International Standard

ISO 13332

Reciprocating internal combustion engines — Test code for the measurement of structure-borne noise emitted from high-speed and medium-speed reciprocating internal combustion engines measured at the engine feet

Moteurs alternatifs à combustion interne — Code d'essai pour le mesurage du bruit solidien émis par les moteurs alternatifs à combustion interne à vitesse élevée et à vitesse moyenne, mesuré aux pieds du moteur

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Contents

Page

Foreword ... **iv**

Introduction ... **vi**

1 Scope ... **1**

2 Normative references ... **1**

3 Terms and definitions ... **1**

4 Measure environment ... **3**
4.1 Acoustic environment ... 3
4.2 Meteorological conditions ... 4

5 Measuring instruments ... **4**
5.1 General rule ... 4
5.2 Verification ... 4

6 Installation and operating conditions ... **4**
6.1 General rule ... 4
6.2 Installation conditions ... 4
6.3 Mounting Requirements ... 4
6.4 Operating conditions ... 5

7 Acceleration measurement ... **5**
7.1 General rule ... 5
7.2 Uncertainty ... 5
7.3 Mount selection ... 6
7.4 Accelerometer Position ... 6
7.4.1 Recommended Position ... 6
7.4.2 Alternative arrangement ... 8
7.5 Accelerometer Installation ... 10
7.6 Preliminary Test ... 10
7.7 Formal Test ... 11

8 Calculation ... **11**
8.1 Calculation of Velocity and Angular Velocity ... 11
8.2 Calculation of time-averaged velocity levels and time-averaged angular velocity levels in each measurement direction ... 12

9 Recorded Information ... **12**

10 Test Report ... **13**

Annex A (normative) **Other connections between the engine and test surroundings** ... **14**

Annex B (normative) **Corrections if the accelerometers are not in the contact plane between the machinery foot and isolator** ... **15**

Annex C (normative) **Determination of Frequency range of measurement** ... **17**

Annex D (normative) **Test record** ... **20**

Bibliography ... **22**

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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 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 13332:2000), which has been technically revised.

The main changes are as follows:

— revised Clause 3;

— "Symbols" in Clause 4 of the previous edition has been deleted and the requirements for "measuring environment" has been added (see Clause 4);

— "Technical Background" in Clause 5 of the previous edition has been deleted and provisions for "measuring instruments" has been added (see Clause 5);

— content related to the installation and operating conditions of the measured object has been moved to Clause 6 of this document (see Clause 6);

— content related to "acceleration measurement" has been moved to Clause 7 of this document, requirements of measurement uncertainty have been supplemented; measurements of angular velocity and angular acceleration have be added (see Clause 7);

— "calculation" has been added (see Clause 8);

— added provisions on "record information" (see Clause 9);

— requirements related to "Test report" has been added (see Clause 10);

— requirements related to "connections between engine and test environment" has been added (see Annex A);

— content on “sensor contact plane height correction” has been added (see Annex B);

— relevant content of "Frequency range" in the previous edition Clause 7 has been moved to Annex C;

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— "Engine-Structure-borne Noise Characterization - Test Report Form" has been moved to Annex D.

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

Noise in buildings, structures, ships, aircraft and land vehicles often arises from the use of internal combustion engines, particularly reciprocating engines, and there can be situations where these are the dominant noise source. Even where it is not dominant, it can form an unwelcome background noise. These noises, arising within the building, etc., can be transmitted in at least two ways as given below.

a) Directly into the surrounding air. This is called airborne sound and the ISO 6798 series specifies methods for determining the airborne noise output of internal combustion engines.

b) Through excitation or vibration in the supporting structure, pipes and shafts. These vibrations then pass through the structure as structural vibration, exciting in turn the walls and panels of the structure, resulting in the radiation of so-called secondary sound or structure-borne noise.

The ability of the source of vibration (the engine) to generate vibration in the structure in which it is mounted depends on the amount of motion of the engine at its mounting points, the properties of the engine mounting system and the mobility of the receiving structure. Vibration from the engine feet can be in the vertical orientation, which is the one most easily visualised, but can also be longitudinal or transverse with respect to the crankshaft axis. The vibration source can also cause rotational input, resolved about each of the three orthogonal axes.

The passage through the structure of any vibration which has been caused in it can be very difficult to control, particularly at low frequencies. There are many possible modes of vibration of the structure that can be responsible for the transmission (compression, torsional or flexural modes). Only breaks in the continuity of the structure are likely to be completely effective, and this is not usually possible. Damping of the structure may be effective for some propagation modes, particularly at high frequencies/short wavelengths, but will not be sufficiently effective at low frequencies.

In spite of the difficulties in controlling the propagation of vibration within the structure, there are obvious benefits in knowing the characteristics of the engine as a potential vibration source so that a choice can be made amongst various competing mounting engines, or the structure and engine mounts can be designed to conform with the properties of the engine selected.

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Reciprocating internal combustion engines — Test code for the measurement of structure-borne noise emitted from high-speed and medium-speed reciprocating internal combustion engines measured at the engine feet

1 Scope

This document specifies the procedure for measuring the capacity of a high-speed or medium-speed engine to generate vibration and the determination of the frequency limits of validity of the information quoted. The method described in this document is not suitable for low-speed engines. This document describes an engineering and not a precision method. Whether the tests are carried out on the test bed or on site will be agreed between the user and the manufacturer.

This document is applicable to high-speed and medium-speed reciprocating internal combustion engines for land, rail traction and marine use; this document is not applicable to engines used to propel agricultural tractors, road vehicles and aircraft. This document can also be applied to engines used to propel road-construction and earth-moving machines, industrial trucks and for other applications with engines where no suitable International Standard exists.

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 1503, *Spatial orientation and direction of movement — Ergonomic requirements*

ISO 2954, *Mechanical vibration of rotating and reciprocating machinery — Requirements for instruments for measuring vibration severity*

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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1503, ISO 2954, ISO 3046-1 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
structure-borne noise
vibration transmitted through solid structures in the frequency range of audible sound

Note 1 to entry: In this document, 'structure-borne noise' specifically denotes vibrations transmitted through the engine's base.

3.2
contact area
area of engine supports in contact with the surrounding structure, in particular rubber mounts

Note 1 to entry: See Figures 3 and 4.

3.3
translational velocity level
L_v
log base 10 of the ratio of the square of the velocity (v) to the square of the base velocity (v_0) times 10

Note 1 to entry: The translational velocity level can be calculated by Formula (1):

$$L_v = 10\lg\left(\frac{v^2}{v_0^2}\right) \tag{1}$$

where

v is the value of the translational velocity, in meters per second, about a specific axis;
v_0 is the reference velocity, which is 5×10^{-8} meters per second (m/s).

Note 2 to entry: The unit is decibels (dB).

Note 3 to entry: There are two reference velocity commonly used, i.e. 10^{-9} m/s and $5x10^{-8}$ m/s. The calculated translational velocity level using a reference velocity of 10^{-9} m/s is 34 dB higher than that using a reference velocity of 5×10^{-8} m/s.

3.4
angular velocity level
L_Ω
ten times the base-10 logarithm of the ratio of the square of angular velocity (Ω) to the square of the reference angular velocity (Ω_0)

Note 1 to entry: The angular velocity level can be calculated by Formula (2)

$$L_\Omega = 10\lg\left(\frac{\Omega^2}{\Omega_0^2}\right) \tag{2}$$

where

Ω is the value of the angular velocity, in radians per second (rad/s), about a specific axis;
Ω_0 is the reference angular velocity, which is 5×10^{-8} radians per second (rad/s).

Note 2 to entry: The unit is decibels (dB).

Note 3 to entry: There are two reference angular velocity commonly used, i.e. 10^{-9} rad/s and 5×10^{-8} rad/s. The calculated angular velocity level using a reference angular velocity of 10^{-9} rad/s is 34 dB higher than that using a reference velocity of 5×10^{-8} rad/s.

3.5
measurement time interval
T
used to determine the time-average structure-borne noise level, one or more operating periods or cycles of the tested object

Note 1 to entry: The unit of measurement is seconds.

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3.6
time-averaged translational velocity level
$L_{v,T}$
square of the velocity (v), the logarithm base 10 of the ratio of the average integral value (from t_1 to t_2) to the square of the reference velocity over the *measurement time interval* (3.5) (T), multiplied by 10

Note 1 to entry: Time-averaged translational velocity level can be calculated by Formula (3).

$$L_{v,T} = 10\lg\left[\frac{\frac{1}{T}\int_{t_1}^{t_2} v^2(t)\,\mathrm{d}t}{v_0^2}\right] \tag{3}$$

where

v is the value of the translational velocity, in meters per second (m/s), about a specific axis;
v_0 is the reference velocity, which is 5×10^{-8} meters per second (m/s);
T is measurement time interval, in second (s).

Note 2 to entry: The unit is decibels (dB).

Note 3 to entry: Because the time-average velocity level must be measured within a certain measurement interval, the subscript 'T' is usually omitted and referred to as the velocity level.

Note 4 to entry: When the time-averaged translational velocity level is A-weighted, it is denoted as $L_{v\mathrm{A},T}$, and is abbreviated as $L_{v\mathrm{A}}$.

3.7
time-averaged angular velocity level
$L_{\Omega,T}$
square of the angular velocity (Ω), the logarithm base 10 of the ratio of the average integral value (from t_1 to t_2) to the square of the reference angular velocity over the *measurement time interval* (3.5) (T), multiplied by 10

Note 1 to entry: Time-averaged angular velocity level can be calculated by Formula (4).

$$L_{\Omega,T} = 10\lg\left[\frac{\frac{1}{T}\int_{t_1}^{t_2} \Omega^2(t)\,\mathrm{d}t}{\Omega_0^2}\right] \tag{4}$$

where

Ω is the value of the angular velocity, in radians per second, about a specific axis;
Ω_0 is the reference angular velocity, which is 5×10^{-8} radians per second (rad/s);
T is measurement time interval, in second (s).

Note 2 to entry: The unit is decibels (dB).

Note 3 to entry: Because the time-average angular velocity level must be measured within a certain measurement interval, the subscript 'T' is usually omitted and referred to as the velocity level.

Note 4 to entry: When the time-averaged angular velocity level is A-weighted, it is denoted as $L_{\Omega\mathrm{A},T}$, and it is abbreviated as $L_{\Omega\mathrm{A}}$.

4 Measure environment

4.1 Acoustic environment

If the measurement of airborne noise is required, the acoustic environment shall be in accordance with ISO 6798-1.

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