INTERNATIONAL STANDARD

ISO 11819-1

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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 11819-1:1997(E)

Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 11819-1 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise.*

ISO 11819 consists of the following parts, under the general title *Acoustics — Measurement of the influence of road surfaces on traffic noise*:

— *Part 1: Statistical Pass-By method*

— *Part 2: Close-proximity method*

Annexes A to F of this part of ISO 11819 are for information only.

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Introduction

The emission and propagation of road traffic noise greatly depend on road surface characteristics, notably on texture and porosity. Both these characteristics influence the generation of tyre/road noise and, in addition, the porosity can influence the propagation of sound, particularly when the propagation 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, may also be affected during propagation 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 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 part of ISO 11819 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.

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

Part 1:
Statistical Pass-By method

1 Scope

This part of ISO 11819 describes 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 other driving conditions where traffic is not free-flowing, such as at junctions and where the traffic is congested, the road surface is of less importance.

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

The Statistical Pass-By (SPB) method is intended to be used essentially for two main purposes. First it may be used to classify surfaces in typical and good condition as a type according to their influence on traffic noise (surface classification) and, secondly, it may be used to evaluate the influence on traffic noise of different surfaces at particular sites irrespective of condition and age. This latter type of application may be useful for example where a road is to be resurfaced and "before" and "after" measurements are required in order to assess the differences in traffic noise following resurfacing. However, due to severe requirements on the acoustical environment at the site, the method cannot generally be used for approval of works at any given site.

Clause 4 gives a general description of the SPB method.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 11819. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 11819 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 10844:1994, *Acoustics — Test surface for road vehicle noise measurement.*

ISO 13473-1:1997, *Acoustics — Characterization of pavement texture using surface profiles — Part 1: Determination of mean profile depth.*

IEC 60651:1979, *Sound level meters.*

IEC 60942:1988, *Sound calibrators.*

IEC 61260:1995, *Electroacoustics — Octave-band and fractional-octave-band filters.*

3 Definitions

For the purposes of this part of ISO 11819, the following definitions apply.

3.1 Traffic noise, vehicle noise, tyre/road noise and power unit noise

3.1.1 traffic noise

overall noise emitted by the traffic running on the road under study

3.1.2 vehicle noise

total noise from an individual vehicle, the two major components of which are power unit noise (3.1.4) and tyre/road noise (3.1.3)

3.1.3 tyre/road noise

noise generated by the tyre/road interaction

3.1.4 power unit noise

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

3.2 Statistical Pass-By (SPB) method

measurement procedure designed to evaluate vehicle and traffic noise generated on different sections of road surface under specific traffic conditions

NOTE — 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

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

3.3.1 "low" road speed category

conditions which relate to traffic operating at an average speed of 45 km/h to 64 km/h

NOTE — These conditions are usually associated with urban traffic.

3.3.2 "medium" road speed category

conditions which relate to traffic operating at an average speed of 65 km/h to 99 km/h

NOTE — These conditions are mostly found in suburban areas or on rural highways.

3.3.3 "high" road speed category

conditions which relate to cars operating at an average speed of 100 km/h or more; heavy vehicles may operate at lower average speed due to speed restrictions

NOTE — These conditions are usually associated with motorway traffic in rural or suburban areas.

3.4 Vehicle categories

A *vehicle category* consists of vehicles which have certain common features easy to identify in the traffic stream, such as the number of axles and the size. The common features are assumed to correspond to similarities in their sound emission when driven under the same operating conditions. The following vehicle categories are considered to be sufficient for description of the noise characteristics of road surfaces and are used in this part of ISO 11819 (see also annex A).

3.4.1 Category No. 1 — cars

passenger cars excluding other light vehicles

3.4.2 Category No. 2 — heavy vehicles

all trucks, buses and coaches with at least two axles and more than four wheels

NOTE — This category consists of Categories 2a and 2b together.

3.4.2.1 Category No. 2a — dual-axle heavy vehicles

trucks, buses and coaches with two axles and more than four wheels

3.4.2.2 Category No. 2b — multi-axle heavy vehicles

trucks, buses and coaches with more than two axles

3.5 maximum sound level

highest sound pressure level recorded by the measuring instrument during a vehicle pass-by, using the appropriate frequency weighting and time weighting F, for vehicles which are acoustically identifiable, i.e. are not significantly disturbed by other vehicles (see also 7.2)

3.6 Vehicle Sound Level, L_{veh}

maximum A-weighted sound pressure level determined at a reference speed from a regression line of the maximum A-weighted sound pressure level versus the logarithm of speed, calculated for each vehicle category

3.7 Statistical Pass-By Index (SPBI)

noise index for comparison of road surfaces, that is based on the Vehicle Sound Levels and takes into account the mix and speeds of vehicles

3.8 reference surface

surface selected according to the purpose of the measurement, following certain rules listed in this part of ISO 11819; levels on the reference surface are normalized to zero level (0 dB) and levels on all other surfaces are presented as differences from this reference level

NOTE — The main purpose of this method is to compare road surfaces with respect to traffic noise emission. Sound levels measured on a certain surface may, therefore, be presented in comparison to sound levels measured on another surface which is then considered as a reference surface.

3.9 absorptive surfaces

1) For road or ground surfaces: surface for which a substantial part of the incident acoustical energy is absorbed

EXAMPLES — Typical absorptive surfaces are loose gravel, sand, some porous pavements and ground covered by grass, ivy, or other low-growing vegetation.

2) For noise barriers: type of surface with which some noise barriers are equipped on the source side with the intention of reducing sound reflections.

4 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 road-side location together with the vehicle speeds. Each measured vehicle is classified into one of three vehicle categories: "cars", "dual-axle heavy vehicles" and "multi-axle heavy vehicles". Other vehicle categories are not used for this evaluation, since they do not provide any additional information regarding road surface influence.

For each of three speed ranges defined in 3.3, as well as for each of the three vehicle categories, a nominated reference speed is given. 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. From this line, the average maximum A-weighted sound pressure level is determined at the reference speed. This level is called the Vehicle Sound Level, L_{veh}.

For the purpose of reporting the acoustic performance of road surfaces the Vehicle Sound Levels for cars, dual-axle heavy vehicles and multi-axle heavy vehicles are added on a power basis, assuming certain proportions of these vehicle categories, to give a single "index" which constitutes the final result. This index is called the Statistical Pass-By Index (SPBI) and 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.

5 Measuring instruments

5.1 Sound level instrumentation

The sound level meter (or the equivalent measuring system) shall meet the requirements of a Type 1 instrument according to IEC 60651.

A windscreen shall be used and should be of a type specified by the microphone manufacturer as suitable for the particular microphone. It should be ascertained from the manufacturer that the windscreen does not detectably influence the performance of the sound level meter under the ambient conditions of the test.

5.2 Frequency analysis instrumentation

Frequency analysis of the measured sound using one-third-octave band resolution is recommended, but not mandatory. The frequency range of 50 Hz to 10 000 Hz (centre frequencies of one-third-octave bands) shall be covered. The one-third-octave-band filters shall conform to IEC 61260.

5.3 Calibration

At the beginning of the measurements, and following any warm-up time specified by the manufacturer, the overall sensitivity of the sound level meter or the equivalent measuring system (including the microphone) shall be checked. If necessary, it shall be adjusted according to the manufacturer's instructions. This may require use of a sound calibrator. These checks shall be repeated at the end of the measurements and the values obtained recorded. Any deviations shall be recorded in the test report. If the calibration readings on the sound level meter differ by more than 0,5 dB during a series of measurements, the test shall be considered invalid. The same procedure shall be followed if a frequency analyser is used.

The sound calibrator device shall meet the requirements of IEC 60942, Class 0 or Class 1.

The compliance of the sound calibrator with the requirements of the appropriate class of IEC 60942 shall be verified annually. The compliance of the sound level meter, or equivalent measuring system, with the requirements of IEC 60651 shall be verified at least every two years. This shall be performed by a laboratory accredited or otherwise authorized to perform calibrations traceable to the national standards.

5.4 Vehicle speed measurement instrumentation

The vehicle speed at the instant when the vehicle passes the microphone shall be measured with a standard uncertainty of less than ± 3%. Measuring devices which rest on the road surface and are activated by the passage of vehicle tyres should not be used.

5.5 Temperature measurement instrumentation

The temperature measuring instrument(s) shall have a maximum permissible error of 1 °C. Meters using an infrared technique shall not be used for air temperature measurements.

6 Test sites

6.1 Selection of measuring site

The following considerations apply for site selection.

a) Each road test section shall extend at least 30 m on both sides from the microphone location. For the "high" road speed category this distance is increased to 50 m.

b) The road shall be essentially level and straight. Roads with slight bends or with gradient ≤ 1 % may be considered as valid test sites for the purposes of this part of ISO 11819.

c) The number of vehicles judged to be moving at constant speed shall be sufficient in order to allow a reasonable total measuring time.

d) The requirements on background noise at the test site according to clause 12 shall be observed. See also 7.2 regarding selection of vehicles.

e) The road surface should be in a good condition, unless the intention is to study the effect of condition, and be homogeneous over the entire test section. 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.

f) The traffic flowing on the road section of interest should contain sufficient numbers of each category of vehicle to enable a full analysis of each vehicle category to be carried out.

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.

6.2 Paired and single site measurements

Measurements described in this part of ISO 11819 will commonly be taken at a single test surface and then compared with similar measurements taken at other surfaces where traffic may be different. However, in some cases, the noise characteristics of different surfaces can be compared by taking

simultaneous measurements on two or more road sections where the surfaces to be compared have been laid in adjacent road sections. These are referred to as 'paired' measurements since the measurement technique employs the selection of the same vehicles from the traffic stream as they pass each measurement site.

The use of this technique will improve the accuracy of the comparison due to the elimination of differences in traffic composition and climate.

From 6.1 it follows that the measurement locations will need to be separated along the road by at least 60 m (100 m for the "high" road speed category).

Vehicles excluded from one of the paired sites, for example due to selection specified in 7.2, shall also be excluded from the other paired site.

6.3 Deviations from free-field conditions

For surface classification purposes, the measurement microphone should be located in the acoustical free field. In practice, this means that acoustic reflections from surfaces such as building façades, 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.

6.4 Considerations of guard rails and other barriers which may reflect or screen the sound

There shall be no large ***reflecting*** surfaces, such as solid safety barriers or embankments, within 10 m of a line drawn from the measuring microphone position, crossing the roadway perpendicular to the line of travel. This is precisely shown as a rectangle in figure 1a). If safety barriers are present within the rectangle, they shall be 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.

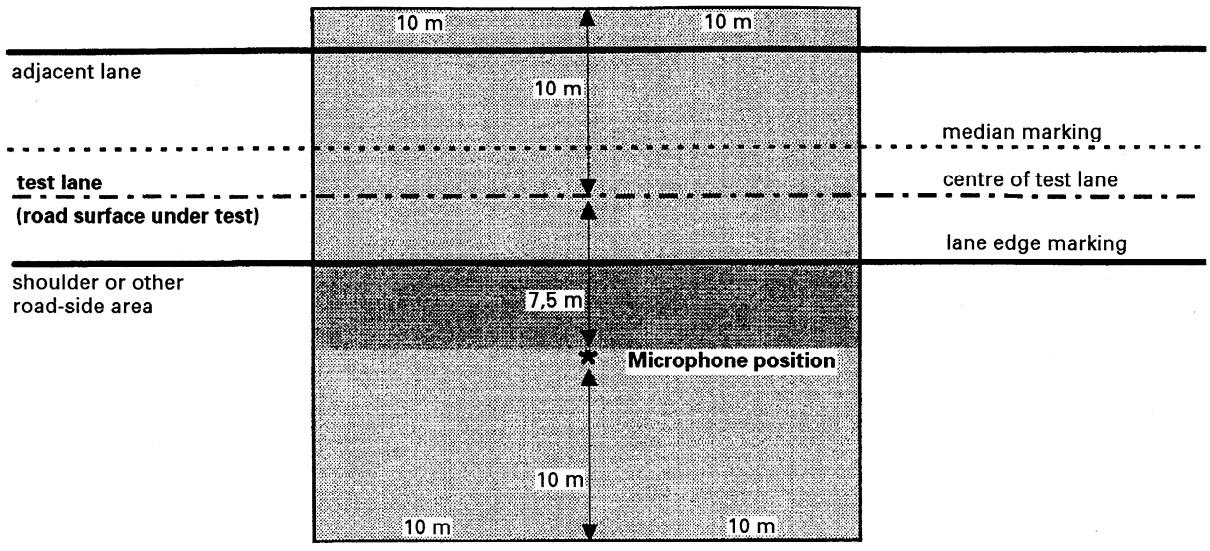
It is necessary to temporarily remove a short section of any safety barrier or guard rail located in front of the measurement microphone to ensure that minimal ***screening*** from the obstacles occurs at the measurement location. Within the part of the rectangle shown in figure 1a) which is between the road and a line parallel to the road and which goes through the microphone position, there shall be no potentially screening roadside barrier or guard rail.

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 1a).

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

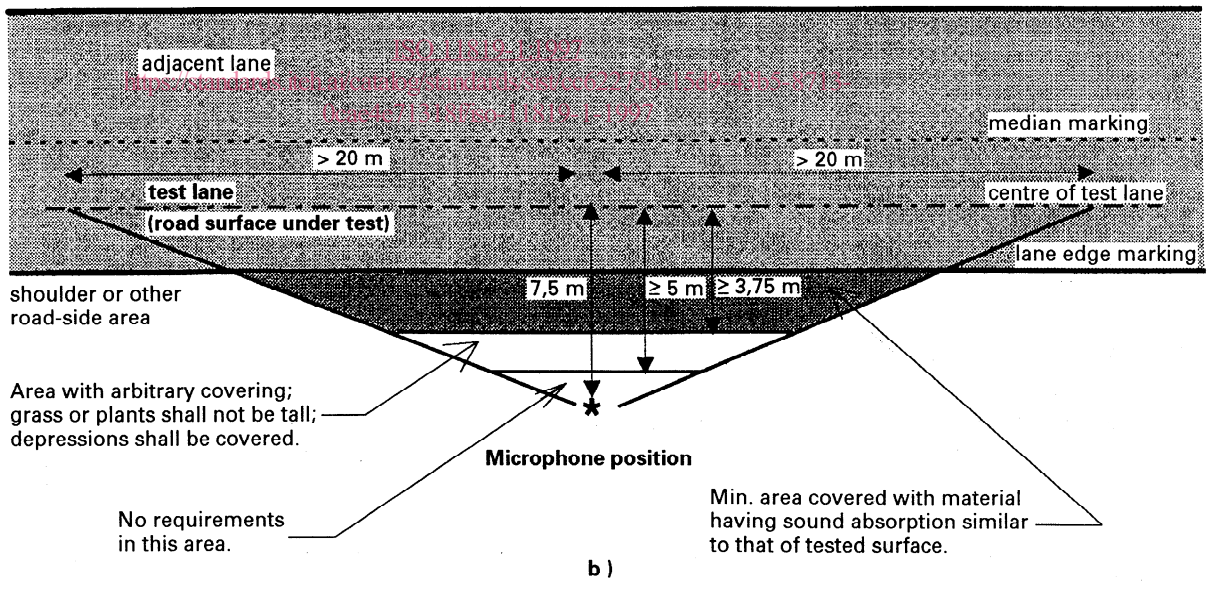
NOTE 2 In ISO 11819, a guard rail is a structure consisting of a metal beam or plate attached to rigid posts and designed to prevent vehicles from leaving the road or crossing the median. There is also a type of guard rail consisting of stretched steel wires attached to rigid posts.

NOTE 3 In ISO 11819, 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 of entering the road.



No reflecting solid safety barrier allowed within this rectangle unless covered with sound absorptive material. No screening rail or safety barrier allowed within the part of this rectangle which is between the microphone position and the test lane (darker shaded part)

a)



b)

Figure 1 — Requirements regarding freedom from reflecting or screening safety barriers or guard rails (upper part, Fig. 1a) and regarding the minimum coverage with acoustically appropriate surface between the test lane and the microphone (lower part, Fig. 1b)
(Figure not to scale)

6.5 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 may not be possible to achieve this condition. When measurements are being made for surface classification purposes, it is necessary to ensure that at least half of the area between the centre of the test lane and the microphone shall have acoustical properties similar to the surface under test, and be essentially level with the road surface. See figure 1b). This may be accomplished by placing an appropriate covering material over non-conforming surfaces. The selection of this material is left to the judgement of the person responsible for the measurement. Figure 1b) shows the angles over which the covering should be applied. If this practice is undertaken, full details shall be summarized in the report.

The 3,75 m nearest the microphone may be grass or another surface with significant absorption. Any vegetation in this area shall be kept as short as possible.

Any roadside ditch or other significant depression shall be at least 5 m from the centre of the test lane.

When these propagation conditions cannot be met, the site is not suitable for acoustical classification measurements (note, however, the possibility specified in 8.1 and figure 3 of using a microphone on the other side of the road in cases where it is difficult to meet the requirements with the "normal" microphone position).

6.6 Special site conditions

In cases where the intention is to investigate the effect of a modification or other change in the road surface, it may be desirable to make a "before/after" study. In such studies it is not necessary to meet all the site requirements, as long as it can be ascertained that there are no changes of importance for sound emission, propagation or reflections from the "before" until the "after" situations. One shall then observe that significant changes in vegetation from season to season might have an influence.

Such special studies shall be duly identified as being "special" in the measuring protocol and any site conditions at variance with the specifications given in 6.1 to 6.5 shall be reported.

7 Traffic conditions

7.1 Vehicle classification

Only vehicles which clearly fall within any of the categories described in 3.4 shall be measured. Where there is any doubt in classifying a vehicle, the measurement for that vehicle shall be discarded from the study.

A more detailed vehicle classification is optional. See annex A for the categories that should be used in such cases.

7.2 Selection of vehicles for measurement

Measurements shall only be taken on individual vehicle pass-bys which can be clearly distinguished acoustically from other traffic on the road. The following criteria shall be used to judge if a vehicle pass-by is distinguishable.

a) Just prior to and just after the passage of a vehicle intended for measurement, the A-weighted sound pressure level shall be at least 6 dB below the measured maximum A-weighted sound pressure level during the pass-by. See figure 2.