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Reciprocating internal combustion engines — Measurement of sound power level using sound pressure

Part 2: Survey method

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Reciprocating internal combustion engines — Measurement of sound power level using sound pressure —

Part 2: Survey method

Moteurs alternatifs à combustion interne — Mesurage du niveau de puissance acoustique à partir de la pression acoustique —

Partie 2: Méthode de contrôle

Reference number
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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 70, *Internal combustion engines*.

This first edition of ISO 6798-2, together with ISO 6798-1, cancels and replaces ISO 6798:1995, which has been technically revised. The main changes compared to the previous edition are as follows:

— the requirements of the test environment and the measurement uncertainty have been changed;

— the accuracy of measurement results has been changed from 1 dB to 0,1 dB;

— the calculation of background noise correction has been changed from table method to Formula method;

— the requirements of installation of engine and auxiliaries have been changed to be specified clearly;

— the specification for measurement units has been added;

— the criterion for position adequacy of microphone has been added;

— the criterion for acoustic adequacy of test environment has been improved.

A list of all parts in the ISO 6798 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO 6798 series can be used to calculate the sound power level by using the sound pressure level on a measurement surface enveloping a noise source.

The measurement result of sound power level has nothing to do with the test environment and the installation conditions of the noise source, which is one of the important reasons for using sound power level to characterize the noise radiation of all types of machinery and equipment.

Sound power level has the following applications:

— indication of noise radiated from machinery under the specified condition;

— validation of the indicated value of a noise;

— radiation noise comparison of all types and sizes of machinery;

— comparison of the noise limit value specified in the purchase contract or specification;

— making engineering measures to reduce radiation noise of machinery (generally, frequency band sound power level is also needed);

— prediction of the sound pressure level of noise in the specified position.

Table 1 gives the measurement methods for determining the sound power level of two types of accuracy grade; the measurement result of the sound power level is rounded to the nearest 0,1 dB. The method given in this document allows the determination of the A-weighted sound power level, the accuracy of the measurement result is grade 3.

Table 2 gives the measurement uncertainty of the sound power level (upper bound values of the standard deviation of reproducibility). The standard deviations listed in Table 2 are the comprehensive effect of the measurement uncertainty, but do not include variations of the sound power level caused by installation and operation conditions of the noise source.

In the noise control of a reciprocating internal combustion engine, the relevant members (the manufacturers, installers, and users) should conduct effective communication on acoustic information which is obtained by measurement. The measurement result is valid when in the specified measurement conditions from using the instrumentation and measurement method as specified in this document to obtain a clear acoustic value. The ISO 6798 series can be used according to the purpose of noise measurement and measurement conditions.

Table 1 — How ISO 6798 series determines the sound power level using sound pressure

Parameters	ISO 6798-1 Engineering method Accuracy grade 2	ISO 6798-2 Survey method Accuracy grade 3
International Standards referenced	ISO 3744	ISO 3746
Test environment	An essentially free field over a reflecting plane	An acoustic field over a reflecting plane
Noise source volume	Unlimited, depending on the test environment	
Criterion for background noise[a]	$\Delta L_p \geq 6{,}0$ dB $K_1 \leq 1{,}3$ dB	$\Delta L_{pA} \geq 3{,}0$ dB $K_{1A} \leq 3{,}0$ dB
Criterion for acoustic adequacy of test environment[b]	$K_2 \leq 4{,}0$ dB	$K_{2A} \leq 7{,}0$ dB
Criterion for position adequacy of microphone[c]	$s\left(L'_{pAm}\right) \leq 1$ dB	$s\left(L'_{pAm}\right) \leq \sqrt{2}$ dB

Table 1 *(continued)*

Parameters	**ISO 6798-1** **Engineering method** **Accuracy grade 2**	**ISO 6798-2** **Survey method** **Accuracy grade 3**
International Standards referenced	ISO 3744	ISO 3746
Instrumentation[d] sound level meter/filter/sound calibrator	Class 1/class 1/class 1	Class 2/class 2/class 1
Sound power level acquired	A-weighted or frequency bands	A-weighted
Application	Acceptance test of sound power level; making engineering measures	Comparative test of sound power level

[a] The difference of sound pressure level, ΔL_{pA} , and the background noise correction, K_{1A}, see 8.3.2.

[b] The environmental correction, K_{2A}, see 8.3.3.

[c] The standard deviation, $s\left(\dot{L}_{pAm}\right)$, see 7.7.

[d] The requirements of instrumentation, see Clause 5.

Table 2 — Measurement uncertainty of the sound power level (upper bound values of the standard deviation of reproducibility)

Mid-band frequency **Hz**		**ISO 6798-1** **standard deviation of reproducibility** dB	**ISO 6798-2** **standard deviation of reproducibility** dB
Octave bands	**One-third-octave bands**		
63	50 to 80	5,0	—
125	100 to 160	3,0	
250	200 to 315	2,0	
500	400 to 630	1,5	
1 000 to 4 000	800 to 5 000	1,5	
8 000	6 300 to 10 000	2,5	
A-weighted		1,5	3,0

INTERNATIONAL STANDARD ISO 6798-2:2020(E)

Reciprocating internal combustion engines — Measurement of sound power level using sound pressure —

Part 2:

Survey method

1 Scope

This document specifies the survey method, which is the measurement method of the sound power level for reciprocating internal combustion engines.

This document applies to all reciprocating internal combustion engines falling within the field of application of ISO 3046-1 and other internal combustion engines where no suitable International Standard exists.

NOTE In this document, reciprocating internal combustion engines are referred to as engines unless otherwise explained.

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 3046-1, *Reciprocating internal combustion engines — Performance — Part 1: Declarations of power, fuel and lubricating oil consumptions, and test methods — Additional requirements for engines for general use*

ISO 3046-3, *Reciprocating internal combustion engines — Performance — Part 3: Test measurements*

ISO 6798-1, *Reciprocating internal combustion engines — Measurement of sound power level using sound pressure — Part 1: Engineering method*

ISO 6926, *Acoustics — Requirements for the performance and calibration of reference sound sources used for the determination of sound power levels*

IEC 60942, *Electroacoustics — Sound calibrators*

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

3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions given in ISO 3046-1, ISO 6798-1 and IEC 61672-1 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 http://www.electropedia.org/

Symbol	Description	Unit
$2a$	measurement surface length	m
$2b$	measurement surface width	m
c	measurement surface height	m
d	measurement distance	m
FS	flywheel side	—
l_1	reference box length	m
l_2	reference box width	m
l_3	reference box height	m
r_s	size ratio	—
•	key microphone positions	—
	reflecting plane	—
	reference box	—

4 Test environment

4.1 General

The test environment shall be a room or a flat outdoor area which is adequately isolated from background noise and which meets the qualification requirements given in 4.3.

Environmental conditions having an adverse effect on the microphones used for the measurements (e.g. wind, impingement of air discharge, high or low temperatures) shall be avoided. The instructions of the manufacturer on the measuring instrumentation regarding adverse environmental conditions shall be followed. Particular care should be exercised to ensure that any plane does not radiate any appreciable sound due to vibrations.

4.2 Criterion for background noise

The time-averaged sound pressure level (abbreviated as sound pressure level in the following text) of the background noise measured and meant (energy average) over the microphone positions shall be at least 3,0 dB, and preferably more than 10,0 dB, below the corresponding uncorrected sound pressure level of the noise source under test when measured in the presence of this background noise.

4.3 Criterion for acoustic adequacy of test environment

Annex A specifies procedures for determining the environmental correction, K_{2A}.

Measurements in accordance with this document are valid only when $K_{2A} \leq 7{,}0$ dB.

NOTE When $K_{2A} > 7{,}0$, ISO 9614 (all parts) can be used.

5 Instrumentation

5.1 General

The instrumentation system, including the microphones, cables and windscreen, if used, shall meet the requirements of IEC 61672-1, class 2.

5.2 Calibration

Before and after each series of measurements, a sound calibrator meeting the requirements of IEC 60942, class 1 shall be applied to each microphone to verify the calibration of the entire measuring system at one or more frequencies within the frequency range of interest. Without any adjustment, the difference between the readings made before and after each series of measurements shall be less than or equal to 0,5 dB. If this value is exceeded, the results of the series of measurements shall be discarded.

The sound calibrator and the instrumentation system which meet the requirements, and the reference sound source (RSS) that meets the requirements of ISO 6926, shall be verified at intervals in a laboratory making calibrations traceable to appropriate standards.

Unless otherwise specified, the sound calibrator should be calibrated at intervals not exceeding 1 year, the instrumentation system and the reference sound source should be calibrated at intervals not exceeding 2 years.

5.3 Application

To minimize the influence of observers on the noise measurements, the microphones shall be preferably mounted on a rigid frame or stand which is not connected to the vibrating surface, the microphone shall always be oriented in such a way that the angle of incidence of the sound waves is that for which the microphone is calibrated and always be oriented to the centre of the tested object (the measurement unit(s) related to the microphone position).

The sound pressure level shall be measured using an integrating sound level meter. If the sound level meter is used to measure time-weighting sound pressure level, the time-weighting characteristic “S” shall be used for the noise source under test operated in steady condition and the time-weighting characteristic “F” shall be used for the noise source under test operated in non-steady condition (e.g. engine operated in the accelerated or decelerated condition). The measured average value can be expressed as the sound pressure level.

The period of stationary measurement for the sound pressure level shall be at least 4 s, 8 s or above is better.

6 Installation and operation conditions

6.1 General

The way the engine under test is installed and operated has a significant influence on the sound power radiated by a noise source. This clause specifies conditions that are intended to minimize variations in the sound power level due to the installation and operating conditions of the noise source under test.

The engine is a multiple noise source, including the following noise sources:

— air-borne noise (this document);

— exhaust gas noise;

— intake-air noise;

— structure-borne noise.

NOTE For exhaust noise, see ISO 15619; for intake noise, see ISO/TS 19425; for structural noise, see ISO 13332.

6.2 Installation conditions

The engine to be tested should be installed on the reflecting plane (ground), the distances between the surface of noise source (reference box) and the wall(s) and the ceiling should be greater than 0,5 m.

The engine noise radiated is affected by the supporting type of engine, connection type with dynamometer equipment and installation height. If the mounting base is rigid, the engine should be resiliently mounted on the base. If the mounting base is resilient, the engine is permitted rigidly mounted on the base. The engine should be resiliently connected with dynamometer equipment. The distance of the engine lowest noise radiation surface (usually is oil pan bottom) and the reflecting plane (the ground) should be less than or equal to 0,5 m.

6.3 Engine conditions and operation conditions

6.3.1 Engine conditions

The engine noise radiated is affected by the auxiliaries which are equipped on the engine; the condition of engine shall meet the requirements of ISO 3046-1. Any air cleaner, exhaust silencer and cooling fan, etc., if equipped, shall be recorded in the report. A gearbox or any driven machinery which load the engine under test should be stated in the report. Noise radiated from any such driven machinery shall be regarded as extraneous noise.

NOTE 1 For the determination of the sound power level of exhaust noise, see ISO 15619. For special purposes, the test distance starts from the contour of the exhaust pipe and a number of measuring points of two (90° to outlet) can be used although not recommended.

NOTE 2 For the determination of the sound power level of intake noise, see ISO/TS 19425.

If it is essential to use equipment or non-basic auxiliaries (such as a blower for cooling) to do bench test for some engines with specified purposes (such as motorcycles). Noise radiated from this equipment or non-basic auxiliaries shall be regarded as extraneous noise, or this equipment or non-basic auxiliaries shall be temporarily turned off to ensure that the engine can operate normally.

The extraneous noise is a part of background noise; appropriate steps shall be taken to reduce extraneous noise in order to comply with 4.2. This can be done by shielding or wrapping the structure surface with a heavy material that has low transmission capabilities in the frequency range of the extraneous noise, and by using a muffler to reduce the aerodynamic noise (gas/liquid).

6.3.2 Operating conditions

For the noise measurement, the engine shall be operated at the ISO standard power and corresponding rate as defined in ISO 3046-1 under the ISO standard reference conditions in a steady state. At that time, the temperature of the oil and coolant shall be stable, the ambient and intake air temperature shall not be higher than 45 °C.

Measurements can be made in accelerated/decelerated conditions and other operating conditions if necessary, all measurements made in such conditions shall be stated in the test report.

The engine power and corresponding rate shall be measured according to the requirements of ISO 3046-3.

7 Measurement

7.1 General

The survey method (accuracy grade 3) is a method for determining the sound power level (A-weighted) of the noise source from sound pressure levels measured on a measurement surface enveloping the noise source over a reflecting plane. This method can be used for comparative tests.

NOTE If declaration is necessary, see ISO 4871.

In order to facilitate the selection of the measurement surface and the arrangement of the microphones, the reference box and measurement distance shall first be determined.

Measurement results include the sound pressure level of noise source under operation and the sound pressure level of background noise when the noise source does not work.

7.2 Measurement uncertainty

The measurement uncertainty (upper bound values of the standard deviation of reproducibility) of sound power level determined in accordance with this document is 3,0 dB.

7.3 Reference box

When defining the dimensions of the reference box, elements protruding from the engine which are not significant radiators of sound energy should be disregarded. For safety reasons, the parallelepiped reference may be made sufficiently large to include danger areas, for example moving parts of an otherwise stationary machine.

7.4 Measurement distance

For noise source of unfavourable acoustic conditions (e.g. there are many reflectors, the background noise is much higher), a smaller measurement distance can be selected. For noise source satisfying the acoustic conditions, a longer measurement distance can be selected.

The recommended measurement distance, d, is 1,0 m. The selection of measurement distance value from the series: 0,25 m, 0,5 m, 1,0 m, 2,0 m, 4,0 m, 8,0 m takes precedence. The value may also be selected from the following series: 0,25 m, 0,315 m, 0,4 m, …, 5,0 m, 6,3 m, 8,0 m. The distance between the measurement surface and the wall(s) and ceiling should be equal to or greater than 0,25 m.

NOTE For the criterion for position adequacy of microphones, see 7.7.

7.5 Measurement surface and area

The parallelepiped measurement surface area, S, in square metres (m^2), is given by Formula (1):

$$S=4(ab+bc+ca) \tag{1}$$

where

$a=0,5l_1+d$;

$b=0,5l_2+d$;

$c=l_3+d$.

7.6 Microphone positions

Divide each measurement surface into rectangular area units of equal size as few as possible, the maximum length of area unit is $r_s d$ (r_s is size ratio, which is the ratio of the maximum length of the side of the area unit to the measurement distance, $r_s \leq 3$), see Figure 1. The microphone positions specified in this document are located in the centre of each area unit (except those falling into the position of the reflecting plane). Typical examples of the microphone position arrangement are shown in Figure 2 to Figure 6; other types of different number of measurement unit can be obtained by the microphone positions in this way.

NOTE 1 Reducing the value of r_s until the number of rectangular areas increased to increase the microphone positions can generally reduce the value of $s(L'_{pAm})$, see 7.7. If necessary, ISO 9614 (all parts) can be used.

NOTE 2 The engine size shown in Figure 2 to Figure 6 is the size relative to the measurement distance, which does not reflect the absolute size.

If the measurements at any position are not permissible due to machine obstructions (driving shaft, driven machinery, etc.) or safety reasons, or are being adversely affected by air flow etc., another position(s) as close as is practicable to the prescribed position(s) shall be selected. Any such revised microphone position(s) shall be recorded [see Clause 9 d) 2)].

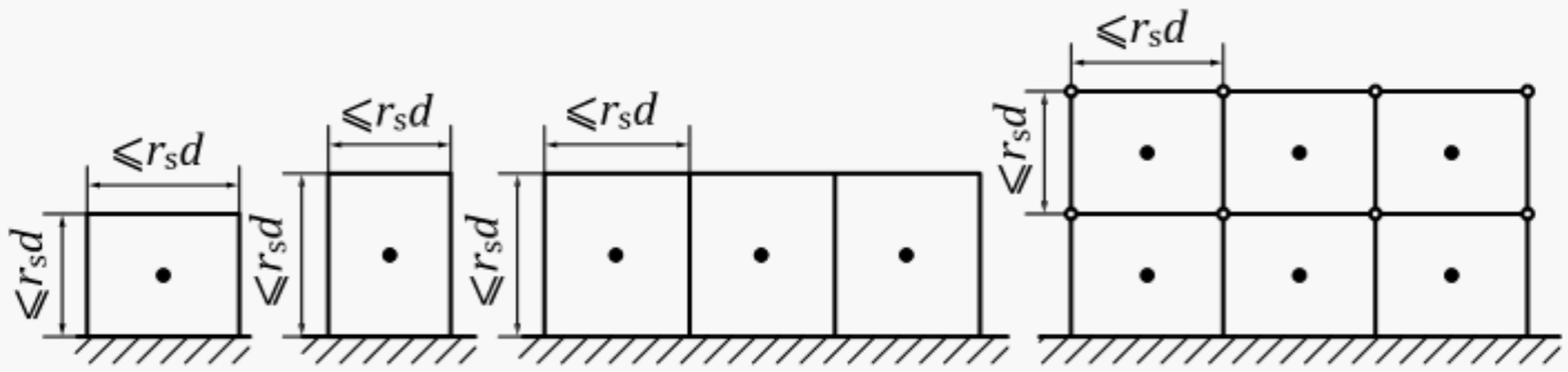
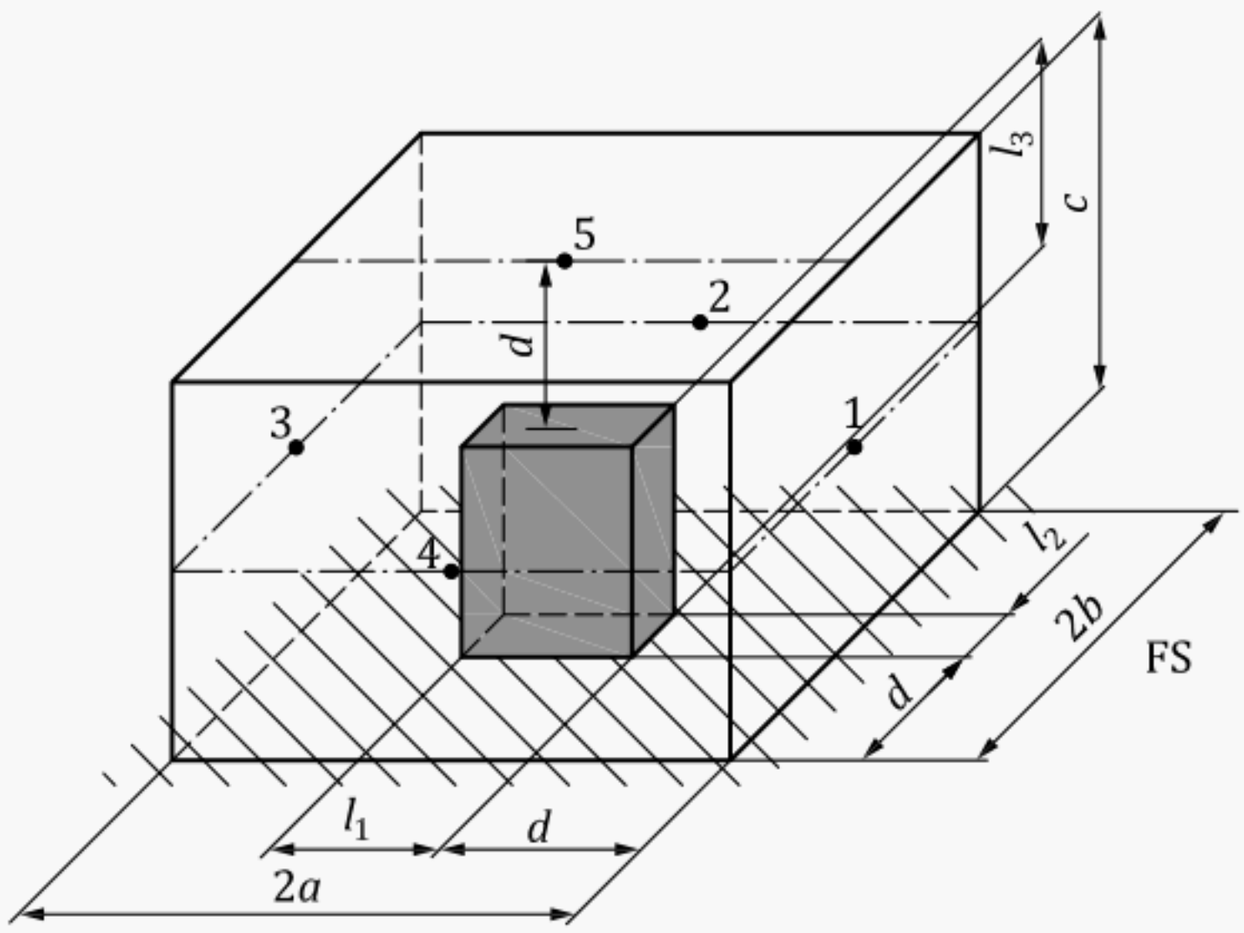
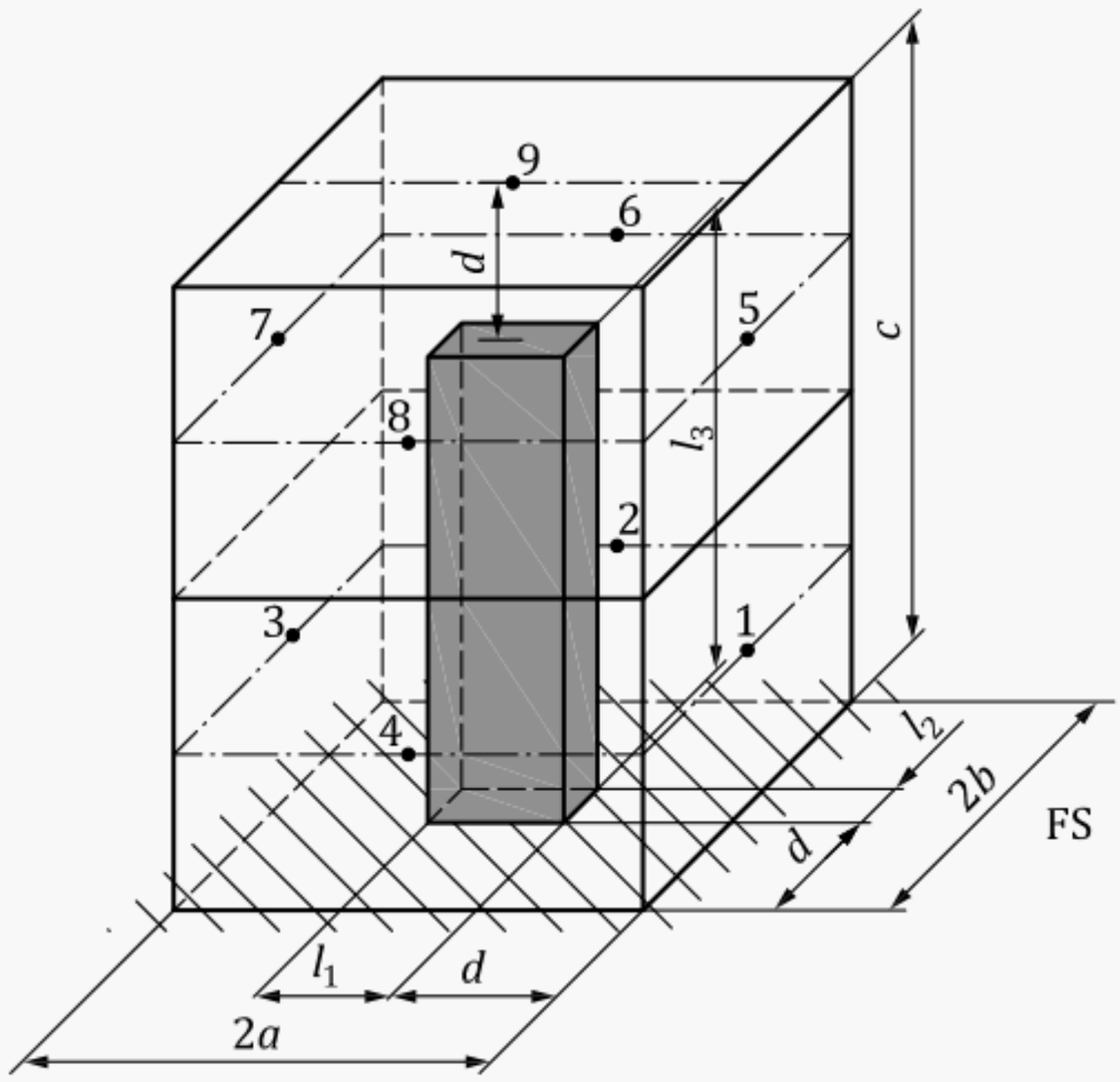


Figure 1 — Microphone positions on the measurement surface



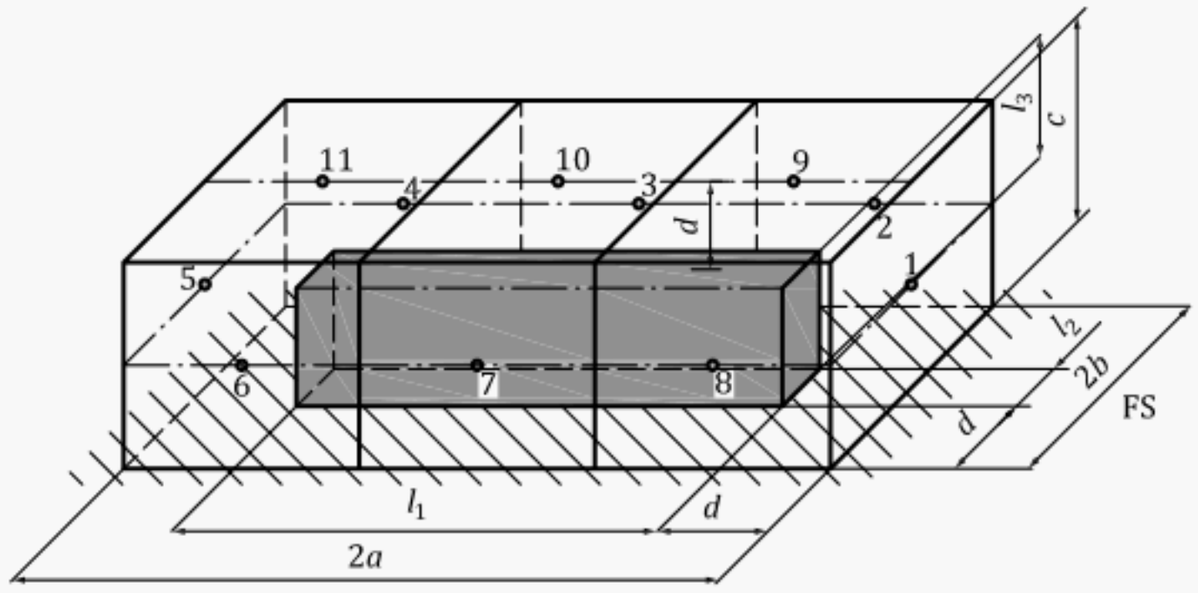
NOTE $l_1 \leq (r_s - 2)\, d$, $l_2 \leq (r_s - 2)\, d$, $l_3 \leq (r_s - 1)\, d$; one measurement unit.

Figure 2 — Microphone positions — Small size engine



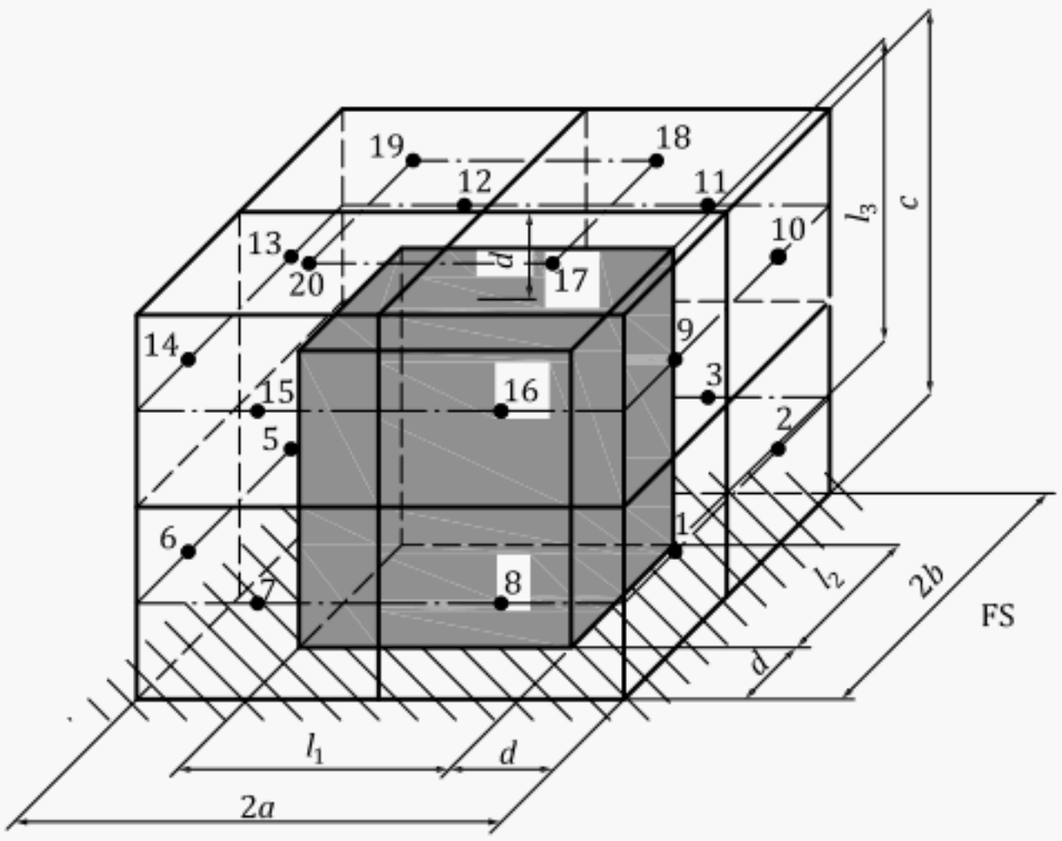
NOTE $l_1 \leq (r_s - 2)\, d$, $l_2 \leq (r_s - 2)\, d$, $(r_s - 1)\, d < l_3 \leq (2r_s - 1)\, d$; two measurement units.

Figure 3 — Microphone positions — Small size erected engine



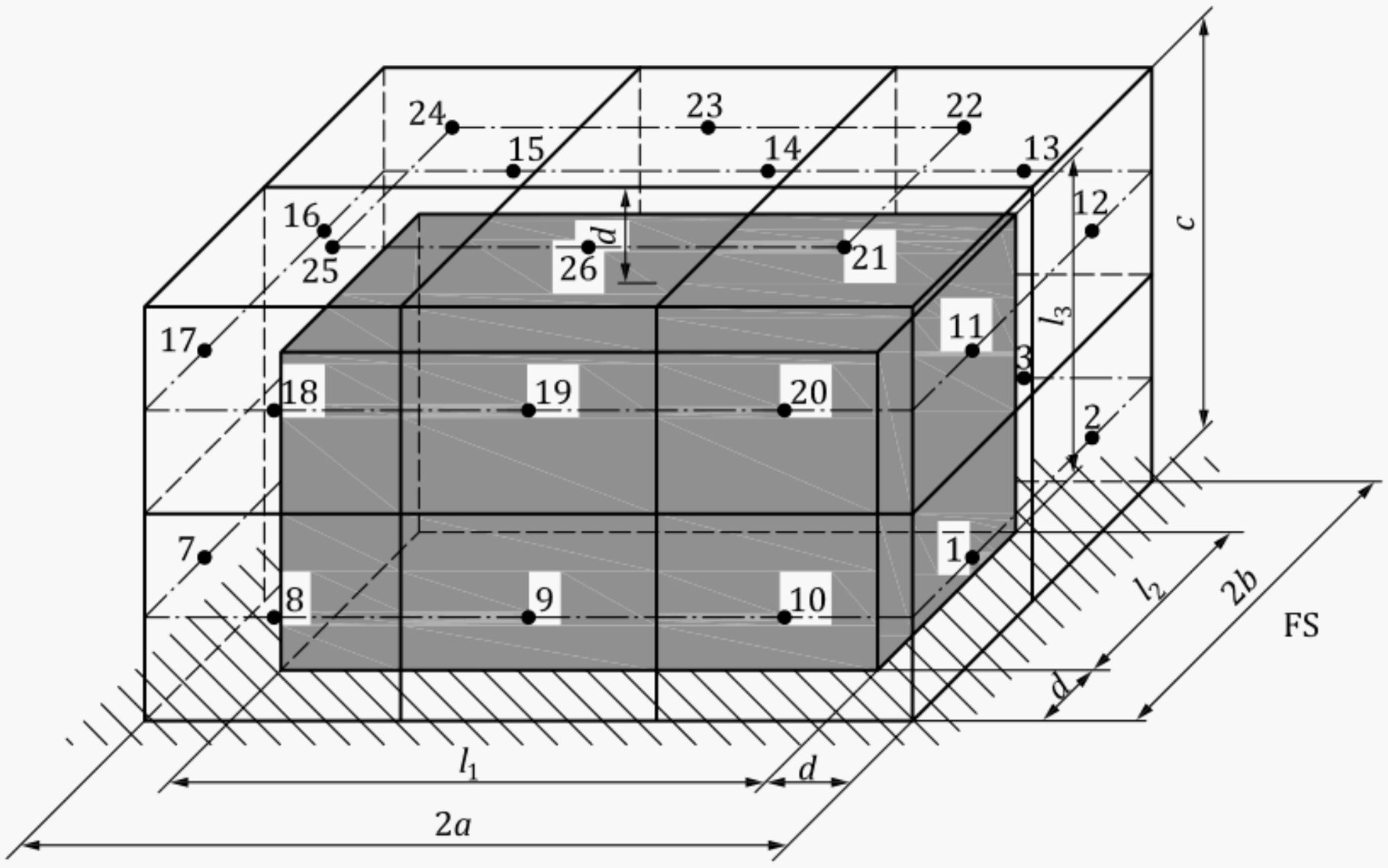
NOTE $2\,(r_s - 1)\, d < l_1 \leq (3r_s - 2)\, d$, $l_2 \leq (r_s - 2)\, d$, $l_3 \leq (r_s - 1)\, d$; three measurement units.

Figure 4 — Microphone positions — Long size engine



NOTE $(r_s - 2)\, d < l_1 \leq 2(r_s - 1)\, d$, $(r_s - 2)\, d < l_2 \leq 2(r_s - 1)\, d$, $(r_s - 1)\, d < l_3 \leq (2r_s - 1)\, d$; eight measurement units.

Figure 5 — Microphone positions — Middle size engine



NOTE $2(r_s - 1)\, d < l_1 \leq (3r_s - 2)\, d$, $(r_s - 2)\, d < l_2 \leq 2(r_s - 1)\, d$, $(r_s - 1)\, d < l_3 \leq (2r_s - 1)\, d$; twelve measurement units.

Figure 6 — Microphone positions — Large size engine

7.7 Criterion for position adequacy of microphones

If the standard deviation, $s\left(L'_{pAm}\right)$, of the mean sound pressure level measured in all microphone positions (see 8.2) is less than or equal to $\sqrt{2}$ dB during the engine operation, the criterion for position

adequacy of microphones is satisfied. If the standard deviation, $s\left(L'_{pAm}\right)$ is larger than $\sqrt{2}$ dB, the measurement is not valid.

NOTE 1 The mean sound pressure level and the surface sound pressure level measured in all microphone positions are not exactly the same. But the standard deviation, $s\left(L'_{pAm}\right)$ of the mean sound pressure level reflects the measurement uncertainty caused by acoustic condition, noise source characteristics, measurement distance, microphone positions and number.

NOTE 2 Increasing the measurement distance and the number of microphone positions generally can reduce the value of $s\left(L'_{pAm}\right)$.

NOTE 3 For $L'_{pAm,}$ see 8.2.

8 Calculation

8.1 General

This clause specifies the calculation methods of the standard deviation of the mean sound pressure level (given in 7.7) and the sound power level.

8.2 Calculation of standard deviation of the mean sound pressure level

The mean (arithmetic average) sound pressure level, L'_{pAm} from all microphone positions, expressed in decibel (dB), shall be calculated using Formula (2):

$$L'_{pAm}=\frac{\sum_{i=1}^{N_M} L'_{pAi}}{N_M} \tag{2}$$

where

L'_{pAi} is the sound pressure level measured at the i^{th} microphone position, in decibels (dB);

N_M is the number of microphone positions.

NOTE The subscript A in L'_{pAm} represents A-weighted, m in L'_{pAm} represents arithmetic average.

The standard deviation of the mean sound pressure level, $s(L'_{pAm})$, from all microphone positions, expressed in decibels (dB), shall be calculated using Formula (3):

$$s(L'_{pAm})=\sqrt{\frac{\sum_{i=1}^{N_M}\left(L'_{pAi}-L'_{pAm}\right)^2}{(N_M-1)N_M}} \tag{3}$$

If $s\left(L'_{pAm}\right)\leq\sqrt{2}$ dB, the measurement is valid. If $s\left(L'_{pAm}\right)>\sqrt{2}$ dB, the measurement is not valid. Another measurement surface or a better test environment shall be chosen to carry out the measurement.

8.3 Calculation of sound power level

8.3.1 Measured surface time-averaged sound pressure levels

The measured surface time-averaged sound pressure level, $\overline{L'_{pA}}$, and the measured surface time-averaged sound pressure level of the background noise, $\overline{L_{pA(B)}}$, from the array of microphone positions over the measurement surface shall be calculated using Formula (4) and Formula (5), expressed in decibels (dB):

$$\overline{L'_{pA}} = 10 \times \lg\left[\frac{1}{N_M}\sum_{i=1}^{N_M} 10^{0,1 L'_{pAi}}\right] \quad (4)$$

$$\overline{L_{pA(B)}} = 10 \times \lg\left[\frac{1}{N_M}\sum_{i=1}^{N_M} 10^{0,1 L_{pAi(B)}}\right] \quad (5)$$

where $L_{pAi(B)}$ is the sound pressure level of the background noise measured at the i^{th} microphone position, in decibels (dB).

8.3.2 Corrections for background noise

The background noise correction, K_1, expressed in decibels (dB), shall be calculated using Formula (6):

$$K_{1A} = -10 \times \lg\left(1 - 10^{-0,1 \Delta L_{pA}}\right) \quad (6)$$

where ΔL_{pA} is the difference between the measured surface time-averaged sound pressure level and the measured surface time-averaged sound pressure level of the background noise from the array of microphone positions over the measurement surface, with the noise source under test in operation, that is $\Delta L_{pA} = \overline{L'_{pA}} - \overline{L_{pA(B)}}$, in decibels (dB).

If $\Delta L_{pA} > 10,0$ dB, K_{1A} is assumed to be zero and no correction for background noise is applied. If $3,0 \text{ dB} \leq \Delta L_{pA} \leq 10,0$ dB, corrections calculated with Formula (6) shall be applied, i.e. $0,5 \text{ dB} \leq K_{1A} \leq 3,0$ dB. If $\Delta L_{pA} < 3,0$ dB, i.e. $K_{1A} > 3,0$ dB, the measurement is not valid.

NOTE If $K_{1A} > 3,0$ dB, the measurement results of sound power level do not satisfy the accuracy grade 3, but measurement result corrected by $K_{1A} = 3,0$ can be used for indicating an upper boundary to the sound power level of the noise source under test.

8.3.3 Environmental correction

Determine the environmental correction, K_{2A}, according to Annex A.

The measurement is valid if $K_{2A} \leq 7,0$ dB and is not valid if $K_{2A} > 7,0$ dB.

NOTE If $K_{2A} > 7,0$ dB, the measurement results of sound power level do not satisfy the accuracy grade 3, but measurement result corrected by $K_{2A} = 7,0$ can be used for indicating an upper boundary to the sound power level of the noise source under test.

8.3.4 Surface time-averaged sound pressure level

The surface time-averaged sound pressure level, $\overline{L_{pA}}$, shall be calculated by correcting the measured surface time-averaged sound pressure level, $\overline{L'_{pA}}$, for background noise, K_{1A}, and for the influence of the test environment, K_{2A}, using Formula (7), expressed in decibels (dB).

$$\overline{L_{pA}} = \overline{L'_{pA}} - K_{1A} - K_{2A} \quad (7)$$

8.3.5 Sound power level

The sound power level, L_{WA}, expressed in decibels (dB), shall be calculated using Formula (8):

$$L_{WA} = \overline{L_{pA}} + 10 \times \lg\left(S/S_0\right) \tag{8}$$

where

S is the area of the measurement surface, in square metres (m^2);

S_0 is equal to 1,0 m^2.

Atmospheric pressure and/or a temperature create a bias in the radiation of sound power. At altitudes higher than 500 m above sea level and/or temperatures below 10 °C, the sound power levels, $L_{W\mathrm{ref,atm}}$, corresponding to the reference static pressure 101,325 kPa and reference atmospheric temperature 23,0 °C shall be calculated in accordance with Annex B and stated in the report.

9 Information to be recorded

The information below marked with * shall be recorded in the report, others are optional.

a) Engine under test

1) the description of the engine under test including the type*, specifications (i.e. form*, number of strokes, number of cylinders, cylinder bore, stroke displacement*, appearance dimensions, type of cooling*, ISO standard power* and corresponding speed*), serial number*, and manufacturer*;

2) the type of fuel used and its octane or cetane number;

3) the injection timing (static and dynamic) for diesel engines or the ignition timing (static and dynamic) for petrol engines;

4) the character of the foundation bed* and the connection type with the engine* (elasticity or rigidity);

5) the connection type of the engine and the dynamometer* (elasticity or rigidity);

6) the mounting conditions, including height of the crankshaft centre and oil pan bottom above reflecting plane*;

7) the description of dependent auxiliaries*, including air filter, exhaust silencer (if any) and cooling fan (if any), encapsulation (if any);

8) the engine power* and the corresponding speed* of rotation during the noise test.

b) Acoustic environment

1) the description of the test environment (including the nature of the floor, walls and ceiling, and the sketch showing the location of the noise source under test and any other contents of the room);

2) the description of the acoustical qualification of the test environment* in accordance with Annex A;

3) the description of the ambient conditions near the noise source under test (including the barometric pressure*, air temperature*, relative humidity and wind speed*).

c) Description of instrumentation

1) the equipment used for the measurements*, including the name, type, serial number, and manufacturer;

2) the date*, place*, results* and methods* used to calibrate the sound calibrator and to verify the calibration of the instrumentation system;

3) the characteristics of the microphone windscreen, if any.

d) Acoustical data

1) the measurement method* and accuracy grade*;

2) the dimensions of the reference box*, measurement distance*, microphone positions* and number and revised microphone positions* (if any, see 7.6);

3) the sound pressure level measured at the i^{th} microphone position with the noise source under test in operation*, L'_{pAi} and the standard deviation of the averaged sound pressure level*, $s\left(L'_{p\text{Am}}\right)$;

4) the correction(s)*, $K_{1\text{A}}$, to account for background noise;

5) the correction(s)*, $K_{2\text{A}}$, to account for the test environment, and the method from Annex A used to determine it (them)*;

6) the surface time-averaged sound pressure levels*, $\overline{L_{p\text{A}}}$;

7) the sound power levels*, L_{WA};

8) the date, place and performing person for the measurements.

10 Test report

Test report should record the data and information required in Clause 9 which only provides the measurement results of sound power level (A-weighted). The report shall specify that the measurement is made in full conformity with the requirements of this document and the test result meets the requirement of accuracy grade 3. The report shall also contain any statements required to be reported by some clauses of this document.

The measurement results of sound power level (A-weighted) in the report should be rounded to the nearest 0,1 dB.

Annex A
(normative)

Qualification procedures for the acoustic environment

A.1 General

This annex specifies procedures to determine the environmental correction, K_{2A}. These procedures can be used to qualify a given measurement surface for an actual noise source under test in accordance with this document.

The first qualification test (absolute comparison test, see A.2) is carried out with a reference sound source (RSS) and can be used outdoors and indoors. This is the preferred procedure for qualifying a test environment, particularly when the noise source under test can be removed from the test site.

The second qualification test (method based on room absorption, see A.3) requires the determination of the equivalent absorption area, A, of the test room, and is based on the assumption that the room is approximately cubic and empty, and that sound is absorbed at the room boundaries. The following four measurement methods are described in which A can be calculated from measurements of reverberation time, or from measurements of sound pressure levels of the noise source under test using a secondary measurement surface, or from measurements on a reference sound source, or estimated from the mean absorption coefficient. If the noise source under test cannot be moved and if its dimensions are large, one of these is the preferred method.

A.2 Absolute comparison test

A reference sound source meeting the requirements of ISO 6926 shall be mounted on the ground in the test environment, in essentially the same centre of its undersurface as that of the projection of reference box undersurface on the ground. The measurement surface, microphone positions and number for the reference sound source shall be the same as that of the noise source under test. The sound power level of the reference sound source shall be determined in accordance with the procedure of Clause 7 without the environmental correction, K_{2A} (K_{2A} is assumed to be zero).

The environmental correction, K_{2A}, expressed in decibels (dB), is given by Formula (A.1):

$$K_{2A} = L^*_{WA} - L_{WA(RSS)} \tag{A.1}$$

where

L^*_{WA} is the environmentally uncorrected sound power level of the reference sound source when using the value 0 for K_{2A}, in decibels (dB);

$L_{WA(RSS)}$ is the sound power level of the calibrated reference sound source under the meteorological conditions of the test, in decibels (dB).

A.3 Determination of the environmental correction based on room absorption

A.3.1 General

The environmental correction, K_{2A}, expressed in decibels (dB), shall be calculated from Formula (A.2):

$$K_{2A} = 10 \times \lg\left[1 + 4\frac{S}{A}\right] \tag{A.2}$$

where

A is the equivalent sound absorption area of the room, in square metres (m^2);

S is the area of the measurement surface, in square metres (m^2).

A.3.2 Reverberation method

This test method shall be used only in rooms of length and width respectively each less than three times the ceiling height.

The equivalent sound absorption area, A, in square metres, of the test room shall be calculated by the Sabine reverberation time Formula (A.3). at room temperatures between 15 °C and 30 °C:

$$A = 0{,}16\frac{V}{T_n} \tag{A.3}$$

where

V is the volume of the test room, in cubic meters (m^3);

T_n is the measured reverberation time, in seconds (s).

This method is not suitable for use in a hemi-anechoic room or for outdoor measurements.

A.3.3 Two-surface method

Two surfaces that surround the noise source shall be selected. The first surface shall be the measurement surface, in accordance with Clause 7, for the determination of the sound power level. The area of the first surface shall be designated S_1. The second surface with area S_2 shall be geometrically similar to the first surface and located further away and symmetrical with respect to the noise source under test. On both surfaces, the background noise criteria specified in 4.2 shall be fulfilled.

The microphone locations on the second surface shall correspond to those on the first surface. The ratio S_2/S_1 shall not be less than 2 and preferably should be greater than 4. The ratio S_1/A in Formula (A.4) is calculated from:

$$\frac{A}{S_1} = \frac{4(M-1)}{1-M(S_1/S_2)} \tag{A.4}$$

where

$$M = 10^{0{,}1\left(\overline{L_{pA1}} - \overline{L_{pA2}}\right)}$$

where

$\overline{L_{pA1}}$ is the surface time-averaged sound pressure level on S_1, see Formula (4), corrected for background noise but not for the influence of the environment (see 8.3.4), in decibels (dB);

$\overline{L_{pA2}}$ is the surface time-averaged sound pressure level on S_2, see Formula (4), corrected for background noise but not for the influence of the environment (see 8.3.4), in decibels (dB);

S_1 is the area of the first measurement surface, in square metres (m^2);

S_2 is the area of the second measurement surface, in square metres (m^2).

The environmental correction K_{2A} of the first measurement surface is obtained from Formula (A.2), with the S_1/A ratio calculated from Formula (A.4).

A.3.4 Determination of the equivalent absorption area *A* with a reference sound source

A reference sound source meeting the requirements of ISO 6926 shall be mounted on the ground in the test environment and hemi-anechoic room respectively, in essentially the same centre of its undersurface as that of the projection of reference box undersurface on the ground, the same measurement surface, the same microphone positions and number as that of the noise source under test. The sound power level of the reference sound source shall be determined in accordance with the procedure of Clause 7 without the environmental correction (K_{2A} is assumed to be zero).

The environmental correction of the measurement surface, K_{2A}, expressed in decibels (dB), is given by Formula (A.5):

$$K_{2A} = L^*_{WA} - L_{WA(SA)} \tag{A.5}$$

where

L^*_{WA} is the environmentally uncorrected sound power level of the reference sound source when using the value 0 for K_2, in decibels (dB);

$L_{WA(SA)}$ is the sound power level of the reference sound source measured in hemi-anechoic room under the meteorological conditions of the test, in decibels (dB).

The equivalent absorption area, A, is then calculated using Formula (A.6)

$$A = \frac{4S}{10^{0,1K_{2A}} - 1} \tag{A.6}$$

where S is the area of the measurement surface, in square metres (m^2).

Then the environmental correction K_2 of other measurement surface is obtained from Formula (A.2).

A.3.5 Approximate method for measurements made with A-weighting

This test method shall be used only in rooms of length and width respectively each less than three times the ceiling height.

In order to ascertain the acoustic characteristics of the test environment, K_{2A} shall be determined from Formula (A.2) using a value of A given by Formula (A.7):

$$A = \alpha \cdot S_V \tag{A.7}$$

where

α is the mean sound absorption coefficient, given for A-weighted quantities in Table A.1;

S_V is the total area of the boundary surfaces of the test room (walls, ceiling and floor), in square meters (m^2).

Table A.1 — Approximate values of the mean sound absorption coefficient

Mean sound absorption coefficient α	Description of room
0,05	Nearly empty room with smooth hard walls made of concrete, brick, plaster or tile
0,10	Partly empty room; room with smooth walls
0,15	Right cuboid room with furniture; right cuboid machinery room or industrial room
0,20	Irregularly shaped room with furniture, irregularly shaped machinery room or industrial room
0,25	Room with upholstered furniture; machinery or industrial room with sound-absorbing material on part of ceiling or walls
0,30	Room with sound-absorbing ceiling, but no sound-absorbing materials on walls
0,35	Room with sound-absorbing material on both ceiling and walls
0,50	Room with large amounts of sound-absorbing materials on ceiling and walls

Annex B
(normative)

Sound power level under reference meteorological conditions

The sound power level under reference meteorological conditions of static pressure 101,325 kPa and atmospheric temperature 23,0 °C, $L_{W\mathrm{ref,atm}}$, expressed in decibels (dB), shall be calculated using Formula (B.1):

$$L_{W\mathrm{Aref,atm}} = L_{W\mathrm{A}} + C_1 + C_2 \tag{B.1}$$

where

$L_{W\mathrm{A}}$ is the sound power level under the meteorological conditions which occurred at the time and place of the test, in decibels (dB);

C_1 is the reference quantity correction, in decibels (dB). C_1 is omitted when K_2 is determined using the absolute comparison test of A.2;

$$C_1 = -10 \times \lg \frac{p_s}{p_{s,0}} + 5 \times \lg \left[\frac{(273{,}15+\theta)}{(273{,}15+\theta_0)} \right]$$

C_2 is the radiation impedance correction, in decibels (dB);

$$C_2 = -10 \times \lg \frac{p_s}{p_{s,0}} + 15 \times \lg \left[\frac{(273{,}15+\theta)}{(273{,}15+\theta_1)} \right]$$

where

p_s is the static pressure, in kilopascals (kPa), at the time and place of the test;

$p_{s,0}$ is the reference static pressure, 101,325 kPa;

θ is the air temperature, in degrees Celsius (°C), at the time and place of the test;

θ_0 = 40,85 °C;

θ_1 = 22,85 °C.

The air temperature, θ, may be estimated, and the static pressure, p_s, can be calculated using Formula (B.2):

$$p_s = p_{s,0} (1 - a H_a)^b \tag{B.2}$$

where

H_a is the altitude, in metres (m), of the test site;

a is equal to 2,256 0 × 10^{-5} m^{-1};

b is equal to 5,255 3.

NOTE The value given for θ_0 that leads to a characteristic impedance of air is 400 N.s/m^3 at the reference static pressure 101,325 kPa.

If the sound power level is calculated under reference meteorological conditions, this fact shall be stated in the test report.

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[3] ISO 4871, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

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[5] ISO 12001, *Acoustics — Noise emitted by machinery and equipment — Rules for the drafting and presentation of a noise test code*

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