



BSI Standards Publication

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

National foreword

This British Standard is the UK implementation of EN ISO 3095:2025. It is identical to ISO 3095:2025. It supersedes BS EN ISO 3095:2013, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EH/1/2, Transport noise.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Date	Text affected
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English Version

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Applications ferroviaires - Acoustique - Mesurage du
bruit émis par les véhicules circulant sur rails (ISO
3095:2025)

Akustik - Bahnanwendungen - Messung der
Geräuschemission von spurgebundenen Fahrzeugen
(ISO 3095:2025)

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European foreword

This document (EN ISO 3095:2025) has been prepared by Technical Committee ISO/TC 43 "Acoustics" in collaboration with Technical Committee CEN/TC 256 "Railway applications" the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2026, and conflicting national standards shall be withdrawn at the latest by March 2026.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 3095:2013.

This document has been prepared under a standardization request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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];
- an improvement of the tonality assessment;
- the introduction of specific measurement conditions for hybrid vehicles;
- a new informative [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](#));
- a new informative [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](#) 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.

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](#) 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

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

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.]

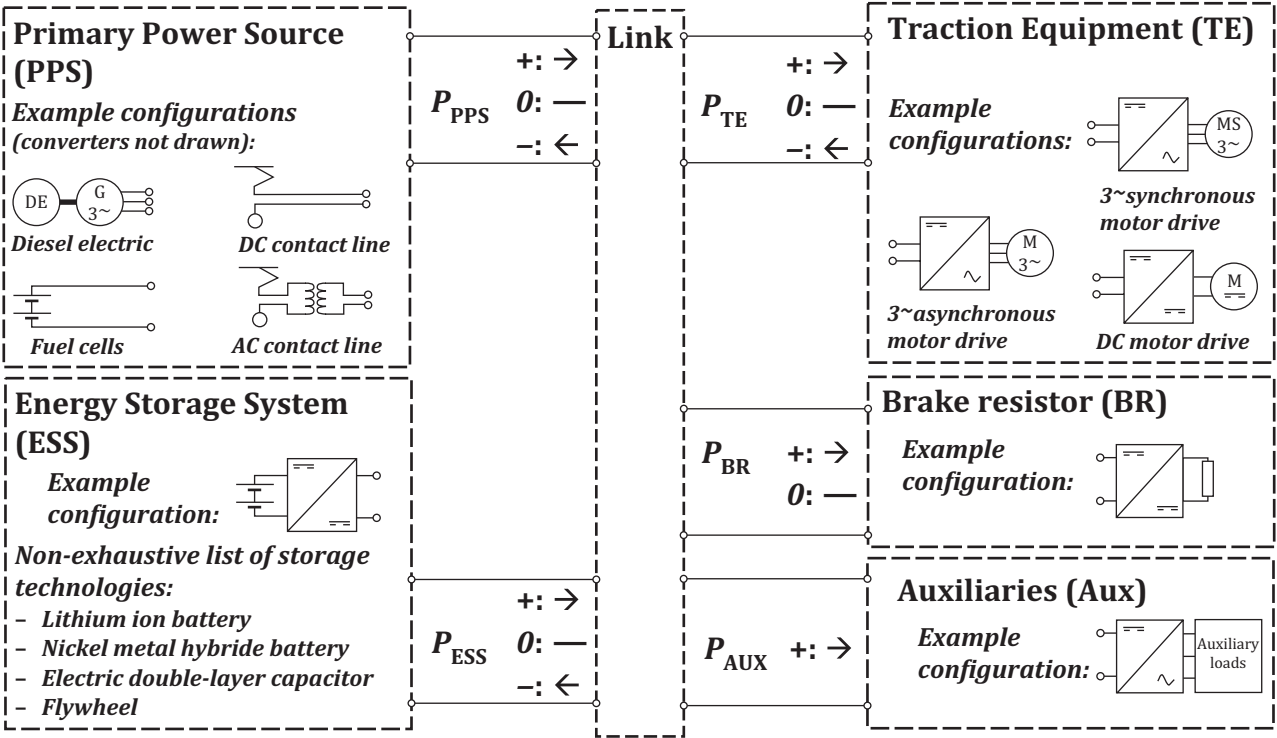
3.1.3

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](#) shows an example block diagram of a series hybrid system.



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 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 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

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

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

test section

specific section of track associated with a particular set of measurements

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

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

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

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

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

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**AF-weighted sound pressure level history** $L_{pAF}(t)$

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**AF-weighted maximum sound pressure level** L_{pAFmax} 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**equivalent continuous sound pressure level** $L_{peq,T}$ 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 t_1 and ending t_2), to the square of the reference sound pressure, p_0

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

$$L_{pAeq,T} = 10 \lg \left[\frac{1}{T} \int_{t_1}^{t_2} \frac{p_A^2(t)}{p_0^2} dt \right] \text{ dB} \quad (2)$$

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**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

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](#).

[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**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

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

activity phase of a noise source

time phase in which the source is active with the same operational parameters

3.4.3

rest phase of a noise source

time phase in which the source is not active

3.4.4

operation cycle

cycle comprising the activity phase and the rest phase

3.4.5

noise source type

group of noise sources with the same acoustic relevant design

3.4.6

car type

group of cars with the same acoustic relevant design

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^[Z]), 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](#).

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](#).

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

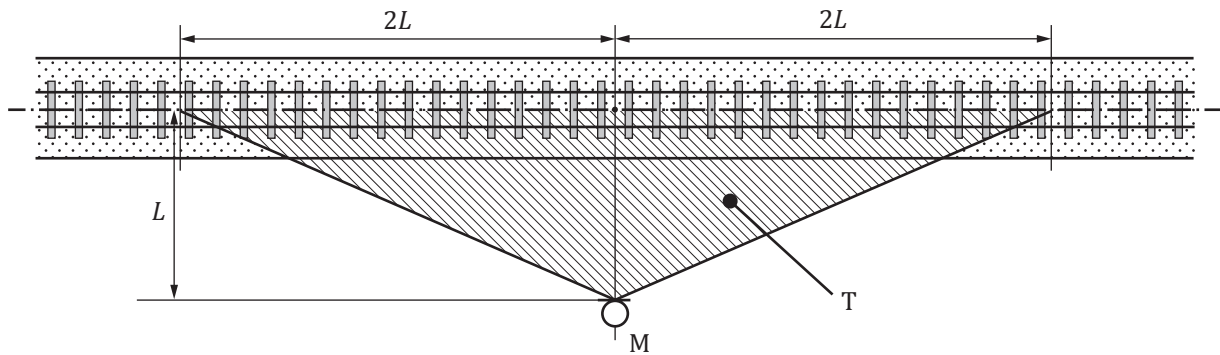
5.2.1 Acoustical environment

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](#)), 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;

NOTE The level of the ground and the nature of the ground surface can affect the spectral content of the measured sound.
- This area shall be free of sound absorbing matter such as lying snow, tall vegetation, and free of reflective covering such as water, ice, tarmac or concrete. No absorptive material shall be added to the propagation path for the purpose of the test;
- No person shall be present in this area, and the person observing the measurement equipment shall be in a position that does not influence the measured sound pressure level significantly;
- The presence of other tracks is permissible in this area as long as the ballast bed height does not exceed the height of the rail surface of the test track.

Additionally, an area around the microphones having a radius which is at least three times the measurement distance shall be free of large reflecting objects like barriers, hills, rocks, bridges, buildings or other vehicles.



Key

- L length between track centre and microphone
- M microphone
- T triangular area

Figure 2 — Triangular area

5.2.2 Meteorological conditions

The standard conditions for measurements shall be: no strong rain, hail or snow. Any noise-relevant weather information (e.g. temperature, humidity, rain, hail, snow, wind speed at the level of the highest microphone) shall be recorded before and after each series of measurements as a minimum.

NOTE Heavy rain or wind speed higher than 5 m/s can affect the background noise, see [5.2.3](#).

5.2.3 Background sound pressure level

Care shall be taken to ensure that the noise from other sources (e.g. other vehicles or industrial plants and due to wind) does not influence the measurements significantly.

The background noise levels shall be recorded before and after each series of measurements.

The maximum value of $L_{pAeq,T}$ with $T = 20$ s of background noise over all microphone positions shall be at least 10 dB below the final result (energy-mean of all the measuring positions, see [5.5.1.1](#), calculated according to [5.8.1](#)) obtained when measuring the noise from the unit in the presence of background noise. For one-third octave band frequency analyses, this difference shall be at least 10 dB in each frequency band of interest.

NOTE In the case of a large spread of levels along a unit under test for specific positions the background noise level can have an influence on the measurement results for single positions.

5.3 Track conditions

The standard superstructure for the stationary test is a ballasted track with ballast bed and wooden or reinforced concrete sleepers.

NOTE 1 If other track designs are used under normal operating conditions for the unit they can be used for the test.

NOTE 2 Measurement results made on other track designs are only comparable with measurements made on that track design.

5.4 Vehicle conditions

5.4.1 General

The unit shall be stationary.

The vehicles shall be unoccupied except for essential train crew and testing personnel.

The vehicle shall be configured and operated during the test to represent the normal operating conditions at stationary (including software e.g. for traction, auxiliaries, and HVAC configuration).

Air management systems, including grilles, filters and fans, shall be clear of any obstruction. During the measurements, the doors and windows of the unit shall be kept closed.

In the case of multi-voltage vehicles or units, the measurements shall be performed under the voltage system which is expected to produce the highest noise level.

NOTE If a unit is designed for AC and DC supply then the AC mode is usually the noisier one.

In the case of dual-mode vehicles or units (diesel and electric) the measurements shall be performed under both modes.

In case of series hybrid vehicles:

- the power source, which is mainly used in normal operation, shall be measured in accordance with IEC 62864-1:2016^[2] Mode XIII or XIV;
- In case of different operating modes are possible during stationary condition, the most representative one during the measurements should be used. If the most representative mode cannot continue for the full length of the measurement period, the other single mode which can continue for the full measurement duration should be used;
- The onboard Energy Storage System ESS (e.g. battery) shall be assumed to be charged at the upper end of the usual range in any case. A regular operation shall be assumed (i.e. no emergency operation).

5.4.2 Normal operating conditions

The measurements shall be carried out in normal operating conditions specified as follows.

All equipment that operates continuously when the unit is stationary shall be operating at normal load. Normal load in this subclause means the performance at an external equivalent temperature of 20 °C except for HVAC systems. For the following systems this requires that:

- the cooling equipment of traction and auxiliary equipment shall be operated in the minimum necessary condition in stable thermal condition;
- the air compressor shall not operate where possible;
- for units with internal combustion engines, the engine shall be at idle with a load corresponding to the necessary power to operate the auxiliaries as specified in this paragraph;
- for heating, ventilating and air conditioning (HVAC) systems conditioning passenger areas and working places as well as for systems supplying energy for this function, normal load is specified as 50 % of the cooling power that is necessary under design conditions according to ISO 19659-2:2020^[2] where the vehicle is regularly operated. For units operated in a fully underground condition, these design conditions should be adapted. In the case of discrete operating points, HVAC shall be operated at the lowest operation mode equal to or above 50 %. At least one compressor per HVAC unit shall be set to operate continuously.

Operational parameters shall be specified and documented in the report.

5.4.3 Additional operating conditions

It is permissible to measure at other vehicle conditions, if required, for instance, to assess other load conditions or intermittent operation (e.g. including compressors and air release systems). In this case, these conditions shall be reported.

5.5 Measurement positions

5.5.1 Standard measurement positions

5.5.1.1 Measurement mesh

Each car (a multiple unit comprises a number of cars) shall be divided into equally distributed areas, each having an identical horizontal length, l_x , of between 3 m and 5 m. The length of the car is the distance between couplers or buffers or between structure ends in the case of a structure that surrounds couplers and buffers. Each measurement position is located at midlength along the relevant area on both sides of the car.

Each measurement position shall be located at a distance of 7,5 m from the centreline of the track at a height of 1,2 m above the top of rail.

Extra measurement positions shall be taken at the front and rear end of the unit: two microphones located at 30° from the centreline of the track, on a half-circle having its centre in the midpoint of the unit end (including couplers or buffers) and a radius equal to 7,5 m, as illustrated in [Figure 3](#). In the case of a trailer unit, these extra positions shall only be measured at ends which are equipped with a cab.

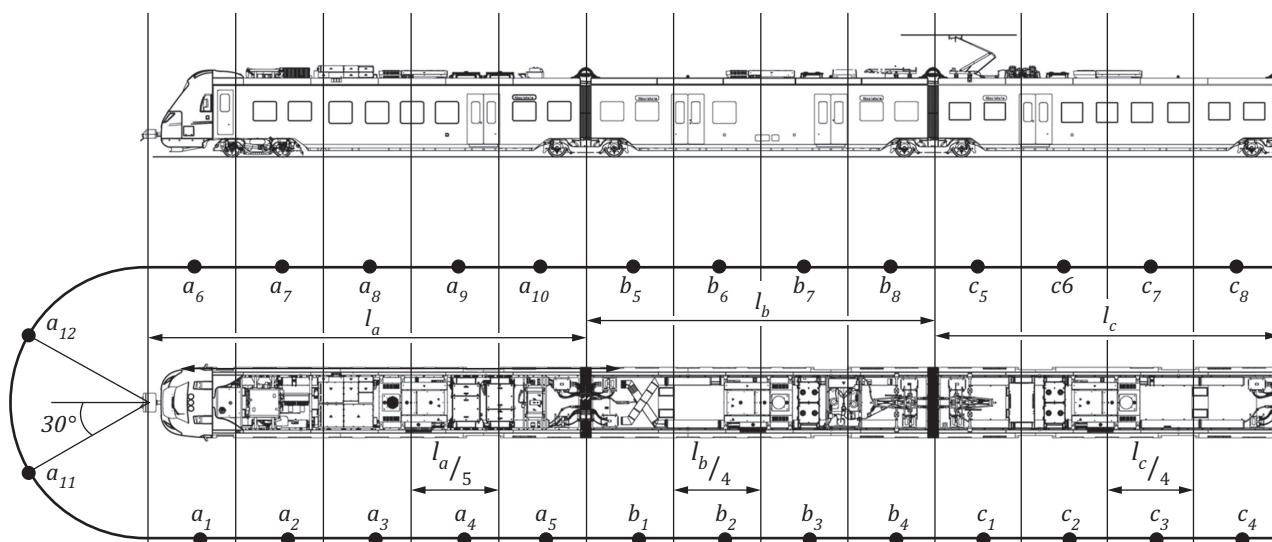
The microphone axis shall be horizontal and directed perpendicularly to the contour of the unit.

5.5.1.2 Reduction of the number of measurement positions

Redundant measurements may be omitted, considering that some measurement positions are equivalent (and will lead to similar noise levels), for example

- if both sides of the unit are acoustically identical (i.e. with a symmetrical distribution of noise sources), then it is permissible to omit the measurement positions on one side of the unit, and
- if several cars, equivalent in terms of source acoustic characteristics, are present within a multiple unit or a fixed formation train, it is permissible to measure only one car representative of this group.

The reduction of the number of measurement positions shall be justified in the report. Omitted positions shall be listed and their assumed equivalent location identified.



Key

- measurement position

Figure 3 — Example of a mesh of measurement positions for the stationary noise measurement of a multiple unit

5.5.2 Additional measurement positions

If important sound sources are present in the upper part of the unit under test (e.g. power units or low floor rolling-stock), a second mesh of measurement positions at a distance of 7,5 m from the centreline of the track at a height of 3,5 m above the top of rails is recommended.

If an assessment of single noise sources (e.g. converters, air compressor, doors) is required, additional measurement positions may also be located directly opposite the individual noise sources considered to be relevant, at a distance of 7,5 m from the centreline of the track and at a height of 1,2 m or 3,5 m.

This information is not to be included in the averaging process described in [5.8.1](#).

5.6 Measured quantities

The basic measured acoustic quantity is $L_{pAeq,T}$ with $T = 20$ s. If required other acoustic quantities such as frequency spectrum, L_{pAFmax} , tonality, impulsiveness can be determined.

5.7 Test procedure

The unit shall be stationary.

At least three valid measurement samples at each position are required, taken either sequentially at each position or sequentially from position to position. The validity of the measurements shall be assessed against the background sound pressure level, see [5.2.3](#), and the acceptable spread of the measurement samples, see [9.4](#).

Where the measurements are not valid (see [5.2.3](#)), they may still be used for an assessment against upper limit values, but they are not comparable.

NOTE When vehicles are very quiet, it is difficult to maintain the extraneous noise ratio of 10 dB.

The measurement time interval, T , shall be at least 20 s. If, however, as an exception it is not possible to maintain the source of noise at its nominal load for 20 s, the measurement time interval T may be reduced to a minimum of 5 s. This reduction shall be specified and justified in the test report.

Where additional measurements are required for equipment that works intermittently, the measurement shall be carried out during an operating cycle of this equipment including the start-up, the steady state and the shutdown. The duration of the operation shall then be registered.

5.8 Data processing

5.8.1 Standard processing

The standard processing shall only include the results from the standard measurement positions (height of 1,2 m).

For each set of measurements (one sample at each position), the noise levels $L_{pAeq,T}^i$ measured at all positions i shall be energy averaged as follows to derive a single noise indicator representative of the unit:

$$\langle L_{pAeq,T} \rangle_{\text{unit}} = 10 \lg \left(\sum_{i=1}^n \frac{l_i}{l_{\text{tot}}} 10^{L_{pAeq,T}^i/10} \right) \quad (3)$$

where

$L_{pAeq,T}^i$ is the sound pressure level measured at the measurement position i ;

n is the number of measurement positions;

l_i is the length associated with the measurement position i . For the additional measuring positions at the front, this length is equal to $(\pi/2) \times 7,5$ m.

$$l_{\text{tot}} = \sum_{i=1}^n l_i \quad (4)$$

The n measurement positions used in the summation shall correspond to the whole mesh specified in [5.5.1.1](#), before any possible reduction, see [5.5.1.2](#). Where appropriate, the noise levels of measured equivalent positions shall be assigned to omitted positions.

A $\langle L_{pAeq,T} \rangle_{\text{unit}}$ shall then be produced for each of the three sets of measurements.

The test result shall be the arithmetic mean of the $\langle L_{pAeq,T} \rangle_{\text{unit}}$ values, rounded to the nearest integer decibel.

The individual $\langle L_{pAeq,T} \rangle_{\text{unit}}$ as well as the mean shall be presented in the report. In addition, the full set of $L_{pAeq,T}^i$ measured at all measurement positions shall be presented in the report.

5.8.2 Additional processing

5.8.2.1 Additional metrics

If noise sources are present in the upper part of the unit under test, a $\langle L_{pAeq,T} \rangle_{\text{unit}}$ should also be determined for the secondary measurement mesh position at a height of 3,5 m.

If required, the noise emission level of a single car within a unit shall be calculated by energy averaging the $L_{pAeq,T}^i$ corresponding to that car only according to [Formula \(5\)](#):

$$\langle L_{pAeq,T} \rangle_{\text{car}} = 10 \lg \left(\sum_{i=1}^{n_{\text{car}}} \frac{l_i}{l_{\text{tot car}}} 10^{L_{pAeq,T}^i/10} \right) \quad (5)$$

where n_{car} is the number of measurement positions for the car.

If an assessment of single noise sources is required, the arithmetic mean of the three samples of $L_{pAeq,T}$ measured at specific positions should be determined. Moreover, in the case of intermittent sources, the $L_{pAeq,T}$ should be calculated over the duration of the operating cycle. Additionally, the maximum noise level may be determined using the L_{pAFmax} .

5.8.2.2 Impulsivity

If an assessment of the impulsive character of the sound is required, the rise speed in accordance with [Annex A](#) shall be calculated and the duration of the event shall be recorded.

5.8.2.3 Spectral assessment

When spectra are required, they should be supplied in one-third octave bands in the range of at least 31,5 Hz to 8 000 Hz.

5.8.2.4 Tonality assessment

When an assessment of tonality is required, the simplified method specified in ISO 1996-2:2017, Annex K, based on a one-third octave band spectral analysis of the whole measurement time shall be used. The “possible choice” of level differences specified in ISO 1996-2:2017 shall be used. Where this method identifies a one-third octave band containing a tone, it shall be reported. It shall also be reported whether the difference in A-weighted level between this one-third octave band and the overall noise level, $L_{pAeq,T}$, is less than 6 dB. In this case, it indicates that this one-third octave band is prominent and affects the A-weighted overall level of the noise.

When an evaluation of audibility of tones is required, a method based on a narrow band spectral analysis according to ISO/TS 20065:2022^[11] is recommended. Details for that evaluation is provided in the informative [Annex I](#). No adjustment of any measurement quantity shall be applied.

6 Constant speed test

6.1 Environmental conditions

6.1.1 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](#)), 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.

NOTE The level of the ground and the nature of the ground surface can affect the spectral content of the measured sound.

- This area shall be free of other tracks, of sound absorbing matter such as lying snow or tall vegetation, and free of reflective covering such as water, ice, tarmac or concrete. No absorptive material shall be added to the propagation path for the purpose of the test.
- No person shall be present in this area, and the observer shall be in a position that does not influence the measured sound pressure level significantly.

Additionally, an area around the microphones having a radius which is at least three times the measurement distance shall be free of large reflecting objects like barriers, hills, rocks, bridges, buildings or other vehicles.

6.1.2 Meteorological conditions

The standard condition for measurements shall be: no falling rain, hail or snow. Any noise-relevant weather information (e.g. temperature, humidity, falling rain, hail, snow, wind speed at the level of the highest microphone) shall be recorded before and after each series of measurements as a minimum.

NOTE Heavy rain or wind speed higher than 5 m/s can affect the background noise, see [6.1.3](#).

6.1.3 Background sound pressure level

Care shall be taken to ensure that the noise from other sources (e.g. other vehicles or industrial plants and due to wind) does not influence the measurements significantly.

The maximum value of the $L_{pAeq,T}$ with $T = 20$ s of background noise over all microphone positions shall be at least 10 dB below the $L_{pAeq,Tp}$ obtained when measuring the noise from the unit in the presence of background noise. For frequency analysis this difference shall be at least 10 dB in each frequency band of interest.

6.2 Track conditions

6.2.1 General

The noise emission contains contributions from the rolling stock and the track. Therefore, vehicle noise emission values are only comparable between sites where the equivalence of track parameters in terms of acoustic performance is controlled.

NOTE This comparability between sites is a required condition to achieve reproducible type tests.

Default specifications for these parameters, i.e. the acoustic roughness of the rail surface and the vertical and lateral dynamic responses of the track, are supplied hereafter. They ensure that the measurement procedure is of engineering grade (grade 2 as defined in ISO 12001:1996^[7]) and that the influence of the track due to roughness or dynamic response on the vehicle type test result is limited.

For further information about the track influence see [Annex C](#).

The reference track section shall have a consistent superstructure over a minimum length of twice the microphone distance to either side. This includes geometry of the line, track quality, acoustic rail roughness and track decay rates as described hereafter.

All the track specifications contained within [6.2](#) apply specifically to the situation where the unit has steel wheels running on steel rails.

Where less strict track specifications are used for noise emission measurements of railway units, they can lead to test results which are more strongly influenced by the track properties. However, they can be of interest e.g. for measurement on specific types of network. In such cases it is advisable to measure the track parameters and to supply them always together with the noise measurements. Such measurements are exceptional cases if used for vehicle type-testing and do not fully comply with this standard.

For systems other than conventional railway units (e.g.: people mover on pneumatic rubber tyres), the noise measurements shall apply on the track type where the unit is usually operated. In that case, no measurements of the track conditions are required and no status of comparability with noise results obtained on other tracks is conferred.

6.2.2 Geometry of the line

The radius of curvature r of the track shall be:

- a) $r \geq 1\,000$ m for tests at train speed $v \leq 70$ km/h;
- b) $r \geq 3\,000$ m for tests at train speed $70 \text{ km/h} < v \leq 120$ km/h;

c) $r \geq 5\,000$ m for tests at train speeds $v > 120$ km/h.

Where powered units are tested, the level gradient at the track shall be 5 ‰ at the most.

6.2.3 Track superstructure

The standard superstructure for the constant speed test is a track with ballast bed and wooden or reinforced concrete sleepers without any type of rail or track shielding (use of rail dampers is accepted to comply with track decay rate limits, see [6.2.6](#)). Where measurements are taken on track where a third rail is present, there shall not be any protective shielding boards between the target vehicle and microphone.

NOTE 1 If other track designs are used under normal operating conditions for the unit they can be used for the test.

NOTE 2 Measurement results made on other track designs are only comparable with measurements made on that track design.

The ballast shall be loose, i.e. not bound together by ice or glue and not blocked by debris, snow or ice.

6.2.4 Track quality

The track at the measuring section shall be laid without rail joints and be free of visible surface defects such as corrugations, rail burns or pits and spikes. No audible impact noise due to welds or loose sleepers shall be present.

6.2.5 Acoustic rail roughness of the test track

The acoustic rail roughness of the test section shall be assessed according to EN 15610:2019+A1:2025. For type test measurements, the default upper limit provided in [Figure 4](#) shall apply considering the flexibility provided by the application of [Annex D](#).

The measured acoustic rail roughness values remain valid during a period starting three months before and ending three months after the pass-by measurement, provided that during this period no track maintenance has been performed which influences the acoustic rail roughness. Preferably the roughness measurement should be as close as possible in time to the pass-by tests.

NOTE Rail roughness can change in short time when rail grinding has taken place shortly before the measurements or when heavy traffic takes place on the track.

For train speeds up to 190 km/h, the one-third octave centre wavelength measurement of rail roughness shall be at least in the range 0,315 cm to 10 cm. For higher speeds, the range shall be at least 0,315 cm to 25 cm.

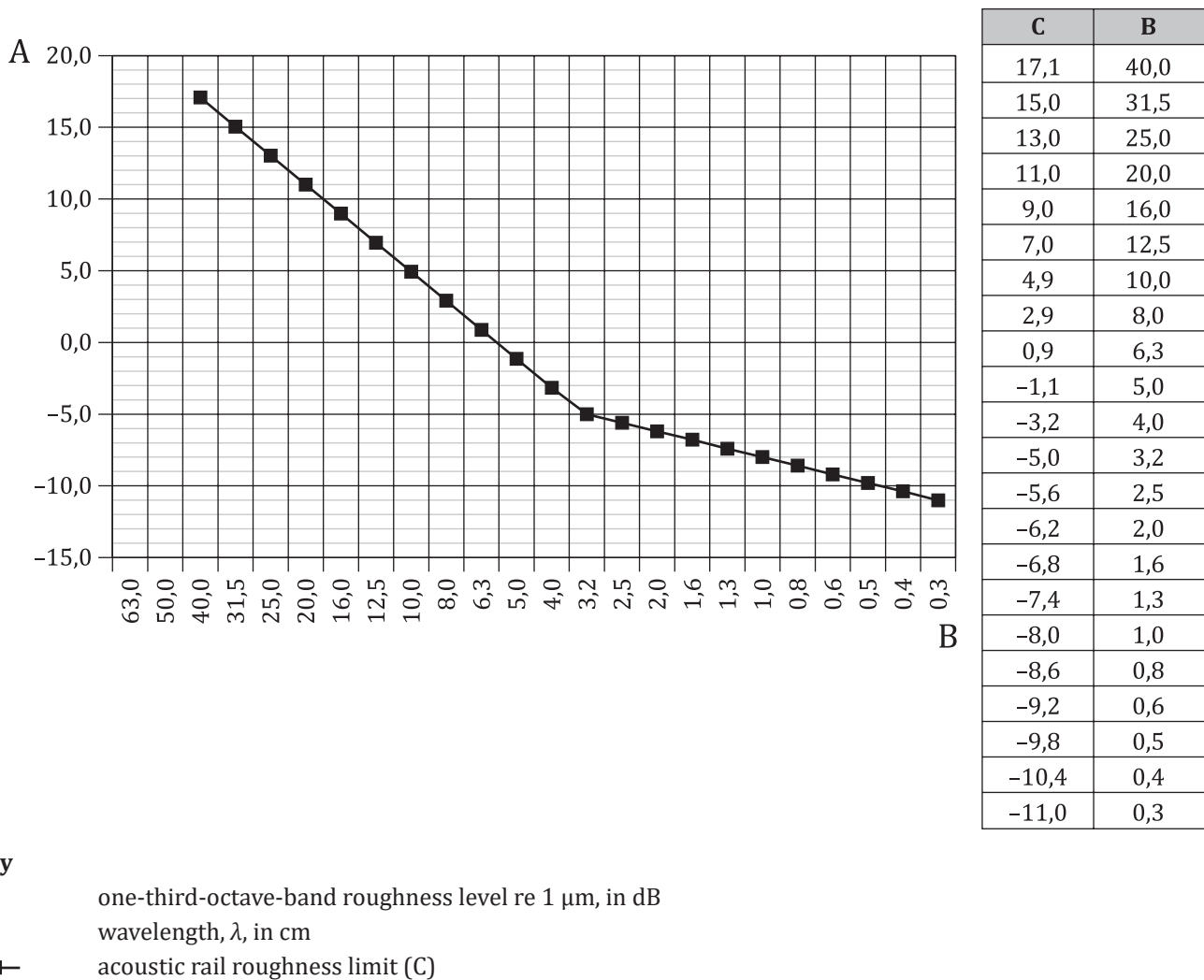


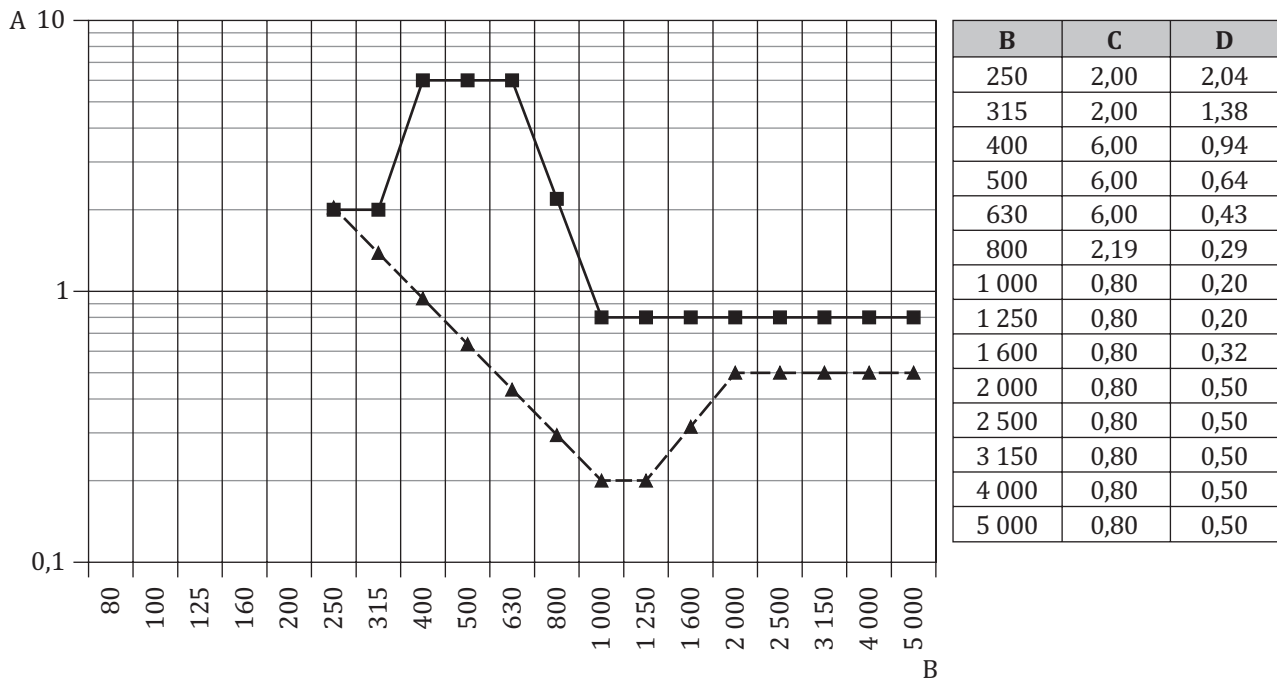
Figure 4 — Default upper limit curve for the acoustic rail roughness level

6.2.6 Dynamic properties of the test track

The dynamic properties of the track shall be assessed according to EN 15461:2008+A1:2010.

The temperature of the rail during the assessment of the dynamic properties and during pass-by shall be recorded and reported. Where possible the temperature shall be measured on the underside of the rail foot close to the rail fastening. If it is not possible (e.g. embedded rails) then the rail temperature on the upper side of the rail foot shall be reported. The effects of temperature on track decay rates and therefore pass-by noise can be significant (see [Annex C](#)). Therefore, the dynamic properties measurement should be preferably made at rail temperatures as close as possible to the pass-by tests.

For type test measurements the default lower limits of the vertical and lateral track decay rates provided in [Figure 5](#) shall apply. The measured track decay rate values of the test track shall remain valid during a period starting one year before and ending one year after this measurement, provided that during this period no track maintenance has been performed which influences the track decay rates. Preferably the dynamic properties measurement should be made as close as possible in time to the pass-by tests.



Key

- A track decay rate (TDR), dB/m
 B frequency, Hz
 —■— TDR limit in the vertical direction (C)
 -▲- TDR limit in the lateral direction (D)

Figure 5 — Default lower limit curves for the track decay rates

6.2.7 Special conditions

For non-conventional units tested on dedicated tracks, the track structure shall be described in the test report.

6.3 Vehicle conditions

6.3.1 General

The vehicle shall be configured and operated during the test to represent the normal operating conditions at constant speed (including software e.g.: for traction, auxiliaries and HVAC configuration).

Air management systems, including grilles, filters and fans shall be clear of any obstruction. During the measurements, the doors and windows of the unit shall be kept closed.

In the case of multi-voltage vehicles or units, the measurements shall be performed under the voltage system which is expected to produce the highest noise level.

NOTE If a unit is designed for AC and DC supply then the AC mode is usually the noisier one.

In the case of dual-mode vehicles or units (diesel and electric) the measurements shall be performed under both modes.

In case of hybrid vehicles:

- the measurement shall be performed using the Primary Power Source PPS [IEC 62864-1:2016^[2], Mode II or III].

- If the normal operating condition is not using PPS, then the measurement shall be performed using ESS [IEC 62864-1:2016^[2], Mode IV].
- The onboard Energy Storage System ESS (e.g. battery) shall be assumed to be charged at the upper end of the usual range in any case. A regular operation shall be assumed (i.e. no emergency operation).

6.3.2 Normal operating conditions

The measurements shall be carried out in normal operating conditions specified as follows:

All equipment that operates continuously when the unit is running at constant speed shall be operating at normal load. Normal load in this subclause means the performance at an external equivalent temperature of 20 °C except for HVAC systems. For the following systems this requires that:

- the cooling equipment of traction and auxiliary equipment shall be operated in the minimum necessary condition in stable thermal condition;
- the air compressor shall not operate where possible;
- for heating, ventilating and air conditioning (HVAC) systems conditioning passenger areas and working places as well as for systems supplying energy for this function, normal load is specified as 50 % of the cooling power that is necessary under design conditions according to ISO 19659-2:2020^[9] where the vehicle is regularly operated. For units operated in a fully underground condition, these design conditions should be adapted. In the case of discrete operating points, HVAC shall be operated at the lowest operation mode equal to or above 50 %. At least one compressor per HVAC unit shall be set to operate continuously.

Operational parameters shall be specified and documented in the report.

6.3.3 Occupancy and load

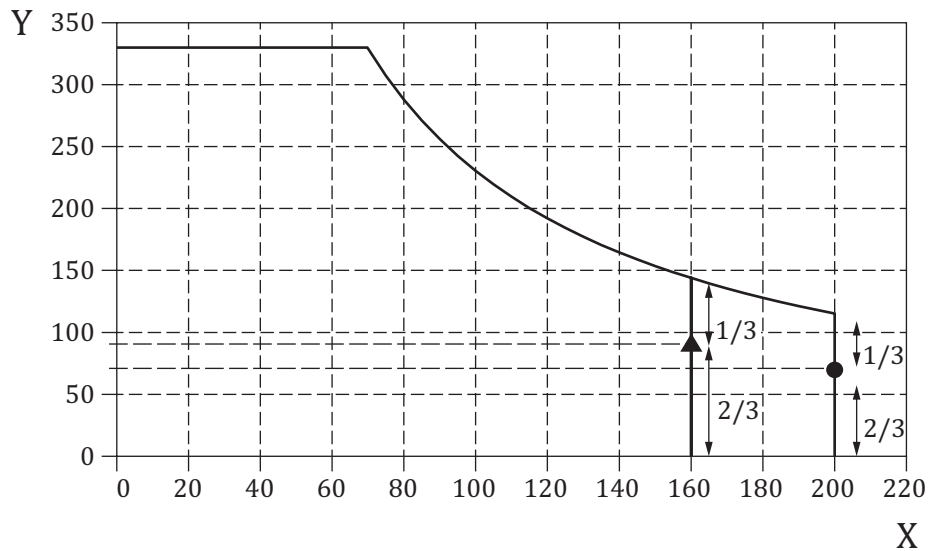
The vehicles shall be unoccupied except for essential train crew and testing personnel.

If the unit is not a locomotive, a minimum tractive effort to maintain the required constant speed of the train shall be continuously applied during the pass-by noise measurement. To ensure a steady operating condition, it might be required to operate the unit a certain time in advance in this operating condition.

If the unit being tested is a locomotive, the tractive effort used at any test speed shall be at least two-thirds of the maximum tractive effort at the maximum speed, see [Figure 6](#).

Where appropriate meters and displays are available within the cab of the traction vehicle under test, the required testing condition can be ensured by operating the traction vehicle with an indicated tractive effort of at least two-thirds of the maximum available tractive effort at each test speed of the train. This condition can be more reliably ensured by including an instrumented brake vehicle within the hauled set of vehicles, thus allowing the tractive effort to be controlled precisely during the test period by brake application.

The test report shall describe the state of the traction equipment during the test and, in the case of locomotives, either the hauled load or the tractive effort applied.



Key

- X train speed v [km/h]
- Y tractive effort F [N]
- tractive effort curve
- ▲ $2/3$ of maximum tractive effort if maximum speed $v_{\max}=160$ km/h
- $2/3$ of maximum tractive effort at maximum speed $v_{\max}=200$ km/h

Figure 6 — Example of tractive effort versus train speed for the case of a locomotive

6.3.4 Wheel tread conditioning

The unit shall have run under representative operating conditions (traction and speed) for at least 1 000 km (or 500 km for trams and metros) since the last reprofiling in order to condition the wheels. Wear of the wheel tread can tend to reduce the roughness of freshly reprofiled or new wheels. Care should be taken to present units for test with in-service conditioned wheels. The wheel treads shall be as free as possible from irregularities such as flats.

For units with tread brakes or scrubber (tread cleaning brakes), the block/tread pair shall be in a run-in condition where block and tread have bedded in sufficiently. Before starting the pass by measurements (typically just before starting the measurements, but not more than 24 h before starting the measurements) such units shall be braked to standstill two times using the tread brakes and assuring the normal activation of the scrubber, if any. Braking shall start at 80 km/h or at the maximum unit speed in the case where it is lower than 80 km/h. The unit shall be braked until a complete stop with a deceleration which is typical in normal operation, but which ensures that no wheel flats are generated. Activation logic of the scrubber shall be noted.

For units with a UIC brake it is advisable to brake with a main pipe pressure of 4 kPa.

6.3.5 Train composition (adjacent vehicles)

Noise from other parts of the train shall not influence the measurements of the unit(s) under test. Therefore, for the measurement of a trailed unit, there shall be an acoustically neutral vehicle on one side of at least two units under test, and no vehicle or an acoustically neutral vehicle on the other side, see [Figure 7](#). For the measurement of locomotives, the adjacent vehicle shall be acoustically neutral.

An adjacent vehicle shall be considered to be acoustically neutral if

- either it is a vehicle of the same class as the unit(s) under test, or

- the $L_{pAeq,Tp1}$ is no more than 2,0 dB greater than $L_{pAeq,Tp}$ where the passing times T_{p1} and T_p are indicated in [Figure 7](#) (for this evaluation round values to one decimal place).

This condition shall be verified and documented at least once for each tested speed.

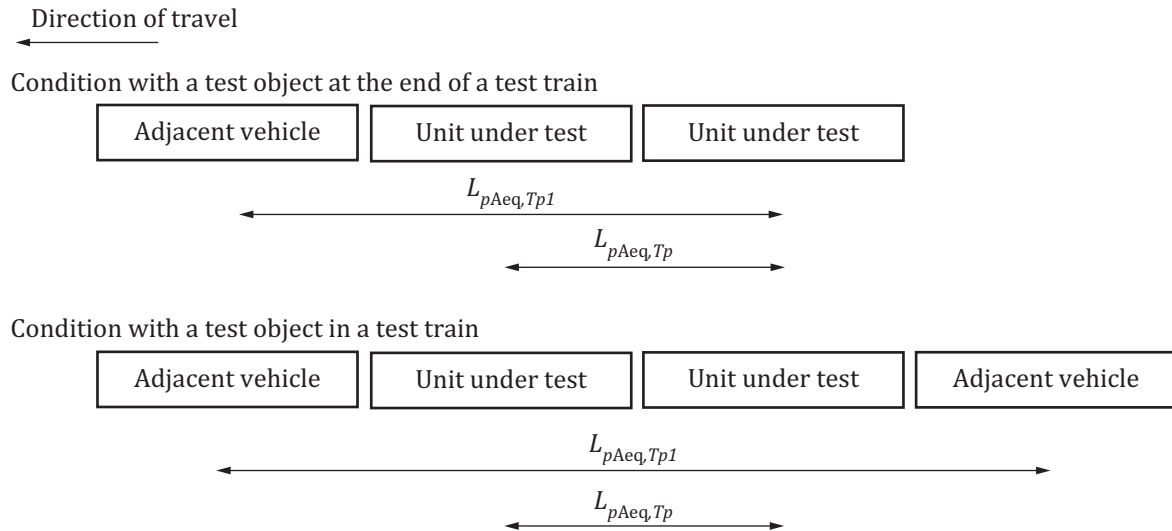


Figure 7 — Passing time for assessing acoustic neutrality of adjacent vehicle(s)

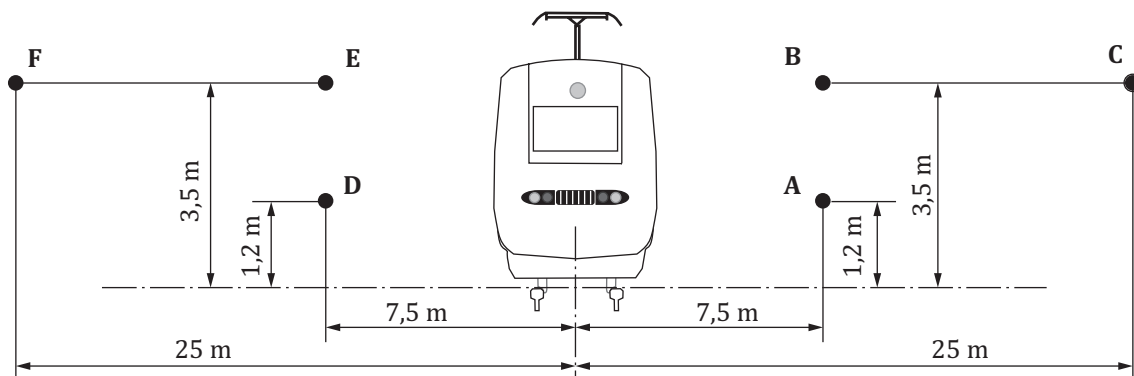
6.4 Measurement positions

6.4.1 Standard measurement positions

The measurement position, see [Figure 8](#), depends on the train speed:

- The measurement positions shall be located at a horizontal distance of 7,5 m from the centreline of the track at a height of 1,2 m above the top of rail;
- Alternatively, for speeds greater than or equal to 200 km/h, the measurement position may be located at a horizontal distance of 25 m from the centreline of the track at a height of 3,5 m above the top of rail.

Measurement shall be carried out on both sides of the unit. Any symmetry of the train in terms of acoustic sources can be used to reduce the number of measurements points (i.e. only one side of the unit).



Key

- A, C, D, F standard measurement positions
B, E additional measurement positions

Figure 8 — Lateral microphone positions for measurements on units at constant speed

6.4.2 Additional measurement positions

If important sound sources are present in the upper part of the unit under test (e.g. with power units or low floor rolling-stock), a measurement position at a distance of 7,5 m from the centreline of the track at a height of 3,5 m above the top of rails is recommended.

Additional measurements at platforms, stopping points and on bridges are described in [Annex F](#).

6.5 Measured quantities

The basic measured quantities are $L_{pAeq,Tp}$, train speed and pass-by time T_p . If required, other quantities such as L_{pAFmax} , frequency spectrum and tonality can be determined.

6.6 Test procedure

6.6.1 General

For each driving direction, a series of at least three measurements shall be made at each measurement position and for each measurement condition (one vehicle condition at one speed).

Any symmetry of the train in terms of acoustic sources can be used to measure only one driving direction. The validity of the measurements shall be assessed against the background noise level, see [6.1.3](#), as well as the acceptable spread of the measurement samples, see [9.4](#).

6.6.2 Pass-by speeds

Two cases apply:

- a) type testing of units with $v_{max} > 80$ km/h: tests shall be performed at $v = 80$ km/h and at v_{max} ;
- b) type testing of units with $v_{max} \leq 80$ km/h: testing shall be performed at v_{max} .

Additional tests, if required, should be performed at one or more of the following preferred speeds: 20 km/h, 40 km/h, 60 km/h, 80 km/h, 100 km/h, 120 km/h, 140 km/h, 160 km/h, 200 km/h, 250 km/h, 300 km/h, 320 km/h, 350 km/h, 380 km/h and 400 km/h.

Where required, periodic testing of in-service trains shall be performed at the preferred speeds except when otherwise agreed by the owner of the rolling stock and the authority defining the measurement.

Over the measurement section of the track, the unit under test shall be run at the chosen speeds stabilized within ± 5 %. The speed shall be measured by a device with a maximum permissible measurement error of 3 %. The speedometer of the train can be used, provided a calibration with a target measurement uncertainty of 3 % can be shown.

6.6.3 Recording and measurement time intervals

Irrespective of the type of rolling stock being measured, the recording time interval, T_{rec} , shall be chosen, so the record starts when the AF-weighted sound pressure level history, $L_{pAF}(t)$, or the short term $L_{pAeq,125\text{ ms}}(t)$ is at least 10 dB lower than found when the front of the train is opposite the microphone position. The record shall not end before the A-weighted sound pressure level is 10 dB lower than found when the rear of the train is opposite the microphone position, see [Figure 9](#).