INTERNATIONAL STANDARD

**ISO 6798-3**

First edition
2022-02

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

## Part 3: Survey method for use in situ



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

*Partie 3: Méthode de contrôle pour utilisation in situ*



Reference number
ISO 6798-3:2022(E)



ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

# Contents

Page

# 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.*

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 different types of machinery and equipment.

Sound power level has the following applications:

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

— validation of indicated value of a noise;

— radiation noise comparison of different 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 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 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 grade of the measurement result is grade 3.



**Table 1 — Determination of the sound power level using sound pressure by the ISO 6798 series**

| Parameters | ISO 6798-1<br>Engineering method<br>Accuracy grade 2 | ISO 6798-2<br>Survey method<br>Accuracy grade 3 | ISO 6798-3<br>Survey method for use in situ<br>Accuracy grade 3 |
|---|---|---|---|
| Basic standards referenced | ISO 3744 | ISO 3746 | ISO 3747 |
| Test environment | An essentially free field over a reflecting plane | An acoustic field over a reflecting plane | An acoustic field over multiple reflecting planes |
| Noise source volume | Unlimited, depending on the test environment | | |
| Criterion for background noise[a] | $\Delta L_{pA} \geq 6{,}0$ dB<br>$K_{1A} \leq 1{,}3$ dB | $\Delta L_{pA} \geq 3{,}0$ dB<br>$K_{1A} \leq 3{,}0$ dB | $\Delta L_{pA} \geq 3{,}0$ dB<br>$K_{1A} \leq 3{,}0$ dB |
| Criterion for acoustic adequacy of test environment | $K_{2A} \leq 4{,}0$ dB | $K_{2A} \leq 7{,}0$ dB | Special requirement |
| Criterion for position adequacy of microphone[b] | $s(L'_{pAm}) \leq 1{,}0$ dB | $s(L'_{pAm}) \leq \sqrt{2}$ dB | $s(L'_{pAm}) \leq 2{,}0$ dB |
| Instrumentation[c] sound level meter/filter/sound calibrator | class 1/class 1/class 1 | class 2/class 2/class 1 | class 2/class 2/class 1 |
| Sound power level acquired | A-weighted or frequency bands | A-weighted | A-weighted |
| Application | Acceptance test of sound power level; making engineering measures | Comparative test of sound power level | Comparative test of sound power level |

**Key**

$K_{1A}$ : background noise correction

$K_{2A}$ : environmental correction

$\Delta L_{pA}$ : 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

$s(L'_{pAm})$ : standard deviation of the mean sound pressure level

[a] For the corrections of background noise, see 8.3.2.

[b] For the criterion for the position adequacy of microphones, see 7.7.

[c] For the requirements, calibration and application of instrumentation, see Clause 5.

Table 2 gives the measurement uncertainty of 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.

**Table 2 — Measurement uncertainty of 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 | ISO 6798-3 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 | 4,0 |

In the noise control of reciprocating internal combustion engine, the relevant members (manufacturer, installers and the users) should conduct effective communication of acoustic information which is obtained by measurement. These measurements are useful only if they are carried out under specified conditions to obtain defined acoustical quantities using the instrumentation and measurement method as specified in this document. The ISO 6798 series can be used according to the purpose of noise measurement and measurement conditions.

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

# Part 3: Survey method for use in situ

## 1 Scope

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

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 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 61260-1, *Electroacoustics — Octave-band and fractional-octave-band filters — Part 1: Specifications*

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

## 3 Terms, definitions and symbols

### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3046-1, ISO 6798-1, IEC 61260-1, IEC 61672-1 and the following apply.

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

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

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

**3.1.1**
**measurement surface**
hypothetical rectangular surface, on which the microphone positions are located at which the sound pressure levels are measured, enveloping the noise source under test and reference sound source (RSS), terminating on a reflecting plane (the ground) or multiple reflecting planes (including the ground)

Note 1 to entry: See ISO 6926.

## 3.2 Symbols

| Symbol | Term | Unit |
|---|---|---|
| $a$ | half of the measurement surface length | m |
| $b$ | half of the measurement surface width | m |
| $c$ | measurement surface height | m |
| $d$ | measurement distance | m |
| $D_1$ | distance between the reference box and ground | m |
| $D_2$ | distance between the reference box and reflecting plane | m |
| $D_3$ | distance between the reference box and reflecting plane | m |
| $D_4$ | distance between the reference box and reflecting plane | m |
| $D_5$ | distance between the reference box and reflecting plane | m |
| $K_{1A}$ | background noise correction | dB |
| $K_{1A(RSS)}$ | background noise correction of the reference sound source | dB |
| $K_{2A}$ | environmental correction | dB |
| $l_1$ | reference box length | m |
| $l_2$ | reference box width | m |
| $l_3$ | reference box height | m |
| $\overline{L_{pA}}$ | surface time-averaged sound pressure level of the noise source under test | dB |
| $\overline{L'_{pA}}$ | measured surface time-averaged sound pressure level | dB |
| $L'_{pAi}$ | sound pressure level measured at the $i^{th}$ microphone position | dB |
| $\overline{L_{pA(B)}}$ | measured surface time-averaged sound pressure level of the background noise | dB |
| $L_{pAi(B)}$ | sound pressure level of the background noise measured at the $i^{th}$ microphone position | dB |
| $\overline{L_{pA(RSS)}}$ | surface time-averaged sound pressure level of the reference sound source | dB |
| $\overline{L'_{pA(RSS)}}$ | measured surface time-averaged sound pressure level of the reference sound source | dB |
| $L'_{pAi(RSS)}$ | sound pressure level of the reference sound source measured at the $i^{th}$ microphone position | dB |
| $\overline{L_{pAj(RSS)}}$ | sound pressure level at the $j^{th}$ reference sound source | dB |
| $L'_{pAm}$ | mean (arithmetic average) sound pressure level | dB |
| $L_{WA}$ | sound power level | dB |
| $L_{WA(RSS)}$ | sound power level of the calibrated reference sound source under the meteorological conditions of the test | dB |
| $N_M$ | number of microphone positions | — |
| $N_{(RSS)}$ | number of reference sound source positions | — |
| $r_s$ | size ratio of the maximum length of the area unit to the measurement distance | — |

| Symbol | Term | Unit |
|---|---|---|
| $s(L'_{p\mathrm{Am}})$ | standard deviation of the mean sound pressure level | dB |
| $\Delta L_{p\mathrm{A}}$ | 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 | dB |
| ① ~ ④ | reference sound source position | — |
|  | reference box | — |
| – – – – | edge of measurement surface (invisible) | — |
| ——— | edge of measurement surface (visible) | — |
|  | reflecting plane | — |
| ● | microphone position | — |

## 4 Test environment

### 4.1 General

The test environment in accordance with this document is a room or on site which meets the requirements given in 4.2.

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 will not radiate 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.

## 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 compliance of the RSS with the requirements of ISO 6926, shall be verified at intervals in a laboratory making calibrations traceable to appropriate standards.

The sound calibrator should be calibrated at intervals not exceeding one year, the instrumentation system and the reference sound source should be calibrated at intervals not exceeding two years.

### 5.3 Application

To minimize the influence of observers on the noise measurements, the microphones shall preferably be mounted on a rigid frame or stand which is isolated against 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 be oriented to the centre of the measurement unit on which the microphone is located.

The sound pressure level shall be measured using an integrating sound level meter. If the sound level meter is able 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 longer is better).

## 6 Operation conditions

### 6.1 Engine conditions

The engine noise radiated is affected by the auxiliaries which are equipped on the engine. Air cleaner, exhaust silencer, 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 sound power level of exhaust noise, see ISO 15619.

NOTE 2 For the determination of 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 test a specified purpose engine (e.g. engines of motorcycle). Noise radiated from this equipment or these non-basic auxiliaries shall be regarded as extraneous noise. Otherwise temporarily turn off this equipment or these non-basic auxiliaries, but it should 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 aerodynamic noise (gas/liquid).

### 6.2 Operating conditions

For the noise measurement, the engine shall be operated at operating power and corresponding speed in a steady-state condition. 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.

## 7 Measurement

### 7.1 General

Survey method for use in situ (accuracy grade 3) is a method for determining the sound power level of the noise source from sound pressure levels measured separately on a measurement surface enveloping the noise source and RSS over multiple reflecting planes. This method can be used for comparative tests.

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

The measurands include the sound pressure level of both noise source under operation and the referenced sound source, as well as 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 4,0 dB.

NOTE The measurement uncertainty depends on the standard deviation of reproducibility and on the degree of confidence that is desired. As examples, for a normal distribution of sound power levels, there is 90 % confidence that the true value of the sound power level of a source lies within the range ±1,64 $\sigma_R$ of the measured value and a 95 % confidence that it lies within the range ±1,96 $\sigma_R$ of the measured value.

## 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 reference box may be made as small as possible, but should include danger areas, for example, moving parts of an otherwise stationary machine.

In this document, the length of the reference box is $l_1$, the width is $l_2$, ($l_2 \leq l_1$), the height is $l_3$.



## 7.4 Measurement distance

The recommended measurement distance, *d,* is 1,0 m, or at least 0,25 m. The selection of the measurement distance value from the series: 0,25 m, 0,5 m, 1,0 m takes precedence. The distance between measurement surface and wall(s) and ceiling should be equal to or more than 0,25 m.



## 7.5 Measurement surface and area

Figure 1 shows the example of one reflecting plane (the ground), the distance between reference box and ground, $D_1$, is equal to zero, Figure 2 to Figure 5 show the examples of more than one reflecting planes, the distances between the reflecting planes (walls) besides the ground and the corresponding surface of the reference box, $D_2$, $D_3$, $D_4$, $D_5$, should be less than ($d$ + 0,25) m.

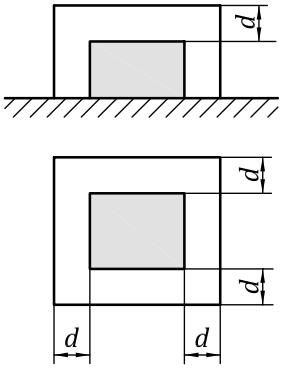


**Figure 1 — One reflecting plane**