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Railway applications — Acoustics — Measurement of noise emitted by railbound vehicles

Applications ferroviaires — Acoustique — Mesurage du bruit émis par les véhicules circulant sur rails

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: + 41 22 749 01 11
~~Email~~E-mail: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 256, *Railway applications*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the third edition (ISO 3095:2013), which has been technically revised.

The main changes are as follows:

— the alignment of measurement conditions with ISO 3381:2021[6]~~[6]~~;;

— an improvement of the tonality assessment;

— the introduction of specific measurement conditions for hybrid vehicles;

— a new informative Annex C~~Annex C~~ providing guidance information on the track influence on pass-by test results;

— an improved specification for additional noise measurements on bridges and other elevated structures in concrete bridge sections (see Annex F~~Annex F~~);~~);~~

— a new informative Annex H~~Annex H~~ specifying the measurement method for noise from parked trains to support a potential regulation aiming at taking into account annoyance produced in that situation;

— a new informative Annex I~~Annex I~~ outlining a procedure for assessing tonal noise using a narrow band analysis at standstill.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This corrected version of ISO 3095:2025 incorporates the following correction:

— In the last sentence of 6.3.4, the value "4 kPa" was corrected into "400 kPa".

Introduction

Railway exterior noise is encountered both along open tracks and in and around depots, stops, stations and other holding locations. It includes a number of different physical sources such as rolling noise, [20][28][29][30] impact noise, traction noise, aerodynamic noise, curving noise, braking noise, horn noise and noise from auxiliary equipment and other components. The noise for any given train type strongly depends on the rolling stock design, operating conditions and the track type and condition.

Rolling noise is one of the main sources from vehicle running on open tracks. It contains a significant and sometimes dominant noise contribution from the track. This document is intended to characterize the noise emission from the unit, minimizing the influence of the track.

These conditions are relevant for type testing of rollingstock, enabling comparisons of rolling stock noise emission levels for train operating and test conditions to comply with regulatory or contractual sound level limits. Where measurements are undertaken on other track designs or with different rolling stock operating conditions, noise levels can differ from the type test conditions described herein.

When project proponents are specifying project noise limits for rolling stock, they should include consideration of what is appropriate to their network/environment, temperature ranges, track type (ballast/slab/tunnel, light rail, etc.), and note that the limit values will be dependent on the network conditions, track decay rates, wheel/rail maintenance expectations, speed range, curves, and so on.

Railway environments carry particular safety risks. The measurement procedures specified in this document need to take into account relevant safe work methods applicable to each network.

Railway applications — Acoustics — Measurement of noise emitted by railbound vehicles

1 Scope

This document specifies measurement methods and conditions to obtain reproducible and comparable exterior noise emission levels and spectra for all kinds of vehicles operating on rails or other types of fixed track, hereinafter conventionally called “unit”.

This document is applicable to type testing of units.

It provides measurement procedures for vehicle exterior noise (in general, a vehicle type test is carried out using only a selected subset of these tests):

— when the vehicle is moving at constant speed;

— when the vehicle is accelerating or decelerating;

— when the vehicle is stationary in different operating conditions.

It does not include all the instructions to characterize the noise emission of the infrastructure related sources (bridges, crossings, switching, impact noise, curving noise, etc.).

This document does not apply to

— the noise emission of track maintenance units while working,

— environmental impact assessment (collection of data to be used in a prediction method for environmental assessment),

— noise immission assessment,

— guided buses, and

— warning signal noise.

The results can be used, for example

— to characterize the exterior noise emitted by units,

— to compare the noise emission of various units on a particular track section, and

— to collect basic source data for units.

NOTE Additional guidance is provided in Annex E~~Annex E~~ for measurements in the specific case of urban rail vehicles.

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 60942:2017, *Electroacoustics — Sound calibrators*

IEC 61094-4:1995, *Measurement microphones — Part 4: Specifications for working standard microphones*

IEC 61260-1:2014, *Electroacoustics — Octave-band and fractional-octave-band filters — Part 1: Specifications*

IEC 61260-3:2016, *Electroacoustics — Octave-band and fractional-octave-band filters — Part 3: Periodic tests*

IEC 61672-1:2013, *Electroacoustics — Sound level meters — Part 1: Specifications*

IEC 61672-3:2013, *Electroacoustics — Sound level meters — Part 3: Periodic tests*

ISO 1996-2:2017, *Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of sound pressure levels*

EN 15461:2008+A1:2010, *Railway applications — Noise emission — Characterisation of the dynamic properties of track sections for pass by noise measurements*

EN 15610:2019+A1:2025, *Railway applications — Acoustics — Rail and wheel roughness measurement related to rolling noise generation*

EN 17343:2023, *Railway applications — General terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 17343:2023 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 General definitions

3.1.1 ~~**3.1.1**~~
type test for noise emission of railbound units
one or more tests performed to prove that a product is capable of conforming to all relevant requirements of a specification

[SOURCE: ISO 12576-1:2001, 3.27, modified — for noise emission of railbound units has been added.]

3.1.2 ~~**3.1.2**~~
hybrid vehicle
vehicle that can store energy in an onboard ESS (Energy Storage System) and is driven by using the stored energy as well as electric power from a generator or overhead lines

Note 1 to entry: Other electric power supply options are possible, e.g. third-rail systems.

Note 2 to entry: Dual-mode (e.g. Electric-Diesel vehicles are not hybrid vehicles because they have no energy storage system on-board.

[SOURCE: IEC 62864-1:2016, 3.1.4, modified — Note 1 to entry and Note 2 to entry have been added.]

3.1.3 ~~**3.1.3**~~
series hybrid
system which drives a (electric) motor supplied via the power converter for combined operation of electric power from multiple power sources

Note 1 to entry: The wheels are driven by the driving force from the (electric) motor only.

Note 2 to entry: ~~Figure 1~~ Figure 1 shows an example block diagram of a series hybrid system.

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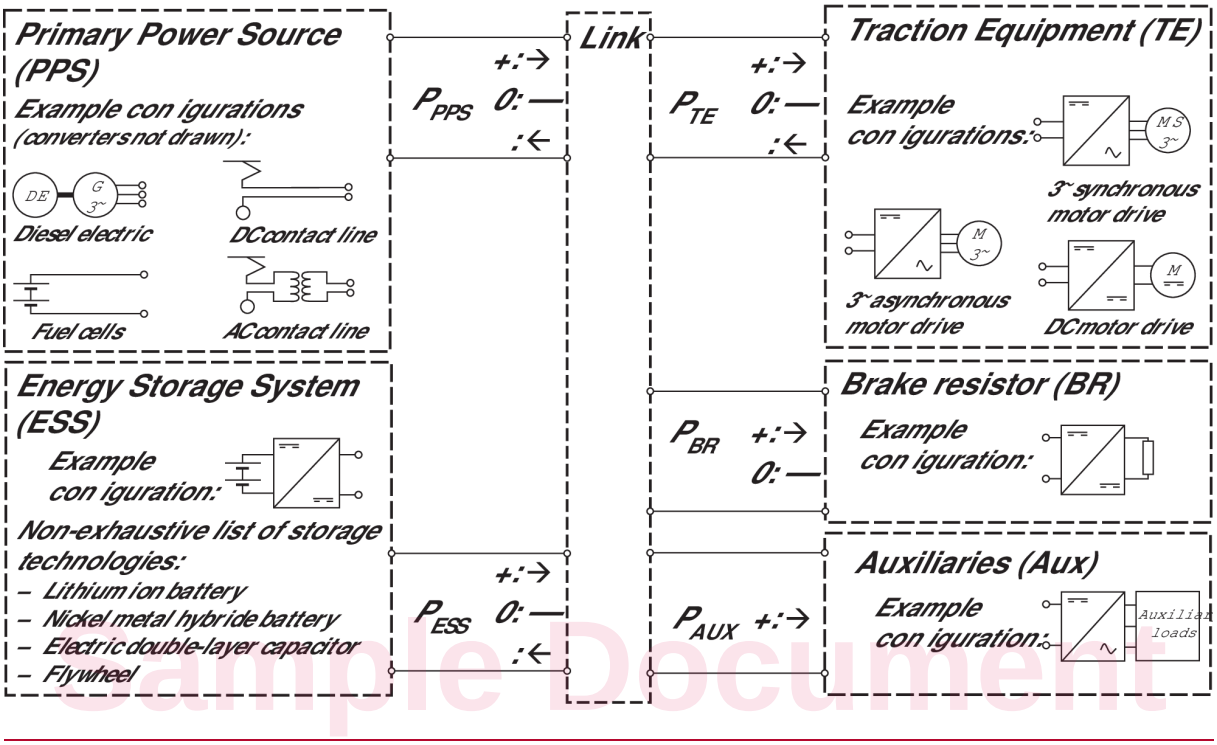

Key

DE	diesel engine
P_{PPS}	power of primary power source (PPS)
P_{TE}	power of traction equipment (TE)
P_{ESS}	power of energy storage system (ESS)
P_{BR}	power of brake resistor (BR)
P_{AUX}	power of auxiliaries (AUX)

Figure 1 — Block diagram of a series hybrid system

[SOURCE: IEC 62864-1:2016, 3.1.3, modified — Note 1 to entry has been modified and Note 2 to entry has been added.]

3.2 Definitions of track properties

3.2.1 ~~3.2.1~~

acoustic roughness

***r*(*x*)**

variation in the height of the running surface associated with rolling noise excitation, expressed as a function of distance *x* along the running surface

[SOURCE: EN 15610:2019+A1:2025, 3.1]

3.2.2 ~~3.2.2~~
acoustic roughness spectrum

$\tilde{r}(\lambda)$
amplitude of the acoustic roughness expressed as a function of the wavelength λ

[SOURCE: EN 15610:2019+A1:2025, 3.2]

3.2.3 ~~3.2.3~~
track decay rate
vibration amplitude decay rate of the vertical or transverse bending waves of the rail

Note 1 to entry: It is represented by a one-third octave band spectrum of the values of the decay rate, expressed in decibels per metre (dB/m) representing the attenuation as a function of the distance.

[SOURCE: EN 15461:2008+A1:2010, 3.6, modified – "as a function of the distance along the rail" deleted]

3.2.4 ~~3.2.4~~
acoustic track characteristics
ATC
characteristics of the track that are defined in terms of acoustic rail roughness and track decay rates

[SOURCE: ISO 3381:2021, 3.5]

3.2.5 ~~3.2.5~~
test section
specific section of track associated with a particular set of measurements

[SOURCE: EN 15610:2019+A1:2025, 3.7]

3.2.6 ~~3.2.6~~
reference track section
portion of track with specific requirements to minimize the contribution of the track for pass-by noise measurements

3.3 Definitions of acoustic measurement quantities

3.3.1 ~~3.3.1~~
sound pressure
p
difference between an instantaneous total pressure and the corresponding static pressure

Note 1 to entry: Sound pressure is expressed in pascals (Pa).

[SOURCE: IEC 61672-1:2013, 3.1]

3.3.2 ~~3.3.2~~
sound pressure level
L**p**
ten times the logarithm to the base 10 of the ratio of the time-mean-square of a sound-signal to the square of the reference value

~~(1)~~

$$L_p = 10\lg\frac{p_{\mathrm{RMS}}^2}{p_0^2}\ \mathrm{dB} \qquad (1)$$

where

p_{RMS} is the root-mean-square pressure in the time domain;

p_0 is the reference value.

Note 1 to entry: Sound pressure level is expressed in decibels (dB).

Note 2 to entry: the reference value is 20 µPa.

[SOURCE: IEC 61672-1:2013, 3.2, modified — equation and definition of terms p_{RMS} and p_0 added]

3.3.3 ~~3.3.3~~
AF-weighted sound pressure level history
$L\mathbf{p}_{AF}(t)$
A-weighted sound pressure level as a function of time with time weighting F (fast)

Note 1 to entry: see also IEC61672-1:2013, definition 3.6 “time-weighted sound level”.

3.3.4 ~~3.3.4~~
AF-weighted maximum sound pressure level
$L\mathbf{p}_{AFmax}$
maximum value of the A-weighted sound pressure level determined during the measurement time interval T by using time weighting F (fast)

Note 1 to entry: see also IEC61672-1:2013, definition 3.7, maximum time-weighted sound level.

3.3.5 ~~3.3.5~~
equivalent continuous sound pressure level
$L\mathbf{p}_{eq,}\mathbf{T}$
ten times the logarithm to the base 10 of the ratio of the time-average of the square of the sound pressure, p, during a stated time interval of duration, T (starting at $t1$ and ending $t2$), to the square of the reference sound pressure, $p0$

Note 1 to entry: the A-weighted equivalent continuous sound pressure level is

~~(2)~~

$$L_{pAeq,T} = 10\,lg\,[\frac{1}{T}\int_{t_1}^{t_2}\frac{{p_A}^2(t)}{{p_0}^2}\mathrm{d}t]\ \mathrm{dB} \qquad (2)$$

where

$p_A(t)$ is the A-weighted instantaneous sound pressure at running time t

p_0 is equal to 20 µPa.

Note 2 to entry: The equivalent continuous sound pressure level is also termed “time-averaged sound pressure level”. It is expressed in decibels (dB).

[SOURCE: ISO 1996-1:2016, 3.1.6]

3.3.6 ~~3.3.6~~
impulsive sound
sound characterized by one or more brief bursts of sound pressure with a duration of usually less than 1 s for each burst

~~EXAMPLES~~EXAMPLE impulsive noise sources: Blowoff valves, relay switches.

Note 1 to entry: This definition does not apply to a whole pass-by event.

Note 2 to entry: The quantification of impulsiveness is set out in Annex A~~Annex A~~.

[SOURCE: ISO 1996-1:2016, 3.4.8, modified – "brief bursts of sound pressure" replaced with "one or more brief bursts of sound pressure"; former Note 1 to entry is incorporated into the definition as "with a duration of usually less than 1 s for each burst"; Example and new Note 1 and 2 to entry added.]

3.3.7 ~~**3.3.7**~~
tonal sound
sound characterized by a single frequency component or narrow-band components that emerge audibly from the total sound

[SOURCE: ISO 1996-1:2016, 3.4.9]

3.4 Definitions for noise from parked trains

3.4.1 ~~**3.4.1**~~
parking
condition of a train out of operational service, with or without external power

Note 1 to entry: it is different from stationary vehicle condition which refers to a vehicle in-service mode at standstill.

3.4.2 ~~**3.4.2**~~
activity phase of a noise source
time phase in which the source is active with the same operational parameters

3.4.3 ~~**3.4.3**~~
rest phase of a noise source
time phase in which the source is not active

3.4.4 ~~**3.4.4**~~
operation cycle
cycle comprising the activity phase and the rest phase

3.4.5 ~~**3.4.5**~~
noise source type
group of noise sources with the same acoustic relevant design

3.4.6 ~~**3.4.6**~~
car type
group of cars with the same acoustic relevant design

3.4.7 ~~**3.4.7**~~
operational parameter
parameter which correlates with the power of a noise source (e.g. rotational speed)

4 Instrumentation and calibration

4.1 Instrumentation

The microphones, signal acquisition units and processing algorithms used shall each comply with the requirements of IEC 61672-1:2013 specifications for class 1 measuring equipment. Periodic tests to demonstrate the compliance with the specification shall be conducted in accordance with IEC 61672-3:2013.

Where measurement equipment other than type-approved sound level meter is used, microphones shall comply with the requirements of IEC 61094-4:1995 specifications for WS2P/F/D measuring equipment.

NOTE Multichannel acquisition systems are generally used to record data.

In the case of measurements of survey grade (grade 3 as defined in ISO 12001:1996[7][7]~~),~~, this requirement is relaxed to class 2 instruments.

The sound calibrator shall meet the requirements of class 1 according to IEC 60942:2017.

Microphones with free-field characteristics shall be used. A suitable microphone windscreen should be used.

Where one-third octave frequency band analysis is required, the filters shall meet the requirements of class 1, according to IEC 61260-1:2014. Periodic tests to demonstrate the compliance with the specification shall be conducted according to IEC 61260-3:2016.

The compliance of the calibrator with the requirements of IEC 60942:2017 shall have been verified within one year of the test date. The compliance of the measurement equipment with the requirements of IEC 61672 series or IEC 61094-4:1995 shall have been verified within two years of the test date. The date of the last verification of the compliance with the relevant standards shall be recorded.

4.2 Calibration

Before and after each series of measurements, a sound calibrator shall be applied to the microphone(s) for verifying the calibration of the entire measuring system at one or more frequencies over the frequency range of interest. If the difference between two consecutive calibrations is more than 0,5 dB, all of the measurement results in between shall be rejected.

The sensitivity of the measurement chain actually applied in the field shall be documented.

5 Stationary test

5.1 General

The stationary condition shall correspond to a halt during train operation (e.g at a station, stop at a signaling point…). This does not include parked train which is one that is taken out of operational service (e.g. parking in a depot or end station). The measurement of noise from parked trains, if required, is specified in Annex H~~Annex H~~.

The noise emitted by a stationary unit depends upon its operating conditions. These will differ according to the situation. The measurements shall be carried out only if noise sources are present at standstill with the operating conditions specified in 5.4~~5.4~~.

NOTE For freight wagons, stationary tests are relevant only when auxiliary devices such as engines, generators, or cooling systems are present. This is mostly applicable, e.g. on refrigerated wagons.

5.2 Environmental conditions

5.2.1 Acoustical environment

In the triangular area between the track and the microphone extending along the track to a distance twice the microphone distance to either side (see Figure 2~~Figure 2~~~~),~~, the test site shall be such that free sound propagation exists. To achieve this result:

— ~~—~~The level of the ground surface over this area shall be within 0 m to −2 m, relative to the top of rail;