INTERNATIONAL STANDARD

ISO 11819-1

Second edition
2023-02

Acoustics — Measurement of the influence of road surfaces on traffic noise —

Part 1: Statistical pass-by method

Acoustique — Mesurage de l'influence des revêtements de chaussées sur le bruit émis par la circulation —

Partie 1: Méthode statistique au passage

Reference number
ISO 11819-1:2023(E)

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Published in Switzerland

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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 documents 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*, in collaboration with ISO Technical Committee TC 227, *Road materials*, in accordance with the agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition of ISO 11819-1:1997 and ISO/PAS 11819-4:2013, which have been technically revised.

The main changes are as follows:

— ISO/PAS 11819-4 has now been integrated as Annex C;

— the backing board method makes possible a wider application of the method, where the old version would not meet the acoustical free field conditions;

— changes to nomenclature for vehicle categories in 3.1, including the introduction of a 'generic' vehicle category and the introduction of a minimum gross vehicle weight (8 t) for dual-axle heavy vehicles;

— changes to some key symbols and abbreviations in Clause 4;

— using a generic speed exponent for heavy vehicles instead of calculating a speed exponent from each measurement;

— using a correction to 2-axle medium vehicles for correcting them to a level typical of 3-axle heavy vehicles;

— more liberal requirement regarding the number of heavy vehicles to measure;

— an additional microphone position (at the height of 3,0 m) can be used in cases where reflecting objects could influence the results.

The objective of the changes and supplements is to make SPB measurements more practical while maintaining or reducing uncertainties.

A list of all parts in the ISO 11819 series can be found on the ISO website.

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

The emission of road traffic noise greatly depends on road surface characteristics, notably on texture and porosity; the latter due to the flow resistivity of the air voids. Both these characteristics influence the generation of tyre/road noise and, in addition, the porosity can influence the emission of sound, particularly when the emission takes place close to the surface. Power unit noise, which is usually generated at a greater height above the road surface than tyre/road noise, can also be affected during emission by the porosity characteristics of the road surface. These effects lead to differences in sound levels, associated with a given traffic flow and composition, from different road surfaces of up to 15 dB, which can have a substantial impact on the environmental acoustic quality alongside a road.

It is therefore important to be able to measure this influence by a standardized method and to arrive at a quantitative ranking of road surfaces with respect to traffic noise. This document offers such a method, the objective of which is to satisfy a need expressed by road planners, road administrators, contractors, manufacturers of so-called "low-noise surfaces" and by other parties concerned with the prediction and control of road traffic noise.

Acoustics — Measurement of the influence of road surfaces on traffic noise —

Part 1: Statistical pass-by method

1 Scope

This document specifies a method of comparing traffic noise on different road surfaces for various compositions of road traffic for the purpose of evaluating different road surface types. Sound levels representing either light or heavy vehicles at selected speeds are assigned to a certain road surface. The method is applicable to traffic travelling at constant speed, i.e. free-flowing conditions at posted speeds of 50 km/h and upwards. For conditions where traffic is not free flowing, such as at junctions and where the traffic is congested, the method is not applicable.

A standard method for comparing the noise characteristics of road surfaces gives road and environment authorities a tool for establishing common practices or limits regarding the use of road surfaces meeting certain noise criteria. However, it is not within the scope of ISO 11819 (all parts) to suggest such criteria.

The statistical pass-by (SPB) method is suitable for use for the following main purposes:

— to classify road surfaces according to their influence on traffic noise (surface classification);

— to assist in verifying conformity of production of road surfaces;

— to evaluate acoustic performance of road surfaces throughout operation relative to new condition;

— to evaluate the influence of different road surfaces on traffic noise at sites irrespective of condition and service time;

— to evaluate acoustic performance of a road surface relative to a reference surface.

Due to practical restrictions, the method cannot be applied at all possible locations. However, the backing board method can allow some locations to be tested that were not previously acceptable.

Clause 5 gives a general description of the SPB method.

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.

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

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

IEC 60942:2017, *Electroacoustics — Sound calibrators*

IEC 61183, *Electroacoustics - Random-incidence and diffuse-field calibration of sound level meters*

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

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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 Types of noise

3.1.1
vehicle noise
total noise from an individual vehicle, including the two major components of *power unit noise* (3.1.3) and *tyre/road noise* (3.1.2)

3.1.2
tyre/road noise
noise generated by the tyre/road interaction

3.1.3
power unit noise
noise generated by the vehicle engine, exhaust system, air intake, fans, transmission, etc.

3.1.4
background noise
unwanted noise interfering with the noise that is intended to be measured

3.2 Measurement method

3.2.1
statistical pass-by method
SPB method
measurement procedure designed to evaluate vehicle and traffic noise generated on different sections of road surface under specific traffic conditions

Note 1 to entry: The measurements are taken from a great number of vehicles operating normally on the road. Results obtained using this procedure are normalized to standard speeds according to the category or type of road being considered.

3.3 Road speed categories

NOTE Three categories of roads are defined with respect to the range of speeds at which the traffic flows and usually associated with certain areas (urban, suburban, rural, etc.).

3.3.1
"low" speed road
road category where traffic operates at an average speed of 45 km/h to 64 km/h

3.3.2
"medium" speed road
road category where traffic operates at an average speed of 65 km/h to 99 km/h

Note 1 to entry: These conditions are mostly found in suburban areas or on rural highways.

3.3.3
"high" speed road
road category where cars operate at an average speed of 100 km/h or more; but where heavy vehicles may operate at lower average speed due to speed restrictions

Note 1 to entry: These conditions are usually associated with motorway traffic in rural or suburban areas.

3.3.4
reference speed
v_{ref}
preferred speed for uniform reporting of measured data

Note 1 to entry: The reference speed is expressed in kilometres per hour. Most commonly used reference speeds are 50 km/h, 80 km/h and 110 km/h (also in ISO 11819-2) but alternative speeds may be used, if required for technical, safety and legislative reasons.

3.4 Vehicle categories

3.4.1
vehicle category
category of vehicles that have certain common features easy to identify in the traffic stream, such as the number of axles and the size, that are assumed to correspond to similarities in sound emission when driven under the same operating conditions

3.4.2
category P – passenger cars
vehicles used for passenger transportation, having two axles and having typically 4 to 5 seats

Note 1 to entry: See further Annex A.

3.4.3
category H – heavy vehicles
categories H2 (3.4.3.1) and *category H3+* (3.4.3.2) combined

3.4.3.1
category H2 – dual-axle heavy vehicles
trucks, buses and coaches with two axles and four or six wheels, and having a gross vehicle mass of at least 8 t

Note 1 to entry: See Annex A.

3.4.3.2
category H3+ – multi-axle heavy vehicles
trucks, buses and coaches with more than two axles

Note 1 to entry: See Annex A.

3.5 Measured noise quantities

3.5.1
maximum sound level
$L_{A,max}$
highest A-weighted sound pressure level recorded by the measuring instrument during a vehicle pass-by, using time weighting F

3.5.2
SPB sound level
$L_{SPB:P,vref}$ or $L_{SPB:H,vref}$
maximum A-weighted sound pressure level determined at a reference speed, v_{ref}, calculated for either vehicle *category P* (3.4.2) or *category H* (3.4.3)

3.5.3
statistical pass-by index
SPBI
noise index for comparison of road surfaces, based on the *SPB sound levels* (3.5.2), $L_{SPB:P,vref}$ and $L_{SPB:H,vref}$, and considering the mix and speeds of vehicles

3.6 Road surface terms applicable in this method

3.6.1
dense road surface
road surface featuring a wearing course with a void content of not more than 10 % (by volume)

3.6.2
porous road surface
road surface featuring a wearing course with a void content of equal to or more than 18 % (by volume)

3.6.3
negatively textured road surface
road surface featuring a relatively flat upper part and relatively narrow valleys or troughs between the main aggregate

Note 1 to entry: The skewness of its profile according to ISO 13473-2 is negative.

3.6.4
reference surface
virtual reference surface
surface which is not existing but being considered as an "average" of a dense asphalt concrete and a stone mastic asphalt surface with a maximum aggregate size of 11 mm

Note 1 to entry: The above definition is incomplete. For further details, refer to Annex F.

Note 2 to entry: This definition is valid only in ISO 11819 (all parts).

3.7 Backing board terms

3.7.1
backing board
rectangular, hard, reflective board on which a microphone is mounted

3.7.2
surface microphone
flush-mounted microphone designed to measure sound pressure on a surface without requiring the drilling of a hole through it

4 Symbols and abbreviated terms

Table 1 lists the symbols used in this document. All acoustic variables are A-weighted.

Table 1 — Symbols and abbreviated terms used in this standard and their value or unit

Symbol	Value/unit	Explanation
$L_{A,max,i,v}$	dB	The maximum sound level, A-weighted, for vehicle No. i when it passes-by at speed v
$L_{SPB:P,v_{ref}}$	dB	The SPB sound level, for vehicle category P (passenger cars), at the reference speed v_{ref}
$L_{SPB:H,v_{ref}}$	dB	The SPB sound level, for vehicle category H (heavy vehicles), at the reference speed v_{ref}

Table 1 *(continued)*

Symbol	Value/unit	Explanation
$L_{\mathrm{SPB:G},v_{\mathrm{ref}}}$	dB	The SPB sound level, for vehicle category G (General; i.e. passenger cars or heavy vehicles), at the reference speed v_{ref}
$L_{\mathrm{A,E}}$	dB	The energy-equivalent A-weighted sound exposure level
A	dimensionless	A constant used in the noise-to-speed relationship
B	dimensionless	Speed coefficient; i.e. increase in SPB level with a 10-fold increase in speed, used to correct for deviations from the reference speed, v_{ref}
v_{meas}	km/h	Measured speed of an individual vehicle during a pass-by measurement
v_{ref}	km/h	Reference speed; used to normalize SPB sound levels to a common speed

5 Measuring principle

In the statistical pass-by (SPB) method, the maximum A-weighted sound pressure levels of a statistically significant number of individual vehicle pass-bys are measured at a specified roadside location, together with the vehicle speeds. Each measured vehicle is classified into the appropriate vehicle category.

For each road and vehicle category, a reference speed is selected. Each individual pass-by level together with its vehicle speed is recorded, and a regression line of the maximum A-weighted sound pressure level versus the logarithm of speed is calculated for each vehicle category, or if the latter appears to be too uncertain, an alternate standard noise-speed relation may be used. From this relation, the average maximum A-weighted sound pressure level is determined at the reference speed. This level, for both vehicle categories P and H, is called the SPB sound level ($L_{\mathrm{SPB:P},v_{\mathrm{ref}}}$ and $L_{\mathrm{SPB:H},v_{\mathrm{ref}}}$) and is the mandatory result of each SPB measurement.

For the purpose of reporting a single number rating of the acoustic performance of road surfaces, the Statistical Pass-by Index (SPBI) can be calculated. This combines the appropriate SPB sound levels on a energetic basis, assuming certain proportions of these vehicle categories. The SPBI can be used for comparison of road surfaces so that their influence on sound level of a mixed traffic flow can be determined. It is not suitable for determining actual traffic noise levels.

6 Instrumentation

6.1 Instruments for acoustical measurements

6.1.1 General

The instruments for measuring sound pressure levels, including microphone(s) as well as cable(s), windscreen(s), recording devices and other accessories, if used, shall meet the requirements for a class 1 instrument according to IEC 61672-1 for free field or random incidence application, as appropriate. The frequency range of 50 Hz to 10 000 Hz (centre frequencies of one-third-octave bands) shall be covered. Filters shall meet the requirements for a class 1 instrument according to IEC 61260-1.

NOTE Frequencies below 100 Hz are not believed to have a significant effect on the result but are required in some models and national regulations[20].

An appropriate windscreen shall be used having a diameter of at least 90 mm.

6.1.2 Verification

Conformity of the sound pressure level measuring instrument including microphone, the filters and the sound calibrator with the relevant requirements of IEC 61672-1, IEC 61260-1 and IEC 60942 respectively shall be verified by the existence of a valid certificate of conformity. Conformity testing in accordance with IEC 61672-3, IEC 61260-3 and IEC 60942:2017, Annex B, respectively is required for verification.

If applicable, random incidence response of the microphone shall be verified by a procedure from IEC 61183.

All conformity testing shall be conducted by a laboratory operated in accordance with ISO/IEC 17025 and that meets the maximum-permitted uncertainty specified in IEC 61672-1, IEC 61260-1 and IEC 60942 respectively.

Unless national regulations dictate otherwise, it is recommended that the sound calibrator should be calibrated at intervals not exceeding 1 year, the conformity of the instrumentation system with the requirements of IEC 61672-1 should be verified at intervals not exceeding 2 years, and the conformity of analog filters with the requirements of IEC 61260-1 should be verified at intervals not exceeding 2 years.

NOTE Testing in accordance with IEC 61672-3 does not fully verify conformity with the requirements of IEC 61672-1, unless it has been pattern approved in accordance with IEC 61672-2.

6.2 Instruments for vehicle speed measurements

6.2.1 General

The maximum permissible uncertainties for instruments used for vehicle speed measurements shall be ±2,5 %, at the instant when the vehicle passes the microphone.

Measuring devices which can cause significant noise by the passage of vehicle tyres should not be used.

6.2.2 Verification

Conformity of the speed measuring instrument shall be verified by the existence of a valid certificate of conformity. In case of home-made systems using photocells at a fixed distance, such verification needs to be made by accurately measuring the distance. The conformity of the speed measurement device is verified at intervals not exceeding 2 years.

6.3 Instruments for temperature measurements

6.3.1 General

The air and road temperature measuring instrument(s) shall have a maximum permissible uncertainty of ±1 °C, as specified by the manufacturer. Meters utilizing the infrared technique shall not be used for air temperature measurements.

The type of sensor used shall be reported.

6.3.2 Verification

Equipment shall be calibrated in accordance with the manufacturer's specification, in most cases requiring a calibration annually by a laboratory authorized to perform calibrations traceable to appropriate standards.

7 Test sites

7.1 Selection of measuring site

The following considerations apply for site selection.

— The measuring location shall be alongside a part of the road where the noise characteristics of the pavement are representative for the type of pavement and the physical conditions between the lane and the microphone as well as the surroundings meet the acoustical requirements.

— Each road test section shall extend at least 30 m on both sides from the microphone location. For cases where a significant number of heavy vehicles have a length exceeding 20 m, this distance is increased to 50 m.

— The road shall be essentially level and straight. Roads with slight bends or with gradient ≤2 % may be considered valid test sites.

— Requirements on background noise at the test site in accordance with Clause 11 shall be observed. See also 8.2 regarding selection of vehicles.

— The road surface condition should be homogeneous over the entire test section. A practical way to check the homogeneity is to make a measurement with the CPX method (see ISO 11819-2) over the test section and note how typical the CPX level is on the intended SPB measurement spot. For dense road surfaces, it would be sufficient with a measurement of MPD according to ISO 13473-1.

— The road surface should be in a good condition, unless the intention of the study is to determine the effect of road condition on vehicle noise. Road surfaces which exhibit unusually high unevenness characteristics, surface cracking, bitumen bleeding, excessive stone loss or contain expansion joints, for example, would not normally be considered as suitable for surface classification purposes.

NOTE Since some types of road surfaces change their noise characteristics rather quickly after opening for traffic, measurements on newly laid surfaces have limited validity.

7.2 Deviations from free-field conditions

For surface classification purposes, the measurement microphone should be located in the acoustical free field. Acoustic reflections from surfaces such as building façades, retaining walls, noise barriers, road cuttings and embankments shall be at least 10 dB lower than the direct sound to be measured. As a guideline, 25 m of space around the microphone free of any reflecting objects other than the ground is usually adequate to ensure that approximate free field conditions exist.

7.3 Considerations of guard rails and other barriers which can reflect or screen the sound

There shall be no large reflecting surfaces, such as solid safety barriers, large road signs or embankments, within a rectangle 30 m × 22 m in Figure 1 marked with a broken line. If safety barriers, large road signs or other major objects are present within the rectangle, they shall be removed for the measurements, if possible, or covered with effective sound absorbing material prior to the measurements. The presence of such surfaces and the type of covering shall be duly stated in the report.

Protective fences will not normally affect the results and can be ignored for the purpose of site and microphone position selection. Treatments on some noise barriers with the intention to reduce sound reflections are not sufficiently absorptive to allow such barriers within the rectangle shown in Figure 1.

NOTE 1 In ISO 11819 (all parts), a solid safety barrier is a concrete wall structure designed to prevent vehicles from leaving the road or crossing the median.

NOTE 2 In ISO 11819 (all parts), a guard rail is a structure consisting of a metal beam or plate attached to rigid posts and designed to prevent vehicles from leaving the road or crossing the median. There is also a type of guard rail consisting of stretched steel wires attached to rigid posts.

NOTE 3 In ISO 11819 (all parts), a protective fence is a structure fabricated of wire or cable (usually chain link) mounted on support posts and intended to prevent animals or human beings from entering the road.

NOTE 4 If the problem is impossible to avoid, the optional microphone position (3 m) described in 9.1 can provide a solution

7.4 Surface between the tested road surface and microphone

Ideally, the surface between the microphone position and the edge of the test lane should be covered with the same material as the road surface in the measuring lane. However, at some sites it cannot