Avant-projet de norme soumis à enquête probatoire jusqu'au :
20 JUIN 2006

Pr NF ISO 5130

Indice de classement : S 31-102

T1 Acoustique

T2 Mesurages du niveau de pression acoustique émis par les véhicules routiers en stationnement

T3

E : Acoustics — Measurements of sound pressure level emitted by stationary road vehicles

D :

Avant-projet de norme française homologuée

Remplace :

Correspondance

Analyse

Modifications

DRAFT INTERNATIONAL STANDARD ISO/DIS 5130

ISO/TC **43**/SC **1** Secretariat: **DS**

Voting begins on: **2006-03-01**

Voting terminates on: **2006-08-01**

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Acoustics — Measurements of sound pressure level emitted by stationary road vehicles

Acoustique — Mesurages du niveau de pression acoustique émis par les véhicules routiers en stationnement

[Revision of first edition (ISO 5130:1982)]

ICS 17.140.30; 43.020

Member bodies are reminded to consult relevant national interests in each of the technical fields concerned [*Acoustics* (ISO/TC 43), *Noise* (SC 1) and *Road vehicles* (ISO/TC 22)] before returning their ballot to the Central Secretariat.

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Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 5130 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

This second edition cancels and replaces the first edition (ISO 5130:1982), which has been technically revised.

Introduction

This sound pressure level measurement procedure has been developed for use in engineering evaluation of the sound pressure level performance of road vehicle in the vicinity of the exhaust systems. The method is intended to check vehicles in use and also to determine variations in the exhaust sound pressure level, which can result from:

— the wear, maladjustment or modification of particular components, when the defect does not appear by visual inspection;

— the partial or complete removal of devices reducing the emission of certain sound pressure levels.

It is possible to determine these variations by comparing the measurements with reference measurements made under similar conditions, for example during the type approval of the vehicle, using the same method.

The document incorporates certain provisions of SAE J1492:1998-05, for measuring the sound pressure levels of exhaust systems of passenger cars and light trucks.

Acoustics — Measurements of sound pressure level emitted by stationary road vehicles

1 Scope

This International Standard specifies a test procedure, environment and instrumentation for measuring the exterior sound pressure levels from road vehicles under stationary condition, providing a continuous measure of the sound pressure level over a range of engine speeds. This standard applies only to road vehicles of categories L, M and N equipped with an internal combustion engines.

The method is designed to meet the requirements of simplicity as far as they are consistent with reproducibility of results under the operating conditions of the vehicle.

It is within the scope of this standard to measure the stationary A-weighted sound pressure level during:

— type approval measurements of vehicle

— measurements at the manufacturing stage

— measurements at official testing stations

— measurements at roadside testing

It does not specify a method to check the exhaust sound pressure level against a general noise limit for categories of road vehicles. Technical background information is given in Annex A.

2 Normative references

The following referenced documents are indispensable for the application 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 5725 (*Parts 1-6*), *Accuracy (trueness and precision) of measurement methods and results*

IEC 60942, *Electroacoustics –Sound calibrators*

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

Guide to the expression of uncertainty in measurement (GUM). International Organization for Standardization, Geneva, Switzerland. ISBN 92-67-10188-9, First Edition 1993, corrected and reprinted 1995.

3 Terms and definitions

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

3.1
vehicle category L
motor vehicles with four wheels or less

NOTE United Nations Economic Commission for Europe (UN ECE) document TRANS/WP.29/78/Rev.1/Amend.4 (26 April 2005) extended the L category to four wheeled vehicles as defined by L6 and L7.

3.2
vehicle category M
motor vehicles with at least four wheels used for the carriage of passengers

3.3
vehicle category N
motor vehicles with at least four wheels used for carriage of goods

3.4
rated engine speed, *S*
engine speed at which the engine develops its rated maximum net power as stated by the manufacturer. If the rated maximum net power is reached at several engine speeds, *S* used in this standard is the highest engine speed at which the rated maximum net power is reached

3.5
target engine speed
engine speed as specified in 6.4.3

4 Instrumentation

4.1 Instrumentation for acoustical measurement

4.1.1 General

The sound level meter or equivalent measuring system, including the windscreen recommended by the manufacturer shall meet the requirements of Class 1 instruments in accordance with IEC 61672-1.

The measurements shall be made using the frequency weighting A, and the time weighting F.

4.1.2 Calibration

At the beginning and at the end of every measurement session, the entire measuring system shall be checked by means of a sound calibrator that fulfils the requirements for sound calibrators of Class 1 according to IEC 60942. Without any further adjustment the difference between the readings of two consecutive checks 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.

4.1.3 Compliance with requirements

Compliance of the instrumentation system with the requirements of IEC 61672-1 and compliance of the sound calibration device with the requirements of IEC 60942 shall be verified by the existence of a valid certificate of compliance. These certificates shall be deemed to be valid if verification of compliance with the standards was conducted within the previous 24 months for the instrumentation system and 12 months for the sound calibration device. All compliance testing must be conducted by a laboratory, which is authorised to perform calibrations traceable to the appropriate standards.

4.2 Instrumentation for engine speed measurement

The rotational speed of the engine shall be measured with an instrument meeting specification limits of at least ± 2 % or better at the engine speeds required for the measurements being performed.

5 Acoustical environment, meteorological conditions and background noise

5.1 Test site

A suitable test site shall be outdoors and consist of a level concrete, dense asphalt, or similar hard material flat surface, free from snow, grass, loose soil, ashes, or other sound absorbing material. It shall be in an open space free from large reflecting surfaces, such as parked vehicles, buildings, billboards, trees, shrubbery, parallel walls, people, etc., within a 3 m radius from the microphone location and any point of the vehicle.

As an alternative to outside testing, a semi-anechoic chamber may be used. The semi-anechoic chamber shall fulfil the acoustical requirements given above. These requirements shall be met if the testing facility meets the 3 m distance criteria and has a cut-off frequency below the lower of:

— One-third-octave band below the lowest fundamental frequency of the engine during test conditions;

— 100 Hz.

NOTE Indoor testing facilities noise performance is specified in terms of the cut-off frequency (Hz). This is the frequency above which the room can be assumed to act as a semi-anechoic space.

5.2 Meteorological conditions

The tests shall not be carried out if the wind speed, including gusts, at microphone height exceeds 5 m/s, during the sound measurement interval.

5.3 Background noise

Readings on the measuring instruments produced by ambient noise and wind shall be at least 10 dB below the A-weighted sound pressure level to be measured. A suitable windscreen may be fitted to the microphone provided that account is taken of its effect on the sensitivity of the sound level meter.

6 Test procedure

6.1 General comments

It is essential that persons technically trained and experienced in current sound measurement techniques select the test instrumentation and conduct the test.

It should be recognised that variations in measured sound pressure levels may occur due to variations in test sites, atmospheric conditions and test equipment (see Annex B).

Instrument manufacturers' specification for orientation of the microphone relative to the sound source and the location of the observer relative to the microphone shall be followed. The test may be performed with a hand-held sound level meter. However, it is recommended that the sound level meter or microphone be mounted on a stand or fixture for stability, see Clause 9. When possible, it is preferable to use a microphone extension cable and to locate measurement or recording devices away from the microphone.

CAUTION — Caution should be exercised when measuring rear- and mid-engine vehicles because engine and cooling fan noise may prevent accurate measurement of exhaust noise.

6.2 Positioning and preparation of the vehicle

The vehicle transmission shall be in neutral position and the clutch engaged, or in parking position for automatic transmission, and the parking brake applied for safety.

The vehicle air conditioner, if so equipped, shall be turned off.

If the vehicle is fitted with fan(s) having an automatic actuating mechanism, this system shall not be interfered with during the sound pressure level measurements.

The engine hood or compartment cover shall be closed.

Before each series of measurements, the engine shall be brought to its normal operating temperature, as specified by the manufacturer.

In case of a two wheeled motor-driven vehicle having no neutral gear position, measurements shall be carried out with the rear wheel raised off the ground.

6.3 Microphone orientation

The microphone shall be located at a distance of 0,5 m ± 0,01 m from the reference point of the exhaust pipe defined in Figure 1 and at an angle of 45 degree (± 5 degree) to the flow axis of the pipe termination. The microphone shall be at the height of the reference point, but not less than 0,2 m from the ground surface. The reference axis of the microphone shall lie in a plane parallel to the ground surface and shall be directed towards the reference point on the exhaust outlet.

If two microphone positions are possible, the location farthest laterally from the vehicle longitudinal centreline shall be used.

If the flow axis of the exhaust outlet pipe is at 90 degrees to the vehicle longitudinal centreline, the microphone shall be located at the point, which is furthest from the engine.

If a vehicle has two or more exhaust outlets spaced less than 0,3 m apart and connected to a single silencer, only one measurement shall be made. The microphone shall be located relative to the outlet farthest from the vehicle longitudinal centreline, or when such outlet does not exist, to the outlet, which is highest above the ground.

For vehicles having an exhaust provided with outlets spaced more than 0,3 m apart, one measurement is made for each outlet as if it were the only one, and the highest sound pressure level shall be noted.

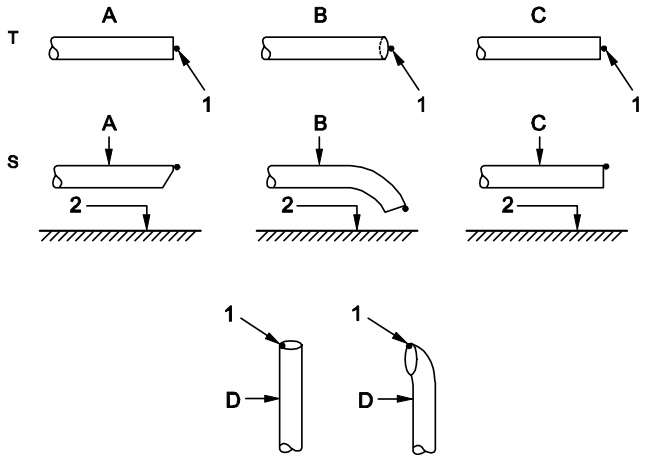
For vehicles with a vertical exhaust (e.g. commercial vehicles) the microphone shall be placed at the height of the exhaust outlet. Its axis shall be vertical and oriented upwards. It shall be placed at a distance of 0,5 m ± 0,01 m from the exhaust pipe reference point as defined in Figure 1, but never less than 0,2 m from the side of the vehicle nearest to the exhaust.

For vehicles, where the reference point of the exhaust pipe is not accessible, or located under the vehicle body, as shown in Figures 2c and 2d, because of the presence of obstacles which form part of the vehicle (e. g. spare wheel, fuel tank, battery compartment), the microphone shall be located at least 0,2 m from the nearest obstacle, including the vehicle body, and its axis of maximum sensitivity must face the exhaust outlet from the position least concealed by the above mentioned obstacles.

When several positions are possible, as shown in Figure 2d, the microphone position giving the lowest value of d_1 or d_2 shall be used.

Figures 2a-e show examples of the position of the microphone, depending on the location of the exhaust pipe.

NOTE For the purpose of roadside checking, the reference point may be moved to the outer surface of the vehicle body.



T = Top view S = Side view

A = Mitered pipe B = Bent down pipe

C = Straight pipe D = Vertical pipe

1 = Reference point 2 = Road surface

Figure 1 - Reference point

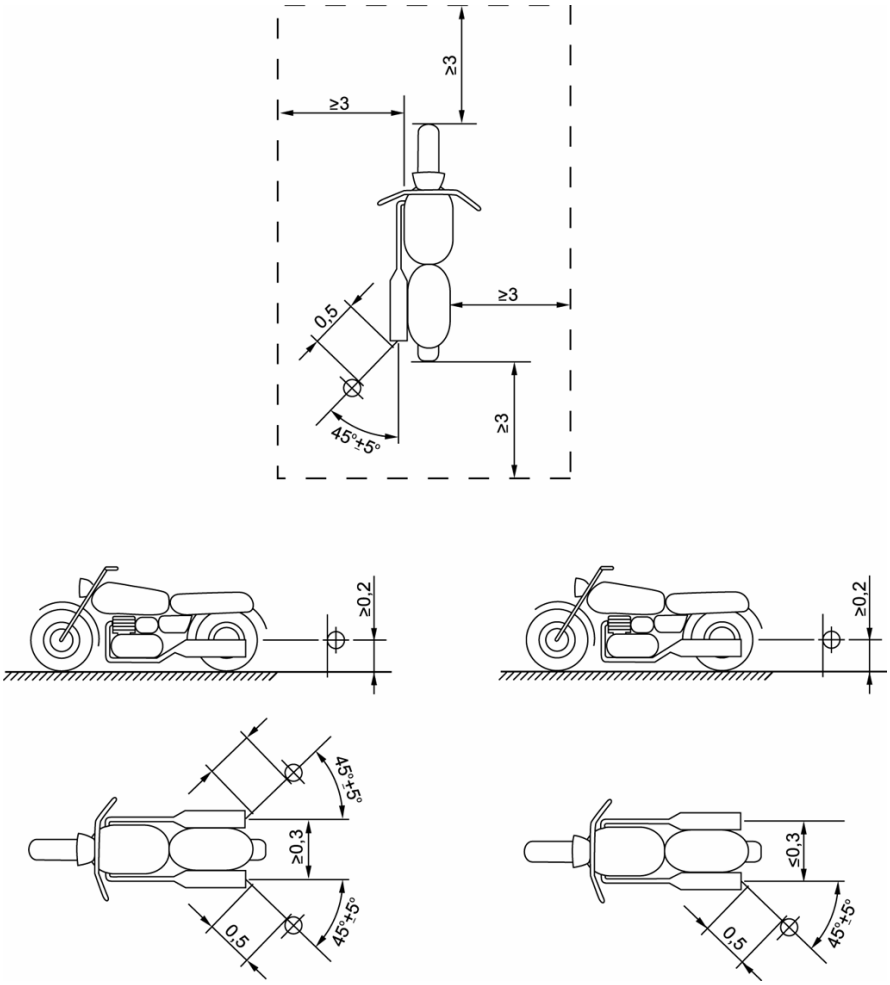


Figure 2a

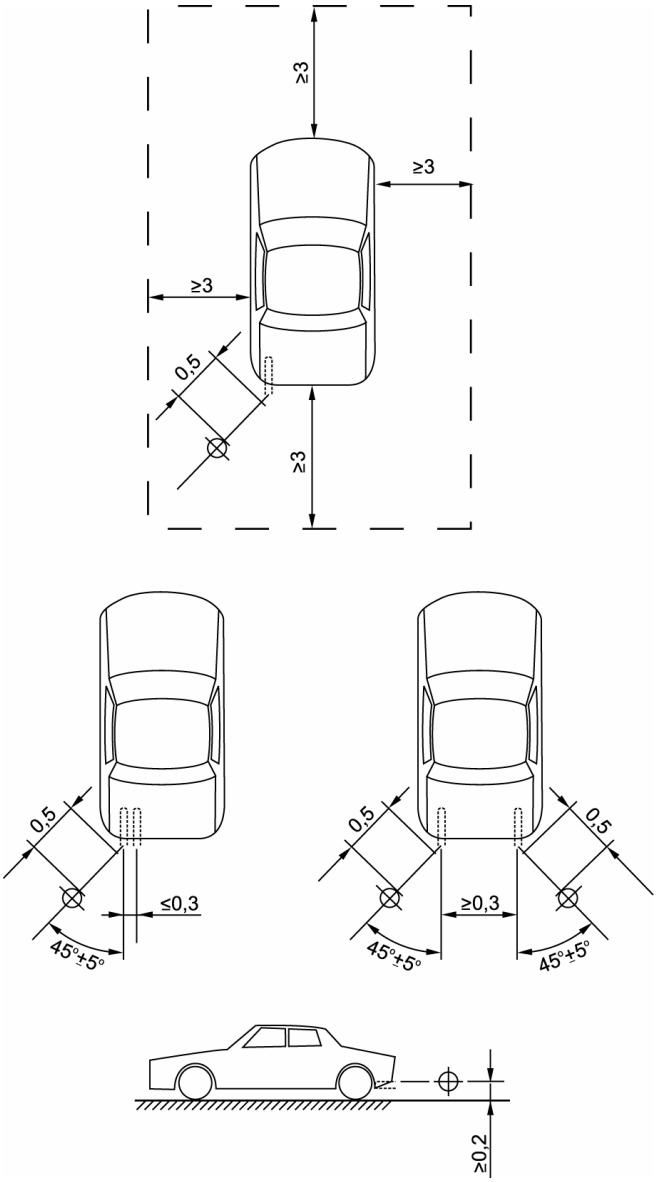


Figure 2b

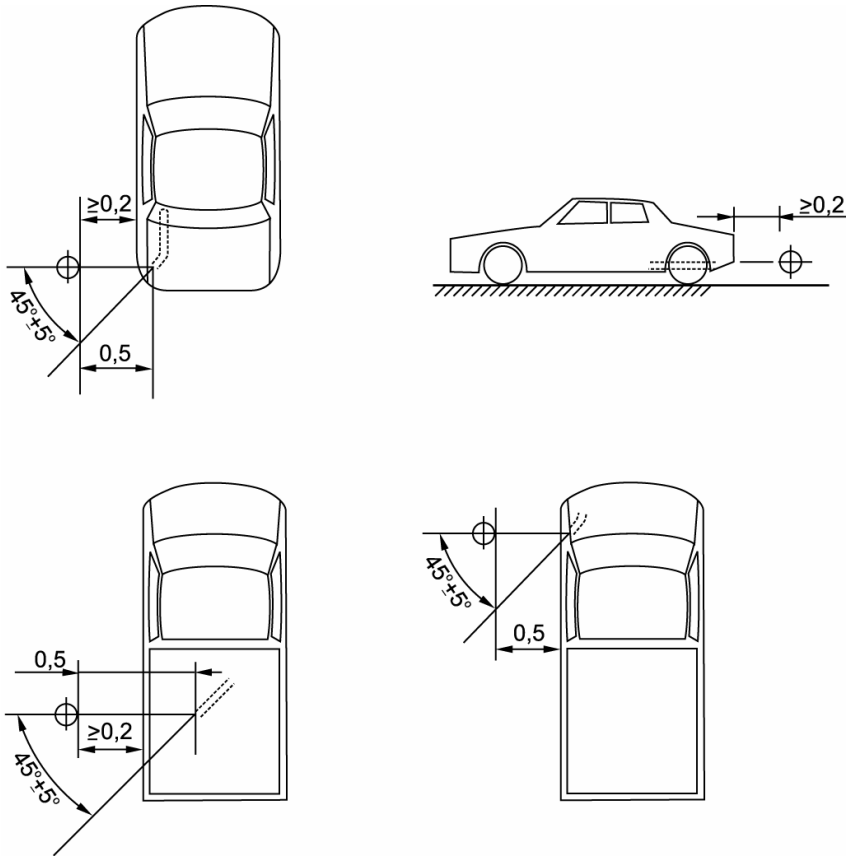


Figure 2c

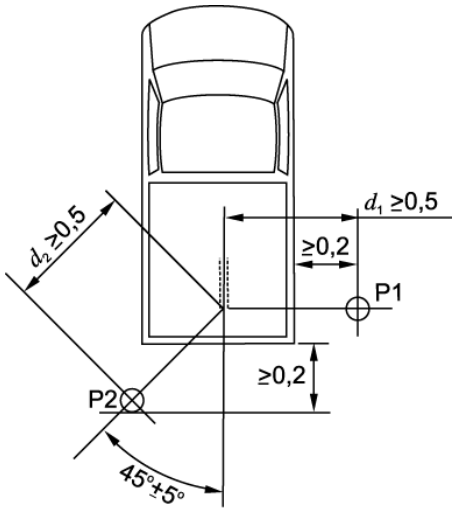


Figure 2d

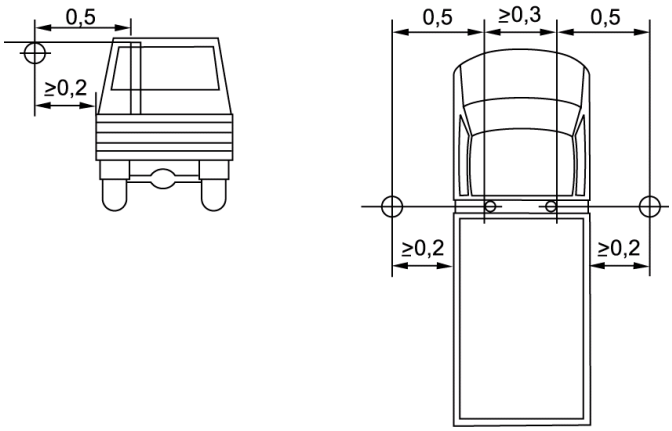


Figure 2e

Figures 2a-e — Examples of microphone positions for various exhaust locations

6.4 Target engine speed

6.4.1 General

If the vehicle cannot reach the engine speed as stated below, the target engine speed shall be 5% below the maximum possible engine speed for the stationary test.

6.4.2 Vehicles of category L

The target engine speed is defined as:

— 75% of the rated engine speed S for vehicles with $S \leq 5000$ min^{-1};

— 50% of the rated engine speed S for vehicles with $S > 5000$ min^{-1};

with a tolerance of ± 5 %.

6.4.3 Vehicles of category M, N

The target engine speed is defined as:

— 75% of the rated engine speed S for vehicles with $S \leq 5000$ min^{-1};

— 3750 min^{-1} for vehicles with a rated engine speed $5000 < S < 7500$ min^{-1};

— 50% of the rated engine speed S for vehicles with $S \geq 7500$ min^{-1};

with a tolerance of ± 3 %.

6.5 Engine operating conditions

The engine speed shall be gradually increased from idle to the target engine speed, not exceeding the tolerance band as given in 6.4.2 and or 6.4.3 and held constant. Then the throttle control shall be rapidly released and the engine speed shall be returned to idle. The sound pressure level shall be measured during a period consisting of constant engine speed of at least 1 s and throughout the entire deceleration period. The maximum sound level meter reading shall be taken as the test value.

The measurement shall be regarded as valid if the test engine speed does not deviate from the target engine speed by more than the tolerances given in 6.4.2.and 6.4.3, for at least 1 s.

6.6 Multi-mode exhaust system

Vehicles equipped with a multi-mode exhaust system and a manual exhaust mode control shall be tested with the mode switch in all positions.

7 Measurements

Measurements shall be made according to the microphone location(s) described in 6.3.

The maximum A-weighted sound pressure level indicated during the test shall be noted, mathematically rounded to the first significant figure before the decimal place (e.g. 92,4 shall be rounded to 92 while 92,5 shall be rounded to 93).

The test shall be repeated until three consecutive measurements at each outlet are obtained, which are within 2 dB of each other.

The result for a given outlet is the arithmetic average of the three valid measurements, mathematically rounded as given above and shall be reported as the A-weighted sound pressure level, L_{Arep}.

For vehicles equipped with multiple gas outlets, the sound pressure level reported L_{Arep} shall be for the outlet having the highest average sound pressure level.

8 Interpretation of results

The result of testing a vehicle in use may be interpreted by comparison with the results of the reference test in which the vehicle was tested using the same method, for instance during type approval.

9 Measurement uncertainty

The measurement procedure described in the preceding clauses is affected by several parameters that lead to variation in the resulting level observed for the same vehicle or for vehicles belonging to the same type. The source and nature of these perturbations are not completely known and sometimes affect the end result in a non-predictable way. The effect can be both of a random nature or a systematic nature.

The magnitude of the resulting uncertainty can be addressed both by means of an analytical evaluation, given in the GUM, or a statistical approach on base of ISO 5725.

For the present case uncertainty is estimated according to the GUM.

Four levels of uncertainty are distinguished:

— run-to-run variability, indicating the variance in repeated measurements;

— day-to-day variability, indicating the variance in measurements repeated on another day, but on the same site and with identical equipment and operators;

— site-to-site variability, indicating the variance observed in repeating the measurements under conditions that fall within the measurement envelope, but in which equipment, operators and site are different;

— new vehicles-to-vehicles in-use, indicating the variance found in measurement results of the population of in-use vehicles that exhibit normal wear characteristics.

Annex B gives a listing of the sources of uncertainty for all five levels and an insight in how they are build up from partial contributions.

The uncertainty based on averaging over 3 measurements is given in Table 1. The uncertainty is expressed as the 80% coverage value (coverage factor = 1,5).

Tabel 1 — Uncertainty expressed as 80 % coverage value

Run-to-run	Day-to-day	Site-to-site	New vehicles-to vehicles-in-use
0,3 dB	1,0 dB	1,9 dB	3,0 dB

Due to the uncertainty influence, shown in Table 1, differences between the sound pressure level of the vehicle in-use and that in corresponding reference test should not be considered significant unless they are equal or larger than 5 dB.

The variations in the sound pressure level of identical units of a production process are outside the scope of this International Standard. Such variation is within the scope of the quality control systems of the manufacturer.

10 Test report

The test report shall include the following information:

a) Reference to this International Standard,

b) The test site, ground conditions, and weather conditions,

c) The type of measuring equipment including the windscreen,

d) The A-weighted sound pressure level typical of the background noise,

e) The identification of the vehicle, its engine and its transmission system,

f) A general description of the location of the engine and exhaust outlet,

g) The location and orientation of the microphone,

h) The engine operating speed used for the test,

i) The A-weighted sound pressure level, L_{Arep}, determined by the test.

Annex A
(informative)

Technical background information

There are several technical reasons to revise ISO 5130:1982, stationary test method, developed in the late 1970's. Since the last revision of this procedure, there has been continuous development of vehicle technology, including the reduction of exhaust noise, and the design of vehicle exhaust systems.

The original scope of the procedure was to provide a simple method for use in road-side checks of exhaust systems, e.g. by the police or road authorities.

In some countries/regions a general noise limit for different categories of vehicles was introduced, and control was performed to check for faults in the exhaust system. This application of the procedure caused inaccuracies for vehicles with rear - or midengine, as the engine noise could be the dominating noise source thereby interfering with the intent of the measurement. In such cases, flexible shields were necessary to separate the different noise sources during the test, adding complexity and measurement variability.

Investigations have shown that the present method is not particularly suited to check the exhaust system against a general noise limit, because of the influence of other vehicle noise sources at the position of the microphone. The extent to which other noise sources might contribute to the stationary measurement is vehicle design dependent. These investigations have also shown that the noise close to the exhaust pipe is very much dependent on engine speed (rpm) and can vary as much as 20 dB over a typical range of operating engine speed. Because a vehicle exhaust system is an acoustic tuning element, levels of noise do not necessarily increase in a linear fashion with increasing engine speed. Thus, it seems prudent to revise ISO 5130:1982, in order to more clearly define its scope, and enhance the accuracy of the measurement method.

In several countries, for example the Member States of the European Union and Norway, a system is introduced where the stationary level of noise (measured during type approval or when imported as a used vehicle) is labelled in the vehicle registration documents, to be kept with the vehicle. This concept provides a more efficient basis for spot checks of the performance of vehicles using a stationary test. Comparison of results of the level of noise obtained from a road-side, or periodic technical inspection, to the baseline level of noise obtained during type approval gives a more accurate measure of the performance of any given vehicle. It is recommended that this method be added to the scope of this procedure to improve the validity of its application.

ISO 5130:1982 contained an annex describing a close-proximity method for measurement of stationary engine noise. This annex has been deleted, as there seems no need for such a method.

Annex B
(informative)

Determination of the uncertainty in the measurement results

The measurement procedure is affected by several disturbing factors that lead to variation of the resulting level observed for the same subject. The source and nature of these perturbations are not completely known and can affect the end result in a non-predictable way. The effect can be both of a random nature or a systematic nature. In the procedure correction factors are introduced to compensate as good as possible for systematic errors. The non-compensable part is, according to the GUM, treated as random error.

Errors are caused by:

— inaccuracies in measuring devices such as sound level meters calibrators and engine speed measuring devices;

— variations in local environmental conditions that affect sound propagation at the time of measurement of *the ma*ximum A-weighted sound pressure level;

— effect of environmental conditions that influence the mechanical and acoustical characteristics of the source (such as air pressure, air density, humidity, air temperature);

— variation in sound pressure levels of vehicles of the same type due to manufacturing spread;

— variation in sound pressure level of vehicles of the same type due to variations resulting from configuration or build–up;

— variation in sound pressure level of vehicles of the same type due to normal wear of vehicles;

— effect of test site properties (acoustic absorption of local surface, unwanted reflections against obstacles, background noise, etc.).

ISO recommends two approaches for evaluating the effect of the errors:

1) the GUM approach that is based on an inventory of the influencing factors and an analysis of the way these factors affect the end result;

2) the ISO5725 approach that starts from a collecting measuring data on a certain subject within different laboratories and explaining the variance within the values by distinguishing between in-laboratory and inter-laboratory variations.

The GUM approach is followed in this standard since its analytical nature of the causes of errors enables balanced definition to sets of requirements on the test procedure and test equipment Careful inventory of sources of error and assessing the effects has resulted in a first estimate of variances in the measurement result presented in Clause 9.

About 14 factors influencing the final result have been identified. Some of these factors were addressed in an analytical way, for some factors a statistical approach has to be used. Then the factors were grouped such that five levels of test-comparison can be distinguished:

1) run-to-run; depicting the variance within a limited time period in which no structural changes in ambient conditions did take place;

2) day-to-day, representing repeatability of the test result within the same laboratory but under different ambient conditions;

3) site-to-site, representing the variations expected between test sites, mainly due to structural differences in ambient conditions and variances in testing hard-ware (road surface, measuring equipment, etc);

4) new vehicle-to-vehicle-in-use, representing the variations expected due to normal wear of a vehicle.

The variances expressed in Clause 9 are cumulative, meaning that the uncertainty at a certain level comprises the uncertainty up to that level and added to it the uncertainty attributed to specific widening of measurement conditions or vehicle fleet characteristics. For instance the site-to-site variation comprises the effect of direct repetition presented in the run-to-run variation and the effect of changed ambient conditions in the day-to-day variation.

An estimate on the effect of the most important factors is given in the Table B.1 below. In the table below the total expected variance from the different sources is summarised. These data are based on various sources, including measuring experience with measurements according to the former ISO 5130:1982 procedure and additional insights. New insights gained with the new measurement procedure will be necessary to define the factors more precisely.

Table B.1 – Estimated effect of most important factors

	Measuring equipment	Ambient sources	Test site properties	Vehicle sources	Total variance	Standard uncertainty (80 % coverage)
run-to run	0,2	0	0	0	0,2	0,3
day-to-day	0,3	0,6	0	0	0,7	1,0
site-to-site	0,9	0,6	0,6	0	1,2	1,9
new vehicle-to-old vehicle	0,9	0,6	0,6	1,6	2,0	3,0

All institutes involved in application of this procedure are invited to gather their data and subject the proposed figures to a critical evaluation. The procedure in ISO 5725 can be helpful in this task.

Bibliography

SAE J1492:1998-05, *Measurement of Light Vehicle Stationary Exhaust System Sound Level Engine Sweep Method*

SAE J1287:1998-07, *Measurement of Exhaust Sound Levels of Stationary Motorcycles*