FINAL
DRAFT

INTERNATIONAL
STANDARD

**ISO/FDIS
5128**

ISO/TC **43**/SC **1**

Secretariat: **DIN**

Voting begins on:
2023-07-05

Voting terminates on:
2023-08-30

Acoustics — Measurement of interior vehicle noise

Acoustique — Mesurage du bruit intérieur des véhicules

Member bodies are requested to consult relevant national interests in ISO/TC 22 before casting their ballot to the e-Balloting application.

Reference number
ISO/FDIS 5128:2023(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 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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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*.

This second edition cancels and replaces the first edition (ISO 5128:1980), which has been technically revised.

The main changes are as follows:

— new technology neutral test method;

— updated test equipment;

— updated facility descriptions;

— new evaluation principle (instead L_{max} to $L_{A,eq}$)

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

This measurement procedure for interior vehicle noise as presented by this document has been completely revised to better match the application needs.

The interior noise of modern vehicles has such improved, that hearing damages even under high engine speeds and loads are unlikely. Assessments on the application of the document reveal a changed focus on protection of drivers and passenger in a direction of long-term exposure in a sense of working place protection.

In most countries provisions exist, which regulate the noise burden on workers on a basis of a noise exposure over a period of 8 hours per day, a full working week over a work life of 35 years. In addition, aspects of driver distraction and fatigue have become a stronger emphasis. In order to match this application, it is no longer given to determine the maximum sound level from a set of measurements, as was provided by the previous release.

The target of this edition is to determine a time average interior sound level, which is representative for the typical driving and use of a vehicle. Therefore, in-use driving statistics were reviewed and new in-use driving data generated by the group members. A strong focus was put on the WLTP, WHVC and VECTO statistics [1][2][3] which so far provides the biggest source of statistical information.

However, it should be kept in mind that the sound inside a vehicle is strongly influenced by external factors. These factors are different for various vehicle categories. During normal driving for passenger cars at low engine speeds and loads, the sound inside the cabin comes mainly from tyre rolling sound transferred via structure- and air paths. The excitation of the tyre is dependent on the structure of the surface and the characteristics of the tyre, such as the hardness of the rubber and the tyre dimension. This standard cannot cover all eventual excitation models for smooth and rough roads or soft and hard tyres. For reproducibility a road texture has been chosen, which is commonly used in test centre.

For heavy commercial vehicles with large cabin, wind noise can become very dominant at speeds beyond 60 km/h. The wind direction, especially as lateral wind, can be very changeable.

The driving cycles differ strongly with regard to vehicle categories, the used speeds and accelerations dependent on the area, where the vehicles are used. The document provides individual cycles for urban, suburban, rural and motorway conditions, all four applicable to light duty vehicles and three of them for heavy duty vehicles. In urban and rural areas, the interior sound of a vehicle is a mixture of powertrain and tyre rolling sound components. For countryside and motorway conditions the influence of powertrain is reduced but wind noise provides a stronger contribution, especially for large trucks and buses.

The combination of the cycles is very much dependent on the typical use of a vehicle. A large variation may exist for the same product. This document focuses on a typical use for vehicle categories, but it has to be kept in mind, that a substantially different use, may lead to other results. A standardized data processing for a given vehicle category will allow benchmarking of products. The availability of the individual cycle results enables as well an estimation of the interior sound for other conditions of use.

Another important factor is the total driving time within the concept of a working day. While it appears obvious that long haulage trucks are driven many hours per day, a delivery service in a town will have a mix between driving and loading/unloading work. Where test results of this document are used with regard to occupational noise exposure standards, it is essential to consider the time contribution according to the typical use of a vehicle. Again, a large variability should be kept in mind. The test results of this document allow as well the calculation for conditions, other than selected by this document.

All definitions in this document are based on design neutral parameters – as far as practically possible – to enable an application for all kind of vehicle technologies, inclusive of hybrid vehicles and pure electric vehicles.

The test procedures and calculation schemes are engineering methods and compromise between precision, repeatability, feasibility and simplicity.

Acoustics — Measurement of interior vehicle noise

1 Scope

This document specifies an engineering method for measuring the interior sound of road vehicles of categories M and N under typical driving conditions. It does not apply to agricultural tractors and field machinery.

It specifies the conditions for obtaining reproducible and comparable measurements of sound pressure levels inside a vehicle.

These measurements are used to obtain a representative average sound level during a typical driving cycle to enable assessment of adverse effects on human health.

The results can be used for

— standardized assessment of interior sound for comparisons (e.g. benchmark, consumer information programs),

— verification tests, to decide whether or not the sound inside the vehicle is in accordance with specifications,

— regulatory purposes, for example for evaluation of sound in relation to labour or for general health standards, and

— monitoring tests, in order to check that the sound inside the vehicles has not changed since delivery, or between individual units of a consignment of vehicles.

This document does evaluate the exposure to interior sound of vehicles in a way as it is commonly used for scientific effects on human health.

It does not assess maximum interior sound of a vehicle under extreme driving situations, as today's measured maximum sound pressure levels inside vehicles are far away from the risk to create instantaneous hearing damages.

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 10844, *Acoustics — Specification of test tracks for measuring sound emitted by road vehicles and their tyres*

ISO 26101-1, *Acoustics — Test methods for the qualification of the acoustic environment*

ISO 13473-1, *Characterization of pavement texture by use of surface profiles — Part 1: Determination of mean profile depth*

ISO 13473-3, *Characterization of pavement texture by use of surface profiles — Part 3: Specification and classification of profilometers*

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

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

IEC 60942, *Electroacoustics — Sound calibrator*

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

EN 13036-7, *Road and airfield surface characteristics — Test methods — Part 7: Irregularity measurement of pavement courses: the straightedge test*

EN 13043, *Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
Mass

3.1.1
kerb mass
mass of the vehicle, with its fuel tank(s) filled to at least 90 % of its or their capacities, including the mass of the driver, of the fuel and liquids, fitted with the standard equipment in accordance with the manufacturer's specifications and, when they are fitted, the mass of the bodywork, the cabin, the coupling and the spare wheel(s) as well as the tools

[SOURCE: ISO 1176:1990, 4.6, modified — extended based on the today's applied principles used in regulations for sound emission of vehicles (see UN R51.03).]

3.1.2
test mass
m_t
mass of the vehicle subject to testing inclusive all equipment and payload

3.1.3
driver mass
m_d
nominal mass of a driver that shall be 75 kg (subdivided into 68 kg occupant mass at the seat and 7 kg luggage mass)

Note 1 to entry: According to ISO 2416.

3.2
test cycle
test conditions comprising acceleration, deceleration, steady speed and standstill to establish typical operation of a vehicle under either urban, suburban, rural or motorway condition

3.3
total power
P_n
sum of net power of all available propulsion sources

Note 1 to entry: According to ISO 1585, for vehicles with combustion engine only, P_n is the net power of the combustion engine expressed in kilowatt.

Note 2 to entry: According to UN R85, for vehicles with electric propulsion only, P_n is the net power over a time period of 5 minutes, expressed in kilowatt.

Note 3 to entry: According to UN R51, for vehicles with hybrid drive line, P_n is the sum of the net power of all available propulsion sources, expressed in kilowatt.

3.4
rated engine speed
S
engine speed at which the combustion engine develops its rated maximum net power as stated by the manufacturer

Note 1 to entry: If the rated maximum net power is reached at several engine speeds, S used in this document is the highest engine speed at which the rated maximum net power is reached.

Note 2 to entry: ISO 80000-3 defines this term as “rated engine rotational frequency”. The term “rated engine speed” was retained due to its common understanding by practitioners and its use in government regulations.

3.5
active sound system
system that is installed to a vehicle for producing exterior or interior sound, such as but not limited to sound actuators, regardless of its mounting position

3.6
modes
distinct driver-selectable condition which does affect powertrain and transmission setup, such that the emitted sound of the vehicle may vary, including distinct driver-selectable modes which can affect the sound emitted by sound enhancement systems

3.7
Irregularities

3.7.1
irregularity
maximum distance of a surface from the measurement edge of the *straightedge* between two contact points of the *straightedge* when placed perpendicular to the surface

Note 1 to entry: Measured in accordance with EN 13036-7.

3.7.2
longitudinal irregularity
irregularity (3.7.1) in the direction parallel to the longitudinal axis of the track

3.7.3
transverse irregularity
irregularity (3.7.1) in the direction perpendicular to the longitudinal axis of the track

3.8
mean profile depth
MPD
average value of the height difference between the profile and a horizontal line through the highest peak (the peak level) over a 100-mm long baseline

3.9
maximum aggregate size
aggregate upper sieve size (D) based on all-in aggregate grading category of GA90

Note 1 to entry: According to EN 13043.

3.10
Vehicle category M

3.10.1
category M1
vehicles used for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat

3.10.2
category M2
vehicles used for the carriage of passengers and comprising more than eight seats in addition to the driver's seat and having a maximum mass not exceeding 5 000 kg

3.10.3
category M3
vehicles used for the carriage of passengers and comprising more than eight seats in addition to the driver's seat and having a maximum mass exceeding 5 000 kg

3.11
Vehicle category N

3.11.1
category N1
vehicles used for the carriage of goods and having a *kerb mass* (3.1.1) plus the maximum allowable payload not exceeding 3 500 kg

3.11.2
category N2
vehicles used for the carriage of goods and having a *kerb mass* (3.1.1) plus the maximum allowable payload exceeding 3 500 kg but not exceeding 12 000 kg

3.11.3
category N3
vehicles used for the carriage of goods and having a *kerb mass* (3.1.1) plus the maximum allowable payload exceeding 12 000 kg

3.11.4
light duty vehicle
LDV
vehicle primarily used to transport passengers and cargo (e.g., cars, vans, SUVs, pickup trucks), with category M1 and N1 and N2 with $m \leq 4536$ kg and $P_n \geq 150$ kW may be deemed as LDV. (i.e., Class 1 through Class 2 Vehicles, as designated by the U.S. Department of Transportation)

3.11.5
heavy duty vehicle
HDV
vehicle other than defined in 3.11.4 with a maximum allowable payload of more than 4 536 kg

4 Tables of symbols and abbreviated terms

Table 1 lists the symbols, terms, and abbreviated terms in the order where they are used for the first time.

Table 1 — Symbols and abbreviated terms used and corresponding clauses

Symbol	Unit	Subclause	Explanation
P_n	kW	3.3	Total power. Sum of net power of all available propulsion sources.
m_t	kg	7.5	Test mass of the vehicle
m_{kerb}	kg	7.5	Kerb mass of the vehicle
m_{xload}	kg	7.5	Extra loading for vehicles of category N2 and N3
m_{target}	kg	7.5	Target mass of the vehicle for vehicles of category N2 and N3
$m_{ra\ load\ unladen}$	kg	7.5	Unladen rear axle load for vehicles of category N2 and N3
$m_{fa\ load\ unladen}$	kg	7.5	Unladen front axle load for vehicles of category N2 and N3
m_d	kg	7.5	Driver mass
$L_{Aeq,TC}$	dB(A)	8.4.1	A-weighted equivalent continuous sound pressure level for the different test conditions. Index TC means either ACC, CST, DEC, DEC AB, CRS STAT, AC MAX and AC LOW
$L_{Aeq,ACC}$	dB(A)	8.4.2.1	A-weighted equivalent continuous sound pressure level for the acceleration test
$L_{Aeq,DEC}$	dB(A)	8.4.2.2.1	A-weighted equivalent continuous sound pressure level for the deceleration test without any braking applied
$L_{Aeq,DEC,AB}$	dB(A)	8.4.2.2.2	A-weighted equivalent continuous sound pressure level for the deceleration test with auxiliary brake device activated
$L_{Aeq,CRS}$	dB(A)	8.4.2.3	A-weighted equivalent continuous sound pressure level for the steady speed test
$L_{Aeq,STAT}$	dB(A)	8.4.3	A-weighted equivalent continuous sound pressure level for the standstill test
$L_{Aeq,AC,MAX}$	dB(A)	8.4.3	A-weighted equivalent continuous sound pressure level for the standstill test with air conditioning on and ventilation at highest operation level for maximum cooling
$L_{Aeq,AC,LOW}$	dB(A)	8.4.3	A-weighted equivalent continuous sound pressure level for the standstill test with air conditioning off and ventilation speed at lowest operation level
α_{STAT}	%	8.5	Weighting factor for the representative sound pressure level at standstill condition
α_{CRS}	%	8.5	Weighting factor for the representative sound pressure level at steady speed condition
α_{ACC}	%	8.5	Weighting factor for the representative sound pressure level at acceleration condition
α_{CST}	%	8.5	Weighting factor for the representative sound pressure level at deceleration condition
$L_{Aeq,CYCLE}$	dB(A)	8.5	Representative sound pressure level for the vehicle per cycle component
URBAN		8.5	Cycle component for urban condition
SUBURBAN		8.5	Cycle component for suburban condition
RURAL		8.5	Cycle component for rural condition
MOTORWAY		8.5	Cycle component for motorway condition
$L_{Aeq,CST}$	dB(A)	8.5.1	A-weighted equivalent continuous sound pressure level for the deceleration test, weighted combination of deceleration tests with and without auxiliary brake device applied
L'_{TEST}	dB(A)	8.5.1	Representative sound pressure level for the driving cycle without time weighting
L_{TEST}	dB(A)	8.5.1	Representative sound pressure level for the driving cycle inclusive time weighting
t_{exp}	h	8.5.2	Annual average use time of a vehicle per working day

Table 1 *(continued)*

Symbol	Unit	Subclause	Explanation
$L_{Aeq,INTERIOR}$	dB(A)	8.5.3	Representative interior sound level for a vehicle according to this standard

5 Test equipment

5.1 Instrumentation for acoustic measurement

5.1.1 General

The apparatus used for measuring the sound pressure level shall be a sound level meter, or single microphones connected to a data acquisition system or equivalent measurement systems, meeting the requirements of class 1 instruments. These requirements are described in IEC 61672-1.

The entire measurement system shall be checked and adjusted by means of a sound calibrator that fulfils the requirements of class 1 sound calibrators in accordance with IEC 60942.

When no general statement or conclusion can be made about conformance of the sound level meter model to the full specifications of IEC 61672-1, the apparatus used for measuring the sound pressure level shall be a sound level meter or equivalent measurement system meeting the requirements of Class 1 instruments as described in IEC 61672-3.

The instruments shall be maintained and calibrated in accordance with the instructions of the instrument manufacturer.

5.1.2 Calibration

At the beginning of every measurement session, the entire acoustic measurement system shall be checked and adjusted by means of a sound calibrator as described in 5.1.1. At the end of every measurement session, the entire acoustic measurement system shall be checked by means of a sound calibrator as described in 5.1.1. Without any further adjustment, the difference between the readings at the beginning and the end shall be less than or equal to 0,5 dB. If this value is exceeded, the results of the measurements obtained after the previous satisfactory check shall be discarded.

The checking and adjustment described in 5.1.2 does not invalidate the conformity of IEC 61672-1 described in 5.1.3 for the purpose of this document.

A bi-yearly IEC 61672-3 calibration permits the use of a daily sensitivity check and adjustment.

NOTE The purpose of the check at the beginning of the measurement session is twofold:

a) To insure the measurement system is in good working order, and

b) To adjust the level consistent with the environmental conditions of the day.

The purpose of the check at the end of the measurement session is also twofold:

— To insure the measurement system remains in good working order, and

— To verify the adjusted level remains within expected tolerances for a repeatable and reproduceable measurement.

5.1.3 Conformity with requirements

Conformity of the sound calibrator with the requirements of IEC 60942 shall be verified once a year. Conformity of the instrumentation system with the requirements of IEC 61672-1 shall be verified in accordance with the procedures of IEC 61672-3 at least every 2 years or after each modification of the

system (software, microphone, etc.). All conformity testing shall be conducted by a laboratory which is authorized to perform calibrations traceable to the appropriate standards.

NOTE The tests of IEC 61672-3 cover only a limited subset of the specifications in IEC 61672-1 for which the scope is large (temperature range, frequency requirements up to 20 kHz, etc.). It is not feasible to verify the whole IEC 61672-1 requirements on each item of a computerized data acquisition system. Computerized data acquisition system available comply with the necessary specifications of IEC 61672-1 and testing specifications of IEC 61672-3 as required for this document.

5.2 Instrumentation for vehicle speed and rotational engine speed measurements

5.2.1 Vehicle speed

The road speed of the vehicle shall be measured with instruments meeting specification limits of at least ±0,5 km/h.

NOTE There are various means for measuring the vehicle speed. Most common at time of publication are GPS based systems and speed signals taken from the data interfaces available on board. When using such information sources, it is strongly recommended to verify the precision of these sources with regard to signal quality and data refresh rate.

5.2.2 Rotational engine speed (if applicable)

If applicable and necessary, the rotational speed of the engine shall be measured with an instrument meeting specification limit of at least ±2 % at the engine speeds required for the measurements being performed.

NOTE Rotational engine speed signals are commonly taken from the data interfaces available on-board. When using such information sources, it is strongly recommended verifying the precision of these sources with regard to signal quality and data refresh rate.

5.3 Meteorological instrumentation

5.3.1 General

The meteorological instrumentation used to monitor the environmental conditions during the test shall meet the following specifications:

— within ±1,0 °C for a temperature measuring device;

— within ±1,0 m/s for a wind speed measuring device;

— within ±5,0 hPa for a barometric pressure measuring device;

— within ±5,0 % for a relative humidity measuring device.

6 Test facility

6.1 Outdoor test site

The test site shall be such that the sound radiated by the vehicle to the outside contributes to the inside noise only by reflections from the road surface and not by reflections from buildings, walls, or similar large objects outside the vehicle. During the period of measurement, the distance of the vehicle from large objects shall be greater than 20 m.

NOTE Buildings outside the 20 m distance can have a significant influence if their reflection focuses on the test track.