International Standard 5128

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Acoustics — Measurement of noise inside motor vehicles

Acoustique — Mesurage du bruit à l'intérieur des véhicules à moteur

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5128 was developed by Technical Committee ISO/TC 43, *Acoustics*, and was circulated to the member bodies in July 1976.

It has been approved by the member bodies of the following countries :

Austria	Ireland	Poland
Belgium	Italy	Romania
Brazil	Japan	South Africa, Rep. of
Canada	Korea, Rep. of	Spain
Denmark	Mexico	Sweden
Finland	Netherlands	Switzerland
France	New Zealand	Turkey
Germany, F.R.	Norway	United Kingdom
Hungary	Philippines	USA

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Czechoslovakia
USSR

Printed in Switzerland

Acoustics — Measurement of noise inside motor vehicles

1 Scope and field of application

This International Standard is the first stage in the development of a test intended to provide a useful definition of interior noise for engineering and contractual purposes. It specifies the conditions for obtaining reproducible and comparable measurements of the levels of the noise and the noise spectra inside all kinds of motor vehicles intended for road use, including those where the driver and/or passengers occupy an open cabin or even only a well-defined area, but excluding agricultural tractors and field machinery covered by ISO 5131.

The results may be used, for example :

— to decide whether or not the noise inside the vehicle is in accordance with noise specifications;

— to estimate hearing damage risk in conjunction with noise exposure data (see ISO 1999);

— to rate the degree of speech interference;

— to orient a programme of more elaborate measurements for the purposes of studying noise reduction procedures.

The specified procedure is intended neither for the measurement of pressure oscillations at very low frequencies, nor for the assessment of the noise exposure for comfort and security such as fatigue and vigilance. The present state of the art does not yet allow a good correlation between measured data and comfort and security.

NOTES

1 The test procedures described in this International Standard are engineering methods as defined in ISO 2204.

2 Measurements may be made on sources emitting noise of an impulsive character with an impulse sound level meter.

3 When repeating a measurement following this International Standard with other vehicles of the same type or on other measuring sites or with other measuring instruments which comply with instruments of type 1 of IEC Publication 651, differences of the order ± 3 dB may be observed in the test results of the A-weighted sound pressure level measurements.

2 References

ISO 1176, *Road vehicles — Weights — Vocabulary.*

ISO 1999, *Acoustics — Assessment of occupational noise exposure for hearing conservation purposes.*

ISO 2204, *Acoustics — Guide to International Standards on the measurement of airborne acoustical noise and evaluation of its effects on human beings.*

ISO 5131, *Acoustics — Measurement of noise at the operator's workplace on agricultural tractors and field machinery — Survey method.*

IEC Publication 225, *Octave, half-octave and third-octave band filters intended for the analysis of sounds and vibrations.*

IEC Publication 651, *Sound level meters.*

3 Nature of tests

3.1 Verification tests : Measurements performed to prove that the vehicle delivered by the manufacturer is in accordance with noise specifications.

The conditions prescribed for each test shall be complied with as closely as possible, but if unavoidable variations have to be made, these shall be stated in the test report.

3.2 Monitoring tests : Measurements performed in order to check that the noise of the vehicles is still within prescribed limits, and that noticeable changes have not occurred since delivery, or between individual units of a consignment of vehicles.

For monitoring tests, slight deviations from the type test conditions may be tolerated; for example, the number of microphone positions and driving conditions may be reduced. Any variations shall be described in the test report.

4 Measured quantities

4.1 All readings of the sound level meter shall be taken with the dynamic characteristic "fast".

4.2 The values to be measured at all microphone positions during type and monitoring tests are A-weighted sound pressure levels, L_{pA}, expressed in decibels (dB).

4.3 For spectral analysis at selected microphone positions during additional special tests, the values to be measured shall be octave band or 1/3-octave band sound pressure levels in dB covering at least the frequency range from 45 to 11 200 Hz.

Measurement of 1/3-octave band sound pressure levels is preferred.

NOTE — If strong, low frequency components are to be considered the spectral analysis should be extended appropriately below 45 Hz.

5 Measuring equipment

5.1 The sound level meter shall be of the precision class according to IEC Publication 651 (type 1).

NOTES

1 The directivity of the microphone may influence the measurements; therefore, preferably omnidirectional microphones should be used. The type of microphone should be stated in the test report.

2 A suitable wind shield may be used to reduce the influence of wind on the measurements in open vehicles. Wind shields recommended by the sound level meter manufacturer will generally be suitable.

5.2 If additional measuring equipment, including for example a tape recorder and/or level recorder, is used, its overall electro-acoustic performance shall conform to the relevant clauses of IEC Publication 651 concerning type 1 instruments.

NOTE — If a tape recorder is used as part of the measuring equipment, it may be necessary to include suitable additional pre-emphasis and de-emphasis networks for recording and reproduction to provide an adequate signal-to-noise ratio over the whole frequency range of interest.

5.3 For the measurement of noise spectra, the filters shall meet the requirements of IEC Publication 225.

5.4 The overall acoustic performance of the measuring equipment shall be checked according to the instructions of the manufacturer, preferably with a standard sound source (for example pistonphone), at the beginning and at the end of each series of measurements. At time intervals no longer than 2 years, the sound level meter shall be calibrated for compliance with instruments of type 1 of IEC Publication 651.

NOTE — It is essential that care should be taken that spurious signals are not induced on the microphone output by vibration, electromagnetic pick-up or other extraneous influences. It is practical to check for all such signals by capping the microphone to ensure that all non-acoustically generated signals which may be present are at least 10 dB below the acoustic signal obtained with the uncapped microphone under the same measuring conditions. This cap should be suitably heavy and rigid and should provided a good seal around the microphone.

5.5 It is recommended, especially for the acceleration tests, that either a twin-track tape recorder is used to record noise and vehicle speed simultaneously or an XY plotter is used to plot noise versus speed directly in the vehicle.

5.6 The measuring equipment shall cover at least the frequency range 45 to 11 200 Hz (see note in 4.3).

5.7 Vehicle and engine speed shall be measured with an accuracy of at least 3 %.

6 Acoustical environment, weather conditions, background noise

6.1 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.

6.2 The ambient air temperature in which the vehicle is operating shall be in the range -5 to $+$ 35 °C. The wind speed along the test track measured at a height of approximately 1,2 m shall not exceed 5 m/s. The other meteorological conditions shall be such that they do not influence the measurements. The speed of the wind and the direction of the wind relative to the test track shall be stated in the test report.

6.3 For all measurements of A-weighted sound pressure levels, the lower limit of the dynamic range set by the background noise and by the inherent noise level of the measuring equipment shall be at least 10 dB below the A-weighted sound pressure levels of the vehicle noise.

In the case of frequency analysis corrections, K shall be applied as calculated from the formula

$$K = 10 \lg(1 - 10^{-0,1\Delta L}) \text{ dB, if } \Delta L < 10 \text{ dB}$$

where ΔL, in decibels, is the difference between the frequency band sound pressure levels of the noise inside the vehicle, and the inherent noise of the measuring equipment plus the background noise. No results shall be reported with $K < (-3)$ dB which corresponds to $\Delta L < 3$ dB.

7 Test road conditions

Interior sound pressure levels of motor vehicles are greatly influenced in general by the macrotexture of surface roughness of the road, with smooth road surfaces producing consistent interior levels. Accordingly the test road shall be hard and as smooth and level as possible, without gaps or ripples or similar macrotexture of surface roughness which might contribute to the interior sound pressure levels of the motor vehicle.

The surface shall be dry and free from snow, dirt, stones, leaves, etc.

8 Vehicle conditions

8.1 Engine and tyre conditions

During the test, all operating conditions of the engine shall correspond to the specifications given by the manufacturer, for example fuel, lubricating oil, timing of ignition or fuel injection pump. The engine shall be stabilized at its normal operating temperature immediately before commencing the test, for example by driving the vehicle for an adequate distance at a medium speed.

The tyres used shall be of a type specified by the manufacturer of the vehicle as being appropriate to the conditions under which it is normally used, and should be inflated to the pressure recommended by the vehicle manufacturer.

If the use of off-road tyres is optional, tyres for road use shall be fitted.

The tyres shall be nearly new but with a minimum of 300 km of wear.

The type of tyres and inflation pressures at the time of testing shall be stated in the test report. The wheels of the vehicle should be statically and dynamically balanced if it is considered that wheels out-of-balance may affect the internal noise of the vehicle.

If the engine coolant radiators are equipped with devices such as flaps, the measurements shall be carried out in the two possible conditions (opened and closed); the position corresponding to each series of measurements shall be indicated in the test report. The engine cooling fan shall operate normally.

8.2 Loading of the vehicle

The initial conditions for the loading of the vehicle shall correspond to ISO 1176 (sub-clause 4.4 or 4.6 as specified by the manufacturer of the vehicle). The vehicle shall be unloaded.

Only standard vehicle equipment, measuring equipment and necessary personnel shall occupy the interior of the vehicle. In passenger cars, and in the cabs of trucks, tractors and similar vehicles, no more than two persons (the driver and observer) shall be present, and in public service vehicles with more than eight seats no more than three persons shall be present.

NOTE — This measuring condition is specified for the reason of simplicity, but it is not necessarily representative of the conditions during normal use, especially for trucks, buses and other commercial vehicles, and may cause an over estimation of the noise inside the vehicle.

8.3 Openings, windows, auxiliary equipment, adjustable seats

Openings such as skylights, all windows and ventilating inlets and/or outlets shall be shut if possible, unless their influence upon the sound level inside the vehicle is to be investigated.

Auxiliary equipment such as windscreen wipers and heating and/or ventilating fans and air-conditioners shall not operate during the tests. If the contribution of the noise of the ventilating system, and of any auxiliary equipment, to the total inside noise is to be investigated, the test should be repeated with this equipment operating. If any auxiliary equipment is automatic in operation, its operating condition shall be stated in the test report.

Adjustable seats shall be set in the mid-position of the horizontal and vertical range of adjustment. If the back-rest of the seat is adjustable, it shall be set as near to the vertical position as possible.

Adjustable headrests shall be set at the midposition.

8.4 Vehicle operating conditions

The vehicle operating conditions shall be such as to typify the inside noise under whichever of the following conditions are appropriate for the vehicle under test :

a) steady speeds (see 8.4.1);

b) full throttle acceleration (see 8.4.2);

c) vehicle stationary, with engine idling (see 8.4.3), as an additional monitoring test for commercial vehicles and buses with diesel engines.

The corresponding operating conditions are specified in 8.4.1, 8.4.2 and 8.4.3.

8.4.1 Steady speeds

In the range of 60 km/h or 40 % of maximum vehicle speed, whichever is lower, to 120 km/h or 80 % of maximum vehicle speed, whichever is lower, A-weighted sound pressure levels are to be determined at at least five speeds at equal intervals to cover the range specified above.

The measurements are performed by one of the following methods : either

a) by a slow acceleration over the speed range specified above at a rate of acceleration (for example 0,1 m/s^2) sufficiently low to provide the same values of the A-weighted sound pressure level as with the corresponding steady speed, the values being read at the selected speeds; or

b) by running the vehicle steadily at the selected speeds and reading the corresponding values. For each constant speed condition, a measuring time of at least 5 s shall be used.

The setting of the transmission shall be in the highest overall transmission ratio which allows the whole speed range to be covered without change of ratio.

8.4.2 Full throttle acceleration

The procedure for the acceleration test is as follows :

— the speed of the vehicle and of the engine shall be stabilized at specified initial conditions;

— when stable conditions are attained, the throttle shall be fully opened as quickly as possible and sound recording shall be made until either 90 % of the engine speed for maximum power as specified by the manufacturer of the vehicle (in the following test, referred to as "maximum power speed") or 120 km/h is reached, whichever is lower. Wheel slip, which affects maximum value of the A-weighted sound pressure level, should be avoided.

The initial operating conditions shall be specified as follows :

— the transmission setting shall be the highest position making the test possible without exceeding 120 km/h;

— the setting shall not be changed during the test;

— if, at an engine speed of 90 % of maximum power speed, a road speed of 120 km/h is exceeded in top gear, a lower gear shall be selected, but no lower than third for a four- or five-speed gear-box, and no lower than second for a three-speed gear-box. If 120 km/h is still exceeded in this lower gear, the vehicle shall be tested over the speed range 60 to 120 km/h in that gear;

— if possible, kick-down mechanisms shall be made inoperative;

— the initial engine speed shall be the lowest allowing a continuously increasing engine speed during the test, but no lower than 45 % of the maximum power speed, unless 120 km/h is exceeded at 90 % of maximum power speed in the lowest gear allowed, in which case the initial engine speed shall be that corresponding to a road speed of 60 km/h;

— for vehicles with automatic transmission, the initial engine speed shall be stabilized as near as possible to 45 % of the maximum power speed. The corresponding road speed shall be no higher than approximately 60 km/h.

If, for vehicles with automatic transmissions, the setting changes before the final speed of 90 % of maximum power speed of 120 km/h is reached the initial speed shall be 50 % of that speed where the setting changes.

NOTE — Since difficulties in controlling engine speeds may be encountered in vehicles fitted with torque converters, the test condition should be adhered to as closely as practicable.

8.4.3 Stationary test

The procedure for the stationary tests which shall be carried out in neutral gear are as follows :

a) the engine shall be operated at the low speed idle;

b) the throttle shall be fully opened as quickly as possible allowing the engine to accelerate to high idle and shall be held fully open for at least 5 s.

9 Microphone positions

The noise inside a vehicle may vary considerably with location. Therefore, measuring points should be selected in sufficient number and in such a manner that the distribution of the noise in the vehicle is adequately represented with respect to driver and passenger ear locations.

One measuring point shall be at the driver's position.

For passenger cars it is sufficient to have an additional measuring point at the rear of the vehicle.

NOTE — For buses additional measuring points are likely to be needed at the middle and the rear of the vehicle adjacent to the longitudinal axis of the vehicle.

Both seated and standing positions shall be included where appropriate. The exact position of the measuring points shall be indicated on a plan. During the measurement no person shall occupy the selected position with the exception of the driver's seat.

The microphone shall be no closer than 0,15 m to walls or upholstery.

The microphone shall be oriented horizontally, with the direction of maximum sensitivity specified by the manufacturer of the microphone pointing in the direction in which a person occupying the seat or standing position would be looking or, if such direction is not defined, in the driving direction.

The microphone used during the tests shall be mounted in such a way that it is not affected by vibrations of the vehicle. The mounting shall prevent excessive (more than about 20 mm) amplitudes relative to the vehicle.

If not stated otherwise by the manufacturer of the sound level meter the direction of maximum sensitivity shall coincide with the reference direction.

9.1 Microphone position with respect to a seat (see the figure)

The vertical co-ordinate of the microphone shall be 0,7 ± 0,05 m above the intersection of the unoccupied seat surface and the surface of the back of the seat (see the figure).

The horizontal co-ordinate shall be the middle plane (or plane of symmetry) of the unoccupied seat. At the driver's seat, with the driver present, the horizontal co-ordinate shall be 0,2 ± 0,02 m to the right (to the left for right-hand driven vehicles) from the middle plane of the seat. Adjustable seats shall be set according to 8.3.

9.2 Microphone position for standing locations

The vertical co-ordinate shall be 1,6 ± 0,1 m above the floor. The horizontal co-ordinates shall correspond to a person standing at selected points.

9.3 Microphone position in sleeping-berths

In sleeping-berths, such as in sleeper trucks or stretchers in ambulances, the microphone shall be placed 0,15 ± 0,02 m above the middle of the unoccupied pillow.

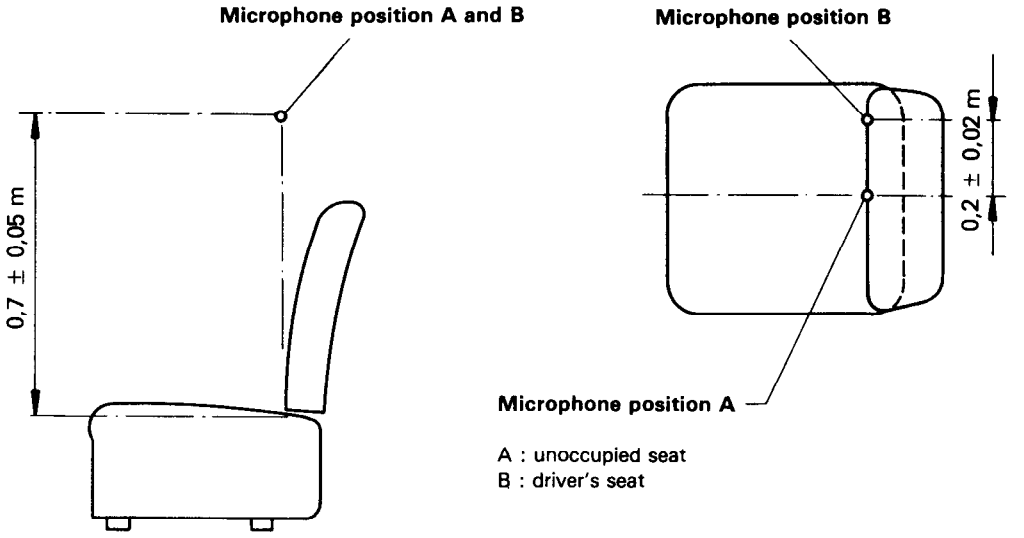

Figure — Microphone position with respect to a seat

10 Test procedure

10.1 At the steady speeds, the values of the A-weighted sound pressure level are recorded for at least five speeds as specified in 8.4.1.

10.2 At full throttle acceleration (see 8.4.2), the maximum value of the A-weighted sound pressure level occurring in the specified acceleration range is retained and stated in the test report.

10.3 In the stationary tests, the value of the A-weighted sound pressure level at low idle and the maximum value occurring while the throttle is open are recorded and stated in the test report. An additional reading may be taken at stabilized high idle (see 8.4.3).

10.4 For verification tests, at least two measurements shall be made at each microphone position and for each operating condition. If the spread of results of the A-weighted sound pressure levels obtained under any measuring condition exceeds 3 dB, further measurements shall be made until the readings of two independent successive measurements fall within a range of 3 dB; the mean value of these two readings shall be recorded as the test result. For tests following 8.4.1, these mean values shall be used to obtain the regression line (see 10.6).

The values stated in the test report shall be rounded to the nearest integral decibel.

For monitoring purposes it is sufficient to perform one measurement under each of the specified measuring conditions at selected microphone positions.

Any peak which is obviously out of character with the general sound pressure level being read should be ignored.

10.5 Whenever the sound level meter reading fluctuates, the mean value of the readings shall be determined. Occasional extreme peaks should be disregarded.

10.6 An evaluation procedure for the steady speed test is described below.

A linear regression line giving the A-weighted sound pressure level as a function of vehicle speed shall be drawn on a graph with linear scales for L_{pA} and speed obtained as described in 8.4.1, 10.1 and 10.4. It is preferable that the method of least squares should be used to determine the regression line.

From this regression line L_{pA} shall be read off for the speed 120 km/h or 80 % of maximum vehicle speed, whichever is lower. If, at or below this speed, sound pressure levels are measured which exceed this value of L_{pA} by more than 3 dB, the highest of these values shall be stated additionally.

Octave or 1/3-octave band spectra shall be determined for a speed as close as possible to the speed selected in the previous paragraph such that the A-weighted values of the spectra are within 2 dB of the regression line specified above.

The vehicle speeds corresponding to the spectra shall be stated in the test report.

NOTES

1 The intention of this procedure is to avoid the over-estimation of noise due to resonances at the specified speed.

2 To provide a more comprehensive description of the noise encountered in the vehicle, the value of the A-weighted sound pressure level at 60 km/h or 40 % of maximum vehicle speed, whichever is lower, may be read off from the regression line and stated additionally.

10.7 The presence of clearly audible pure tones or noise of distinct impulse character should be stated additionally in the test report.

11 Test report

The test report shall include the following information :

a) nature of tests;

b) test site, road and weather conditions, speed and direction of wind;

c) measuring equipment;

d) background noise and corrections applied to the data, if any;

e) vehicle, its engine, setting of the gearbox and speed during the tests, tyres (tread design and stated wear), tyre pressures, radiator-flaps (blinds), and cooling fan;

f) auxiliary equipment and its operating conditions; position of openings and of adjustable seats;

g) load of the vehicles, number of persons in the vehicle;

h) microphone positions (indicated in plan);

j) A-weighted sound pressure levels at specified microphone positions; the noise spectrum, if measured, stating any corrections applied to the data;

k) the presence of pure tones or noise of an impulsive character.