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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

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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).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 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, $s\left(L'_{pAm}\right)$, 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	ISO 6798-2 standard deviation of reproducibility
Octave bands	One-third-octave bands	dB	dB
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

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):

$$S = 4(ab + bc + ca) \qquad (1)$$

where

$a = 0{,}5 l_1 + d$;

$b = 0{,}5 l_2 + d$;

$c = l_3 + d$.

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.

