International Standard

ISO 15619

Reciprocating internal combustion engines — Measurement method for exhaust silencers — Sound power level of exhaust noise and insertion loss using sound pressure and power loss ratio

Moteurs alternatifs à combustion interne — Méthode de mesure pour silencieux d'échappement — Niveau de puissance acoustique du bruit à l'échappement et perte par insertion à partir de la pression acoustique et du rapport de perte de puissance

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Foreword

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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 document 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).

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This document was prepared by Technical Committee ISO/TC 70, *Internal Combustion Engines*.

This second edition cancels and replaces the first edition (ISO 15619:2013), which has been technically revised.

The main changes are as follows:

— added sources for terms and definitions cited in clause 3.

— deleted 4.2.1.2 of the original document;

— described the use of the instrument in the 7.1 as a separate subclause, 5.3;

— removed duplicate descriptions mentioned in ISO 3046-1 and revised the text appropriately in 6.4 and 7.3.2;

— moved 1.1 in the original document to 7.2;

— revised descriptions in A.3.3;

— bibliography supplement.

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.

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Introduction

This document specifies methods for measuring the sound power level of exhaust noise and the insertion loss of exhaust silencers installed on reciprocating internal combustion engines and a method for measuring the power loss ratio of reciprocating internal combustion engines.

Sound power level of exhaust noise, insertion loss, and transmission loss are parameters to characterize the acoustic performance of exhaust silencers. Sound power levels of exhaust noise and insertion loss are important parameters to characterize the acoustic matching performance of exhaust silencers and reciprocating internal combustion engines. Transmission loss is the difference in sound power level of exhaust noise between the noise before and after transmitting through the exhaust silencer, which is the parameter to characterize the acoustic performance of the exhaust silencer itself and not relevant to the reciprocating internal combustion engine. Power loss ratio and pressure loss are parameters to characterize the aerodynamic performance of exhaust silencers. Power loss ratio is an important parameter to characterize the aerodynamic matching performance of exhaust silencers and reciprocating internal combustion engines, whereas resistance coefficient which is closely related to pressure loss is to characterize the aerodynamic performance of the exhaust silencer itself and is irrelevant with the reciprocating internal combustion engine on which the exhaust silencer is installed. The matching parameters of the sound power level of exhaust noise, the insertion loss, and the power loss ratio are used in this document as the measurement parameters.

For sound power level of exhaust noise, the measurement results at 90° direction and 45° direction can be different. The measurement results at 45° direction is slightly greater than the actual value, the measurement results at 90° direction is much closer to the actual results. For insertion loss, the measurement results at 90° direction and 45° direction may be different, but the measurement uncertainty at 90° direction is smaller than that at 45° direction. Measurement at 90° direction is used for the laboratory measurement (engineering method). The measurement at 90° or 45° direction is used for laboratory measurement (survey method). The measurement at 45° direction is used for site measurement.

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Reciprocating internal combustion engines — Measurement method for exhaust silencers — Sound power level of exhaust noise and insertion loss using sound pressure and power loss ratio

1 Scope

This document specifies a measurement method and requirements for exhaust silencers which are installed on reciprocating internal combustion engines, including laboratory measurement and site measurement.

This document applies to all exhaust silencers installed on reciprocating internal combustion engines falling within the field of application of ISO 3046 1. This document can also apply to other exhaust silencers for which no suitable International Standard exists.

NOTE Throughout the text, exhaust silencer is referred to as silencer and reciprocating internal combustion engine as engine.

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

ISO 7967-12, *Reciprocating internal combustion engines — Vocabulary of components and systems — Part 12: Exhaust emission control systems*

IEC 60942, *Electroacoustics — Sound calibrators*

IEC 61260-1, *Electroacoustics — Octave-band and fractional-octave-band filters*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3046-1, ISO 3046-3, ISO 6926, ISO 7967-12, IEC 60942, IEC 61260-1 and 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/

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3.1
sound pressure
p
difference between instantaneous pressure and static pressure, expressed in pascals

[SOURCE: ISO 3744:2010, 3.1]

3.2
sound pressure level
L_p
ten times the logarithm to the base 10 of the ratio of the square of *the sound pressure*, p (3.1), to the square of a reference value, p_0

$$L_p = 10\lg\frac{p^2}{p_0^2} \quad (1)$$

where the reference value, p_0, is 20 µPa

Note 1 to entry: If specific frequency and time weightings, as specified in IEC 61672–1, and/or specific frequency bands are applied, this is indicated by appropriate subscripts, e.g. L_{pA} denotes the A-weighted sound pressure level.

Note 2 to entry: It is expressed in decibels.

[SOURCE: ISO 3744:2010, 3.2]

3.3
time-averaged sound pressure level
$L_{p,T}$
ten times the logarithm to the base 10 of the ratio of the time average of the square of the *sound pressure*, p (3.1), during a stated time interval of duration, T (starting at t_1 and ending at t_2), to the square of a reference value, p_0 text of the definition

$$L_{p,T} = 10\lg\left[\frac{\frac{1}{T}\int_{t_1}^{t_2} p^2(t)\,\mathrm{d}t}{p_0^2}\right] \quad (2)$$

where the reference value, p_0, is 20 µPa

Note 1 to entry: In general, the subscript "T" is omitted since time-averaged sound pressure levels are necessarily determined over a certain measurement time interval.

Note 2 to entry: Time-averaged sound pressure levels are often A-weighted, in which case they are denoted by $L_{\mathrm{pA},T}$, which is usually abbreviated as L_{pA}.

Note 3 to entry: It is expressed in decibels.

[SOURCE: ISO 3744:2010, 3.3]

3.4
surface time-averaged sound pressure level
$\overline{L_p}$
mean (energy average) of the *time-averaged sound pressure levels* (3.2) over all the microphone positions, or traverses, on the *measurement surface* (3.11), with the *background noise correction*, K_1 (3.13), and the *environmental correction*, K_2 (3.14), applied

Note 1 to entry: It is expressed in decibels.

[SOURCE: ISO 3744:2010, 3.18]

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3.5
measurement time interval
T
portion or a multiple of an operational period or operational cycle of the noise source under test for which the *time-averaged sound pressure level* (3.2) is determined

Note 1 to entry: It is expressed in seconds.

[SOURCE: ISO 3744:2010, 3.5]

3.6
acoustic free field
sound field in a homogeneous, isotropic medium free of boundaries

Note 1 to entry: In practice, an acoustic free field is a field in which the influence of reflections at the boundaries or other disturbing objects are negligible over the frequency range of interest.

[SOURCE: ISO 3744:2010, 3.6]

3.7
reflecting plane
sound-reflecting planar surface on which the noise source under test is located

[SOURCE: ISO 3744:2010, 3.8]

3.8
acoustic free field over a reflecting plane
acoustic free field (3.6) in the half-space above an infinite *reflecting plane* (3.7) in the absence of any other obstacles

[SOURCE: ISO 3744:2010, 3.7]

3.9
frequency range of interest
for general purposes, the frequency range of octave bands with nominal mid-band frequencies from 63 Hz to 8 000 Hz (including one-third octave bands with mid-band frequencies from 50 Hz to 10 000 Hz)

Note 1 to entry: For special purposes, the frequency range can be extended or reduced, provided that the test environment and instrument specifications are satisfactory for use over the modified frequency range. Changes to the frequency range of interest are included in the test report.

[SOURCE: ISO 3744:2010, 3.9]

3.10
measurement radius
r
radius of a spherical *measurement surface* (3.11)

Note 1 to entry: It is expressed in metres.

[SOURCE: ISO 3744:2010, 3.13]

3.11
measurement surface
hypothetical spherical surface of area, *S*, on which the microphone positions are located at which the *sound pressure levels* (3.2) are measured, enveloping the noise source under test

[SOURCE: ISO 3744:2010, 3.14]

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3.12
background noise
noise from all sources other than the noise source under test

Note 1 to entry: Background noise includes contributions from airborne sound, noise from structure-borne vibration, and electrical noise in the instrumentation.

[SOURCE: ISO 3744:2010, 3.15]

3.13
background noise correction
K_1
correction applied to the mean (energy average) of the *time-averaged sound pressure levels* (3.2) over all the microphone positions on the *measurement surface* (3.11), to account for the influence of *background noise* (3.12)

Note 1 to entry: The background noise correction is frequency dependent; the correction in the case of a frequency band is denoted by K_{1f}, where f denotes the relevant mid-band frequency, and that in the case of A-weighting is denoted by K_{1A}.

Note 2 to entry: It is expressed in decibels.

[SOURCE: ISO 3744:2010, 3.16]

3.14
environmental correction
K_2
correction applied to the mean (energy average) of the *time-averaged sound pressure levels* (3.2) over all the microphone positions on the *measurement surface* (3.11), to account for the influence of reflected sound.

Note 1 to entry: The environmental correction is frequency dependent; the correction in the case of a frequency band is denoted by K_{2f}, where f denotes the relevant mid-band frequency, and that in the case of A-weighting is denoted by K_{2A}.

Note 2 to entry: In general, the environmental correction depends on the area of the measurement surfaceand, usually, K_2 increases with S.

Note 3 to entry: It is expressed in decibels.

[SOURCE: ISO 3744:2010, 3.17]

3.15
sound power
P
through a surface, the product of the *sound pressure*, p (3.1), and the component of the particle velocity, u_n , at a point on the surface in the direction normal to the surface, integrated over that surface

Note 1 to entry: The quantity relates to the rate per time at which airborne sound energy is radiated by a source.

Note 2 to entry: It is expressed in watts.

[SOURCE: ISO 3744:2010, 3.20]

3.16
sound power level
L_W
ten times the logarithm to the base 10 of the ratio of the *sound power* (3.15) of a source, W, to a reference value, W_0

$$L_W = 10 \lg \frac{W}{W_0} \tag{3}$$

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where the reference value, W_0, is 1 pW

Note 1 to entry: If a specific frequency weighting, as specified in IEC 61672–1, and/or specific frequency bands are applied, this is indicated by appropriate subscripts, e.g. L_{WA} denotes the A-weighted sound power level.

Note 2 to entry: It is expressed in decibels.

[SOURCE: ISO 3744:2010, 3.21]

3.17
exhaust silencer
chamber with acoustic lining and/or special structure designed to reduce exhaust noise

Note 1 to entry: The ICE exhaust silencer generally comprises the entire part from its inlet but does not include the exhaust manifold and pipe.

3.18
substitution pipe
rigid, non-absorbing pipe with no secondary noise having the same length and the same cross section area of outlet as the tested silencer

3.19
straight transition pipe
straight pipe used to connect two pipes of different cross section areas

3.20
bent transition pipe
bent pipe used to change the airflow direction and to connect two pipes of the same cross section area

3.21
centre distance of several exhaust outlets
b
double average distance from one exhaust outlet to the geometric centre of all exhaust outlets

3.22
insertion loss
D_1
loss of *sound power* (3.15) due to the insertion of a component or device at some point in a transmission system

$$D_1 = L_{W(\mathrm{SP})} - L_{W(\mathrm{AC})} \tag{4}$$

where

$L_{W(\mathrm{SP})}$ is the sound power level of exhaust noise when the substitution pipe is installed on the engine, in decibels;

$L_{W(\mathrm{AC})}$ is the sound power level of exhaust noise when the silencer is installed on the engine, in decibels.

Note 1 to entry: Specifically, it is the difference between the sound power level of exhaust noise when the substitution pipe is installed on the engine and when the exhaust silencer is installed on the engine. It is expressed in decibels.

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3.23
power loss ratio
r_p
ratio of the difference between the engine power when the *substitution pipe* (3.18) is installed on the engine and when the *exhaust silencer* (3.17) is installed on the engine, to the engine power with the *substitution pipe* (3.18) installed on the engine in the declared condition

$$r_P = \frac{P_{r(SP)} - P_{r(ES)}}{P_{r(SP)}} \times 100\,\% \quad (5)$$

where

$P_{r(SP)}$ is the engine power when the substitution pipe is installed on the engine under standard reference condition, in kilowatts;

$P_{r(ES)}$ is the engine power when the exhaust silencer is installed on the engine under standard reference condition, in kilowatts.

Note 1 to entry: It is expressed in percentage.

4 Test environment

4.1 General

Environmental conditions having an adverse effect on the microphones used for the measurements (e.g. strong electric or magnetic fields, wind, impingement of air discharge from the noise source being tested, high temperatures) shall be avoided. The instructions of the manufacturer of the measuring instrumentation regarding adverse environmental conditions shall be followed.

In an outdoor area, care shall be taken to minimize the effects of adverse meteorological conditions (e.g. temperature, humidity, wind, precipitation) on sound propagation and sound generation over the frequency range of interest or on the background noise during the course of the measurements.

When the altitude is higher than 1 500 meters, the sound power level should be corrected in accordance with the baseline meteorological conditions specified in Annex D.

When a reflecting surface is not a ground plane or is not an integral part of a test room surface, particular care should be exercised to ensure that the plane does not radiate any appreciable sound due to vibrations.

4.1.1 Engineering method

The test environments that are applicable for measurements in accordance with this document are the following:

a) a laboratory room or a flat outdoor area which is adequately isolated from background noise (see 4.2) and which provides an acoustic free field over a reflecting plane;

b) a room or a flat outdoor area which is adequately isolated from background noise (see 4.2) and in which an environmental correction can be applied to allow for a limited contribution from the reverberant field to the sound pressures on the measurement surface.

4.1.2 Survey method

The test environment that is applicable for measurements in accordance with this document is a room or a flat outdoor area which is adequately isolated from background noise (see 4.2) and which meets the qualification requirements of 4.3.

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