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Reciprocating internal combustion engines — Measurement method for air cleaners — Sound power level of combustion air inlet noise and insertion loss using sound pressure

Moteurs alternatifs à combustion interne — Méthode de mesure du bruit des purificateurs d'air — Niveau de puissance sonore du bruit d'entrée d'air de combustion et de perte d'insertion utilisant une pression sonore

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 70, *Internal combustion engines*.

Introduction

This Technical Specification specifies methods for measuring the sound power level of combustion air inlet noise and the insertion loss of air cleaners installed on reciprocating internal combustion engines.

Sound power level of combustion air inlet noise, insertion loss, and transmission loss are parameters to characterize the acoustic performance of air cleaners. Sound power levels of combustion air inlet noise and insertion loss are important parameters to characterize the acoustic matching performance of air cleaners and reciprocating internal combustion engines. Transmission loss is the difference in sound power level of combustion air inlet noise between the noise before and after transmitting through the air cleaner, which is the parameter to characterize the acoustic performance of the air cleaner itself and is irrelevant with the reciprocating internal combustion engine. The matching parameters of the sound power level of combustion air inlet noise and the insertion loss are used in this Technical Specification as the measurement parameters.

The enveloping surface method of this Technical Specification is applicable for engineering method (accuracy grade 2) and survey method (accuracy grade 3). Engineering method allows the determination of the A-weighted and frequency-band sound power level, survey method allows the determination of the A-weighted sound power level. The measurement result of sound power level is rounded to the nearest 0,1 dB.

In the combustion air inlet noise control of air cleaner, the relevant members (including manufacturer, installation, and the user) should make effective communication of acoustic information which is obtained by measurement. The measurement result is valid only in the specified measurement conditions by using the instrumentation as specified in this Technical Specification to obtain a clear acoustic value. Engineering method or survey method may be selected according to the purpose of noise measurement and measurement conditions.

The measurement surface defined based on the characteristics of noise source under test in this Technical Specification is spherical. To meet the requirements of the measurement uncertainty, this Technical Specification gives specification of the distance from the installation location of the noise source to the reflecting plane (ground).

Reciprocating internal combustion engines — Measurement method for air cleaners — Sound power level of combustion air inlet noise and insertion loss using sound pressure

1 Scope

This Technical Specification specifies the measurement method and requirements for combustion air inlet noise of air cleaners which are installed on reciprocating internal combustion engines, including laboratory measurement (engineering method and survey method) and site measurement (survey method).

This Technical Specification applies to all air cleaners installed on reciprocating internal combustion engines (reciprocating internal combustion engine is referred to as engine except particular explanation in the following text) falling within the field of application of ISO 3046-1 and/or other air induction installation.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*

IEC 60942, *Electroacoustics — Sound calibrators*

IEC 61260, *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 defined in ISO 3046-1, ISO 3046-3, ISO 6926, IEC 60942, IEC 61260 and IEC 61672-1 and the following apply.

3.1
sound pressure
p
difference between instantaneous pressure and static pressure

Note 1 to entry: It is expressed in pascals.

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* (3.1), p, to the square of a reference value, p_0

$$L_p = 10\lg \frac{p^2}{p_0^2}$$

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.

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* (3.1), p, 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

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

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* (3.5).

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

Note 3 to entry: It is expressed in decibels.

3.4
surface time-averaged sound pressure level
$\overline{L_P}$
mean(energy average) of the *time-averaged sound pressure levels* (3.3) over all the microphone positions, or traverses, on the *measurement surface* (3.11), with the *background noise correction* (3.13), K_1, and the *environmental correction* (3.14), K_2, applied

Note 1 to entry: It is expressed in decibels.

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* (3.3) is determined

Note 1 to entry: It is expressed in seconds.

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.

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

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

3.9
frequency range of interest
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)

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

Note 1 to entry: It is expressed in metres.

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

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.

3.13
background noise correction
K_1
correction applied to the mean (energy average) of the *time-averaged sound pressure levels* (3.3) 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.

3.14
environmental correction
K_2
correction applied to the mean (energy average) of the *time-averaged sound pressure levels* (3.3) 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: It is expressed in decibels.

3.15
sound power
W
through a surface, product of the *sound pressure* (3.1), *p*, 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.

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, expressed in decibels

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

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.

3.17
air cleaner
air filter
device which removes particles suspended in the fresh charge as it is drawn into the engine

Note 1 to entry: The air cleaner generally comprises the entire part from its air inlet but does not include the air induction manifold and pipe.

3.18
substitution pipe
rigid, non-absorbing circular pipe having the same length and the same cross section area of outlet as the tested *air cleaner* (3.17)

3.19
bent transition pipe
bent pipe used to change the airflow direction and to connect two pipes of the same cross section area

3.20
characteristic source dimension
d_0
characteristic dimension of source to determine the *measurement radius* (3.10)

3.21
insertion loss
D_I
the difference between the *sound power level* (3.16) of combustion air inlet noise when the substitution pipe (3.18)is installed on the engine and when the *air cleaner* (3.17) is installed on the engine

$$D_I = L_{W(SP)} - L_{W(AC)}$$

where

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

$L_{W(AC)}$ is the sound power level of combustion air inlet noise when the air cleaner is installed on the engine, in decibels

Note 1 to entry: It is expressed in decibels.

4 Test environment

4.1 General

For engineering method, the test environments that are applicable for measurements in accordance with this Technical Specification are the following:

a) a room or a flat outdoor area which is adequately isolated from background noise 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 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.

For survey method, the test environment that is applicable for measurements in accordance with this Technical Specification is 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 of the measuring instrumentation regarding adverse environmental conditions shall be followed. Particular care should be exercised to ensure that the plane does not radiate any appreciable sound due to vibrations.

4.2 Criterion for background noise

For engineering method, the time-averaged sound pressure level of the background noise measured and averaged over the microphone positions shall be at least 6 dB, and preferably more than 15 dB, below the corresponding uncorrected time-averaged sound pressure level of the noise source under test when measured in the presence of this background noise.

For frequency band measurements, the criteria for background noise may not be achievable in all frequency bands, even when the background noise levels in the test room are extremely low and well controlled.

For measurements in frequency bands, the following steps shall be followed to determine whether meeting the requirements of the background noise criteria.

a) The A-weighted sound power level is computed using the data from every frequency band within the frequency range of interest.

b) The computation of A-weighted sound power level is repeated but excluding those bands within the frequency range of interest in which the A-weighted sound power level of the noise source under test is at least 15 dB below the highest A-weighted band sound power level and for which $\Delta L_p < 6$ dB (see 8.2.2).

c) If the difference between these two levels is less than 0,5 dB, the A-weighted sound power level determined from the data for all bands may be considered as conforming to the background noise criteria of this Technical Specification, or the measurement is not valid.

For survey method, the time-averaged sound pressure level of the background noise measured and averaged over the microphone positions, shall be at least 3 dB, and preferably more than 10 dB, below

the corresponding uncorrected time-averaged 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 magnitude of the environmental correction, K_2.

For engineering method, as long as it is practicable, the test environment shall be free from reflecting objects other than the reflecting plane(s). The reflecting plane(s) shall extend at least 0,5 m beyond the projection of the measurement surface on the plane(s). The sound absorption coefficient of the reflecting plane(s) shall be less than 0,1 over the frequency range of interest.

NOTE 1 Smooth concrete or smooth sealed asphalt surface(s) are generally satisfactory.

Measurements in accordance with engineering method of this Technical Specification are only valid where $K_{2A} \leq 4$ dB.

NOTE 2 The environmental correction, K_2, is assumed to be zero for measurements made in hemi-anechoic rooms which meet the requirements of ISO 3745.

The environmental correction, K_{2A}, shall first be determined without reference to frequency band data, using one of the procedures of Annex A. Where it is decided to make measurements in frequency bands, the relevant environmental correction K_2 shall be determined in each band over the frequency range of interest in accordance with A.4. L_{WA} of a noise source shall be calculated in accordance with Annex B.

Measurements in accordance with survey method of this Technical Specification are only valid where $K_{2A} \leq 7$ dB.

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 1 for results of accuracy grade 2 and class 2 for results of accuracy grade 3, and the filters shall meet the requirements of IEC 61260.

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 calibration of the sound calibrator, the compliance of the instrumentation system with the requirements of IEC 61672-1, the compliance of the filter set with the requirements of IEC 61260, and the compliance of the reference sound source with the requirements of ISO 6926 shall be verified at intervals in a laboratory making calibrations traceable to appropriate standards.

Unless national regulations dictate otherwise, the sound calibrator should be calibrated at intervals not exceeding 1 y, the reference sound source should be calibrated at intervals not exceeding 2 y, the compliance of the instrumentation system with the requirements of IEC 61672-1 should be verified at intervals not exceeding 2 y, and the compliance of the filter set with the requirements of IEC 61260 should be verified at intervals not exceeding 2 y.

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 not connected to the vibrating surface; the microphone

