the emission limits of Figure 1 ("other rail vehicles") and B in Figure 2 shall apply unless specific measures dictate otherwise (e.g. usage in lower voltage electrified lines).

The emission limits are specified up to 1 GHz due to the fact that there are no significant sources of interference above 1 GHz and that emissions from microprocessor controlled equipment which may give rise to emissions at frequencies greater than 1 GHz are addressed by compliance with IEC 62236-3-2.

Annex A
(informative)

Interference on telecommunication lines

A.1 Harmonics in the traction current

A.1.1 General

The harmonics in the traction current of a railway system may induce noise in a conventional analogue telecommunication system. The acceptable level of noise on conventional analogue telephone lines is specified by ITU-T. The value of this noise is measured with a psophometric filter. The relationship between the current absorbed or generated by the traction vehicle and the noise in the telephone line is neither under the total control of the vehicle manufacturer nor of the operator of the network. Thus, it is the responsibility of the purchaser of the tractive stock in accordance with the rules of the infrastructure manager to specify a frequency weighted current limit at the vehicle interface.

One method commonly used is to specify the psophometric current I_{pso} which has a psophometrical frequency weighting. The background and application of this method is described in this Annex. As it is known that the I_{pso} method does not fully represent the noise effect of the harmonics in the kHz range, alternative methods of frequency weighting may be specified by the purchaser.

A.1.2 Relationship between currents in railway system and noise on telecommunication lines

Conventional telecom copper cables in the vicinity of electrified railway lines are subject to electromagnetic disturbances caused by the currents in the railway system.

These disturbances result in induced longitudinal voltages ranging from the frequency of the fundamental wave to higher frequency harmonics. Sources of the harmonics are converters applied within the traction equipment of the traction stock and/or in the power supply station. Due to imbalances in the cable itself, these longitudinal voltages translate to transverse voltages or noise.

The acceptable level of noise on conventional analogue telephone lines is specified by the ITU-T. The value of this noise is measured with a psophometric filter.

The relationship between the current absorbed by the traction vehicle and the noise on the telecom line is neither under the total control of the vehicle manufacturer nor of the railway and telecommunication network operators.

This relationship depends on:

a) the structure of the telecom cables
   1) shielding, isolation to ground, balance of the cable;
b) the characteristics of the telecom terminals
   1) susceptibility, input balance;
c) the topology of the telecom network
   1) length of parallel sections of the telecom line to the tracks;
   2) the distance between tracks and telecom lines;
   3) the earth-resistivity;
d) the topology of the railway network

1) single/double track;

e) the type of power supply of the catenary

1) AC / DC;

2) substation ripple (DC rectifiers or AC 16,7 Hz static converters in some cases);

3) type of catenary and feeder system (e.g. 1 × 25 kV or 2 × 25 kV);

4) application of return conductors;

5) single-end or double-end supply of the section under consideration;

f) the density of train circulation;

g) the current absorption and generation of harmonics of the tractive stock;

h) the kind of harmonics superposition from a number of converters.

A.2 Psophometric current definition

The psophometric current is an equivalent disturbance current, which represents the effective disturbance of a current spectrum in a power circuit to a telephone line. It is defined by the formula:

$$I_{\mathrm{pso}} = \frac{1}{p_{800}} \sqrt{\sum (p_{\mathrm{f}} I_{\mathrm{f}})^2}$$

where:

I_{f} is the current component at frequency f in the contact line current;

p_{f} is the psophometric weighting.

The values of p_{f} may be found in the ITU-T Directives ITU-T O.41 and ITU-T K.68.

For measurement purposes, voltage and ampere meters which automatically calculate the signal according to these values of p_{f} by means of a psophometric filter are available.

A.3 Limits and test conditions

It is the responsibility of the purchaser to specify the maximum value of the psophometric current, and the conditions under which it is defined, including duration.

The following conditions are covered:

a) Limits of I_{pso} under normal and under reduced performance conditions (one or more traction converters temporarily out of service).

b) In the case of DC supply:

DC railways are normally fed by diode rectifiers from the 3-phase mains supply. Ideally, a single bridge rectifier produces a 6-pulse shape of voltage (i.e. first harmonic at 300 Hz in a 50 Hz mains) or two bridges produce a 12-pulse shape (i.e. 600 Hz). Due to imbalances in the rectifier and due to induction, a fundamental component at 50 Hz is commonly found.

The presence of filters in the substation greatly reduces the effect of the substation.

Nevertheless, in DC systems, the substation is the main source of perturbation.

Thus, to qualify a traction vehicle, the contribution of the rectifier unit and filters of the fixed installation are relevant.

It is also necessary to take into account the distance between the traction vehicle and the substation which affects the line inductance.

c) In the case of AC supply:

If the line voltage distortion has to be taken into consideration, the essential harmonics have to be specified. If special resonance conditions in the power supply line system are relevant, it is necessary to specify the relevant data. Otherwise, the situation of the vehicle nearest to the supply station is assumed to give the highest value I_{pso}.

A.4 Measurement of the psophometric current

During acceptance tests or investigation tests, the disturbance current I_{pso} is measured on board the traction vehicle. Existing current sensors of the vehicle may be used, if their frequency response is sufficient (at least up to 5 kHz). The current is measured at the high voltage input of the vehicle and not on the ground side.

The psophometric current is measured by means of a psophometer or another adequate system which uses filtering according to the psophometric weighting factor p_f.

To obtain additional information about the composition of the spectrum and the sources of disturbance, the use of a dual channel spectrum analyser, applied to vehicle input current and input voltage, is strongly recommended.

The psophometric current is measured in normal and in reduced operation mode (not all converters operating). The interpretation of the measurement results takes into consideration the influence of operating conditions as well as changes in line inductance and supply voltage.

Effects due to transients (switching in the power circuits, pantograph bouncing, third rail/fourth rail gaps, etc.) are out of the evaluation.

A.5 Calculation of the overall psophometric current of a trainset

A.5.1 Current of one tractive unit

A.5.1.1 General

Typically, the total current of a trainset is not available. Instead of installing a special measuring system which can generate an image of the total current from sensors distributed over the whole trainset, it is normally sufficient to pick up the current of one tractive unit of the trainset.

If the psophometric current is being measured at one power terminal of a trainset and this trainset has "n" terminals, the overall current is calculated according to the following rules:

A.5.1.2 DC systems

DC railways are normally fed by diode rectifiers from the three phase supply. If no special filters are applied, the ripple of the rectifier output contributes considerably to the psophometric current absorbed by vehicles in the supply section.

– DC systems with dominating rectifier ripple

(Vehicles with camshaft control; vehicles with chopper or inverter control, substation with 6-pulse rectifier without filtering)

$I_{pso\ (total)} = n \times I_{pso\ (one\ unit)}$

– DC systems with converters on the vehicle and low rectifier ripple

$I_{pso\ (total)}$ may be less than $I_{pso\ (one\ unit)}$, for choppers operating in interlaced mode

$I_{pso\ (total)} = \sqrt{n} \times I_{pso\ (one\ unit)}$, for choppers operating without synchronisation or for inverters directly connected to the power supply.

A.5.1.3 AC systems

The psophometric current generated by vehicles in the supply section depends mainly on the type of converter used on board the vehicle.

– AC systems with phase controlled converters

$I_{pso\ (total)} = \sqrt{n}$ x $I_{pso\ (one\ unit)}$. This seems to be based on a statistical mix of vehicle types, speeds and actual current consumption. But recent experience with high power trainsets shows that this $\sqrt{n}$-law is not applicable in the case of equal speeds, equal power and equal vehicle types, when $I_{pso\ (total)} = n$ x $I_{pso\ (one\ unit)}$ applies.

– AC systems with 4 quadrant converters (4QC, pulse width modulated line converter)

$I_{pso\ (total)}$ may be less than $I_{pso\ (one\ unit)}$, if 4QC depends on the interlacing mode used (normal operating condition)

$I_{pso\ (total)} = n$ x $I_{pso\ (one\ unit)}$, if n equal units operate in non-interlaced mode.

Annex B
(normative)

Radiated electromagnetic disturbances – Test procedure

B.1 Purpose

This annex describes a measurement method for evaluation and qualification of a complete railway vehicle or train concerning the disturbance generated in the range 150 kHz to 1 GHz. It fulfils most of the IEC 62236-2 measurement method recommendations but provides simplified features which significantly reduce the whole test duration.

B.2 Measuring equipment and test method

To reduce test duration, the frequency scanning technique is used. This can be done either by a spectrum analyser or a computer controlled receiver. Each frequency range is divided into several subranges.

Each evaluation of a train or a vehicle consists in doing a test of each subrange.

The apparatus shall scan this subrange continuously and memorize the maximum values reached during the test. This can be achieved by the "peak hold" function or under computer control of the apparatus. This method assumes that the level and characteristics of electromagnetic disturbance do not vary significantly during each scan.

The position, location, type and other features concerning the antennas are the same as described in IEC 62236-2:2018, Clause 5.

The measuring apparatus shall be in accordance with the CISPR 16-1-1:2015 requirements described in Clause 5: "Peak measuring receivers for the frequency range 9 kHz to 18 GHz".

Table B.1 may be used as a guideline for the test:

Table B.1 – Guideline for test

Band	Subrange Hz	Span [a] Hz	Bandwidth kHz	Sweep time [b] ms
B	150 k to 1,15 M	1 M	9 or 10	37
	1 M to 11 M	10 M	9 or 10	370
	10 M to 20 M	10 M	9 or 10	370
	20 M to 30 M	10 M	9 or 10	370
C/D	30 M to 230 M	200 M	100 or 120	42
	200 M to 500 M	300 M	100 or 120	63
	500 M to 1 G	500 M	100 or 120	100

[a] For a spectrum analyser.

[b] May be slightly different from one instrument to another.

Annex C
(informative)

Emission values for lower frequency range

In the early 1990s measurements of emission from railways and vehicles on railways were undertaken to get information about the values to be expected in the neighbourhood of railways. It was experienced that in particular the results of magnetic field measurements, at 10 m distance, gave a poor reproducibility for frequencies below 150 kHz due to several reasons.

Due to the large variation in measured value (up to 20 dB) on the same vehicle depending on the location and other circumstances the reproducibility cannot be achieved and the usefulness is in question.

Since these emission values were published in the first editions of IEC 62236-3-1, the graphs are shown in this informative annex without being a requirement to be fulfilled (see Figures C.1 and C.2).

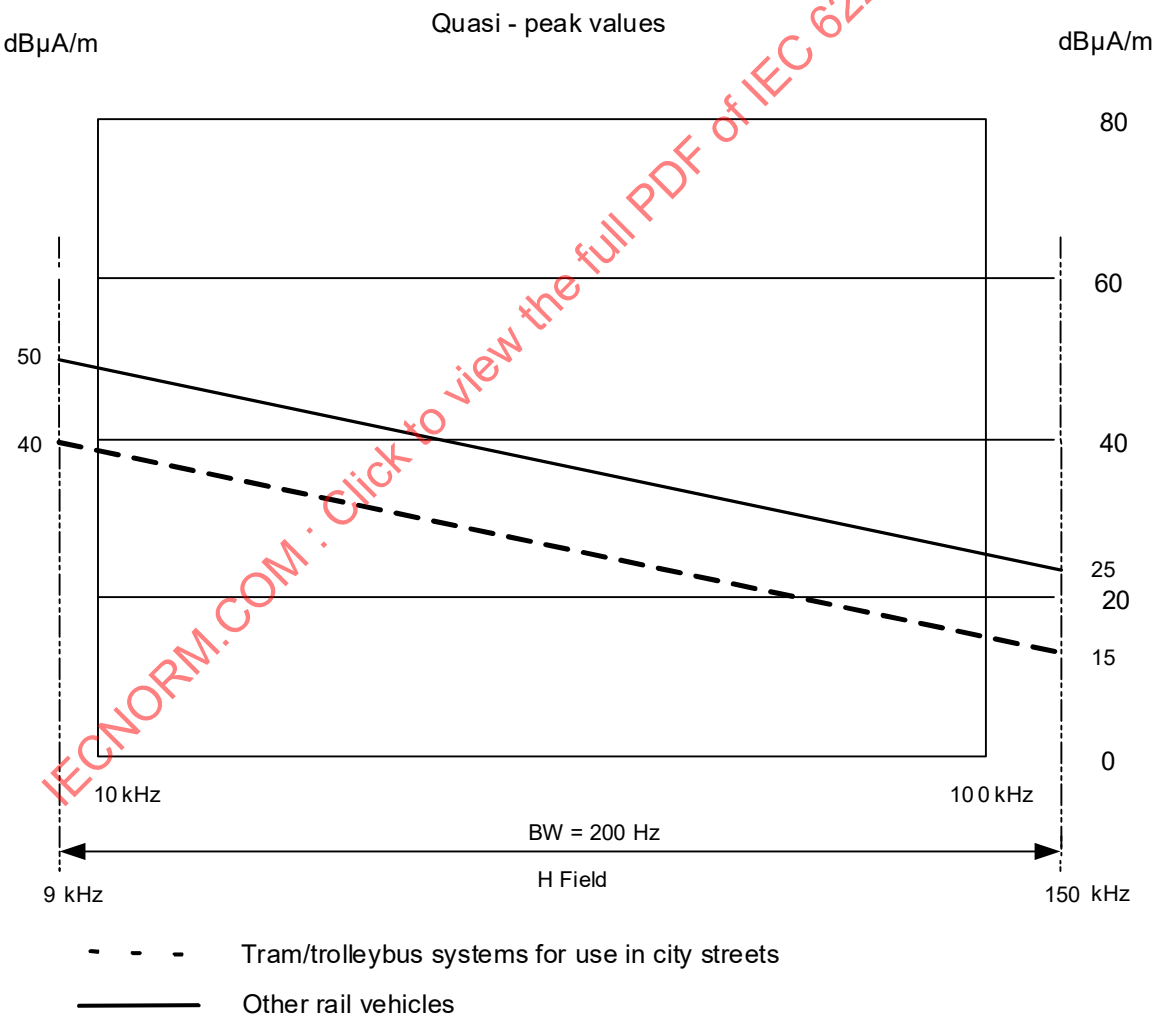

Figure C.1 – Emission values for stationary rolling stock

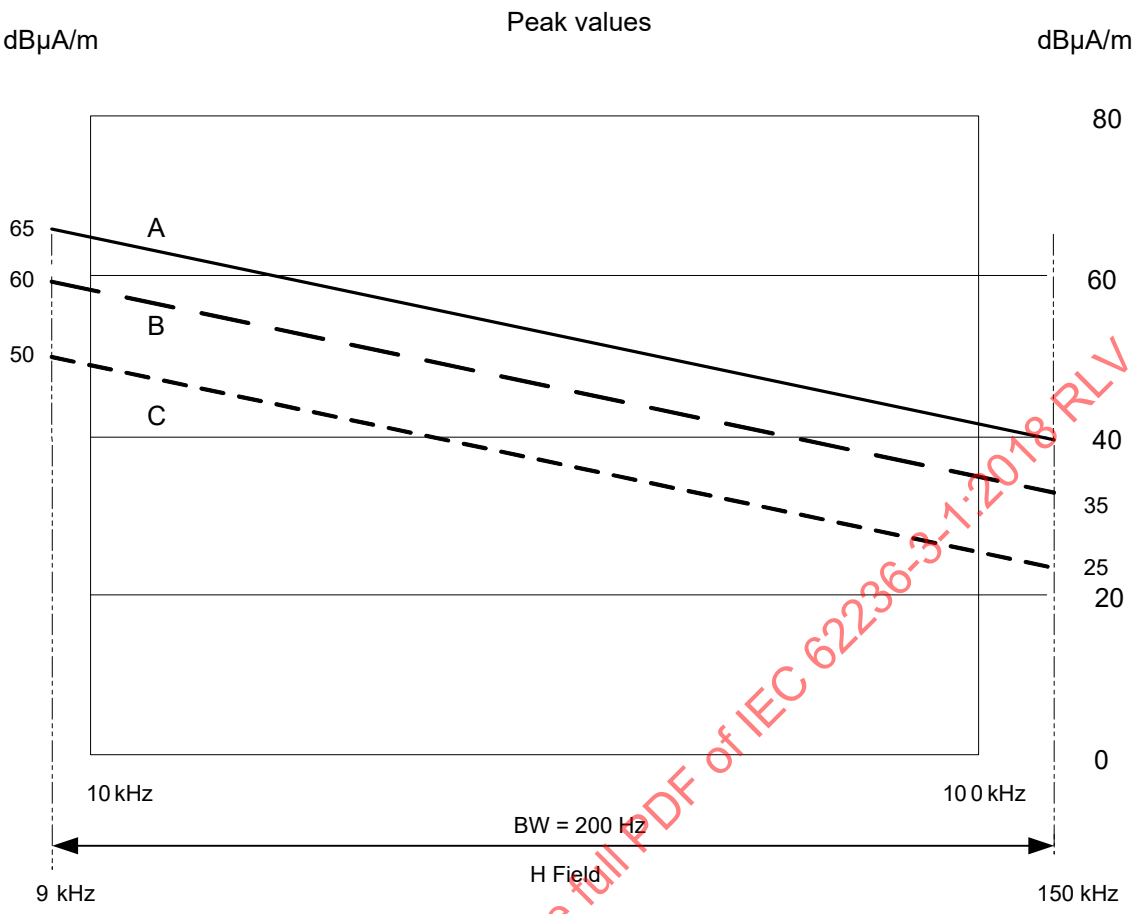

Figure C.2 – Emission values for slow moving rolling stock

Bibliography

IEC 62427:2007, *Railway applications – Compatibility between rolling stock and train detection systems*

ITU-T K.68:2008, *International Telecommunication Union – Telecommunication Standardization Sector of ITU; Series K: Protection against interference; Operator responsibilities in the management of electromagnetic interference by power systems on telecommunication systems*

ITU-T O.41:1994, *International Telecommunication Union – Telecommunication Standardization Sector of ITU; Specifications for measuring equipment – equipment for the measurement of analogue parameters; Psophometer for use on telephone-type circuits*

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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APPLICATIONS FERROVIAIRES – COMPATIBILTÉ ÉLECTROMAGNÉTIQUE –

Partie 3-1: Matériel roulant – Trains et véhicules complets

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La Norme internationale IEC 62236-3-1 a été établie par le comité d'études 9 de l'IEC: Matériels et systèmes électriques ferroviaires.

Cette troisième édition annule et remplace la deuxième édition publiée en 2008. Elle constitue une révision technique et a été développée sur la base de EN 50121-3-1:2015.

Cette édition inclut les changements techniques significatifs suivants par rapport à l'édition précédente:

a) clarification du domaine d'application (Article 1);
b) clarification des définitions (Article 3);
c) clarification de l'applicabilité (Article 4);

d) clarification de l'inteférence sur les lignes de télécommunications de tierces parties externes (6.2), courrant psophométrique (Annexe A);

e) déplacement des valeurs d'émissions pour les champs H rayonnés de largeurs de bande 9 kHz à 150 kHz dans l'Annexe C pour les raisons suivantes:

   – il y a très peu de victimes du monde extérieur (par exemple services radio);
   – l'émission rayonnée mesurée à 10 m n'est pas représentative de la compatibilité avec les appareils ferroviaires internes;
   – la CEM avec d'autres appareils ferroviaires dans cette bande de fréquence est couverte par d'autres procédures et d'autres normes comme la série IEC 62427;
   – la reproductibilité est faible.

Cette Norme internationale doit être lue conjointement avec l'IEC 62236-1.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
9/2337/FDIS	9/2367/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 62236, publiées sous le titre général *Applications ferroviaires – Compatibilité électromagnétique*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives au document recherché. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

INTRODUCTION

Les équipements électroniques de forte puissance avec leurs microcontrôleurs de faible puissance et d'autres appareils électroniques sont installés en grand nombre à bord des trains. La compatibilité électromagnétique est devenue de ce fait une question importante pour la conception des appareils embarqués ainsi que pour celle des trains dans leur ensemble.

La présente norme de produit concernant le matériel roulant fixe des limites pour les émissions et l'immunité électromagnétiques afin d'assurer le bon fonctionnement du système dans son environnement.

Les limites d'immunité ne sont pas données pour le véhicule complet. La Partie 3-2 de la présente série définit les exigences pour les appareils installés à bord du matériel roulant puisqu'il est impossible, en pratique, de soumettre l'unité complète aux essais. Un plan de CEM inclut les équipements couverts par le présent document.

APPLICATIONS FERROVIAIRES – COMPATIBILTÉ ÉLECTROMAGNÉTIQUE –

Partie 3-1: Matériel roulant – Trains et véhicules complets

1 Domaine d'application

La présente partie de l'IEC 62236 spécifie les exigences d'émission et d'immunité pour tous les types de matériels roulants. Elle s'applique au matériel de traction, au matériel remorqué et aux rames, y compris les véhicules de transport urbain. Le présent document spécifie les limites d'émission du matériel roulant vers le monde extérieur.

Le domaine d'application du présent document s'arrête à l'interface du matériel roulant avec ses entrées et sorties d'énergie respectives. Dans le cas des unités motrices, des rames, des tramways, etc., il s'agit du collecteur de courant (pantographe, frotteur). Dans le cas du matériel remorqué, il s'agit du connecteur de puissance auxiliaire en courant alternatif ou en courant continu. Cependant, comme le collecteur de courant fait partie du matériel de traction, il n'est pas complètement possible d'exclure les effets de cette interface avec la ligne d'alimentation en énergie. L'essai à vitesse lente a été conçu pour minimiser ces effets.

Les systèmes ferroviaires identifiés dans le plan de CEM peuvent faire l'objet d'exigences de compatibilité supplémentaires (spécifiées dans l'IEC 62427, par exemple).

Les emmissions électromagnétiques du système ferroviaire dans son ensemble sont traitées dans l'IEC 62236-2.

Ces dispositions spécifiques sont utilisées avec les dispositions générales données dans l'IEC 62236-1.

La plage de fréquences concernée est comprise entre 0 Hz (courant continu) et 400 GHz. Aucune mesure n'est nécessaire aux fréquences pour lesquelles aucune exigence n'est spécifiée.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 62236-1:2018, *Applications ferroviaires – Compatibilité électromagnétique – Partie 1: Généralités*

IEC 62236-2:2018, *Applications ferroviaires – Compatibilité électromagnétique – Partie 2: Émission du système ferroviaire dans son ensemble vers le monde extérieur*

IEC 62236-3-2:2018, *Applications ferroviaires – Compatibilité électromagnétique – Partie 3-2: Matériel roulant – Appareils*

CISPR 16-1-1:2015, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 1-1: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Appareils de mesure*

3 Termes, définitions et termes abrégés

3.1 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1.1
matériel de traction
unité motrice électrique et diesel, rame grande vitesse, combinaison élémentaire fixe de matériel de traction et de matériel remorqué, unité multiple électrique et diesel (pas d'unité motrice, équipement de traction réparti), véhicule léger sur rail (LRV), tel que tramway, trolleybus ou tout autre véhicule électrique de transport urbain, rame de métro

Note 1 à l'article: L'abréviation «LRV» est dérivée du terme anglais développé correspondant «light railway vehicle».

3.1.2
matériel remorqué
voiture indépendante pour voyageurs et tout wagon pour le fret (s'ils contiennent des appareils électriques tels que des équipements de réfrigération) qui peuvent être remorqués en combinaisons aléatoires par différents types d'unités motrices

3.1.3
véhicules grandes lignes
véhicules tels que les trains à grande vitesse, les trains suburbains, les trains de marchandises, conçus principalement pour circuler entre villes

3.1.4
véhicules urbains
véhicules tels que les rames de métro, les tramways, LRV (véhicules légers sur rail), les trolleybus, conçus principalement pour circuler en ville

Note 1 à l'article: L'abréviation «LRV» est dérivée du terme anglais développé correspondant «light rail vehicle».

3.2 Termes abrégés

CA	Courant alternatif
BW	Band width (largeur de bande)
CC	Courant continu
E	(champ) Electrique
CEM	Compatibilité électromagnétique
EUT	Equipment Under Test (équipement en essai)
H	(champ) Magnétique
RNIS	Réseau numérique à intégration de services
UIT-T	Union internationale des télécommunications – Secteur de la normalisation des télécommunications
LRV	Light Rail Vehicle (Véhicule léger sur rail)
MIC	Modulation par impulsion et codage
QC	Quadrant converters (Convertisseurs à quadrant)

QP Quasi Peak (Quasi-crête)

xDSL **xd***igital* **s***ubscriber* **l***ines* (tous types de lignes d'abonnés numériques)

4 Applicabilité

En général, il n'est pas possible de soumettre à essai la compatibilité électromagnétique en étudiant chaque fonction du matériel. Les essais doivent être réalisés sous des modes de fonctionnement typiques considérés comme générateurs des émissions les plus élevées.

Le mode de fonctionnement classique doit exiger que soient alimentés tous les systèmes en fonctionnement continu normal pendant le service. Pendant l'essai, il n'est pas nécessaire d'utiliser des systèmes qui fonctionnent de manière transitoire comme, par exemple, le fonctionnement des portes internes, même s'il convient de les mettre sous tension. Il n'est pas nécessaire de soumettre à essai les modes de fonctionnement dégradés.

La configuration et le mode de fonctionnement doivent être spécifiés dans le plan d'essai et les conditions réelles pendant les essais doivent être notées de manière précise dans le rapport d'essai.

5 Exigences d'immunité

Aucun essai n'est appliqué au véhicule complet. L'assemblage des appareils en un véhicule complet est censé offrir l'immunité adéquate, sous réserve qu'un plan de CEM ait été établi et mis en œuvre, en prenant en compte les exigences indiquées dans l'IEC 62236-3-2.

Dans des cas exceptionnels, quand un appareil respecte une autre norme CEM, mais que la pleine conformité avec l'IEC 62236-3-2 n'est pas démontrée, la CEM doit être assurée par des mesures adéquates d'intégration de l'appareil dans le véhicule et/ou par une analyse CEM appropriée et un essai qui justifie l'écart par rapport à l'IEC 62236-3-2.

6 Essais d'émission et limites

6.1 Généralités

Il convient que les essais d'émission et les limites pour le matériel roulant donnés par le présent document assurent, dans la mesure du possible, que le matériel roulant ne crée pas de perturbations qui affectent les installations types qui se trouvent à proximité du système ferroviaire.

Les mesures doivent être réalisées dans des conditions bien définies et reproductibles. Il n'est pas possible de séparer totalement les effets du système ferroviaire et du matériel en essai. Pour les émissions rayonnées, les conditions d'essai sont définies en 6.3.1 et 6.3.2.

NOTE 1 Les systèmes de signalisation et de communication, de radio des trains et les autres systèmes ferroviaires (compteurs d'essieux, circuits de voies, systèmes de pilotage des trains, etc.) sont différents d'un pays à l'autre en matière de fréquences de fonctionnement et de formes d'ondes. C'est pourquoi les exigences relatives à la compatibilité sont spécifiées selon le type de système de signalisation et de communication utilisé.

NOTE 2 Dans certains cas, la radio ou d'autres services ferroviaires externes dont les fréquences de travail sont inférieures à 150 kHz peuvent fonctionner à proximité de la voie ferrée. Le plan CEM couvre ces cas, et un niveau approprié d'émission réseau de traction à ces fréquences de fonctionnement peut être trouvé dans les valeurs indiquées dans l'Annexe C informative. Un fonctionnement exempt de perturbation ne peut donc être garanti.