INTERNATIONAL STANDARD

ISO 13472-2

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Acoustics — Measurement of sound absorption properties of road surfaces *in situ* —

Part 2: Spot method for reflective surfaces

Acoustique — Mesurage in situ *des propriétés d'absorption acoustique des revêtements de chaussées —*

Partie 2: Méthode ponctuelle pour les surfaces réfléchissantes

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 13472-2 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

ISO 13472 consists of the following parts, under the general title *Acoustics — Measurement of sound absorption properties of road surfaces* in situ:

— *Part 1: Extended surface method*

— *Part 2: Spot method for reflective surfaces*

Introduction

This part of ISO 13472 specifies a test method for measuring *in situ* the sound absorption coefficient of road surfaces as a function of frequency under normal incidence.

This method enables evaluation of the sound absorption characteristics of a road surface without damaging the surface. It is intended to be used to qualify the absorption characteristics of road surfaces used for vehicle and tyre testing. It may also be used during road construction, road maintenance, and other traffic noise studies. However, the field of application is limited to low absorption surfaces.

The method specified in this part of ISO 13472 is based on propagation of the test signal from the source to the road surface and back to the receiver through an impedance tube. The tube covers an area of approximately 0,008 m^2 and a frequency range, in one-third-octave bands, from 250 Hz to 1 600 Hz. It uses the test procedure and signal processing specified in ISO 10534-2, but because of the defined frequency range of application, the dimensions of the system are not adjustable, but fixed.

This method is primarily intended for smooth low absorption surfaces, such as those in accordance with ISO 10844. The method is not reliable if the measured sound absorption coefficient exceeds 0,15. Surfaces with values above 0,10 are not considered to be reflective.

This method is complementary to the extended surface method (ISO 13472-1[5]) that covers an area of approximately 3 m^2 and a frequency range, in one-third-octave bands, from 250 Hz to 4 000 Hz.

Both methods should give similar results in the frequency range from 315 Hz to 1 600 Hz, but their fields of application and therefore their accuracy differ strongly. The method described in ISO 13472-1[5] has limited accuracy at small sound absorption values and is therefore unsuitable for checking compliance of surfaces with the requirements of such documents as ISO 10844, while the method specified here fails at higher sound absorption values.

Within their ranges, the methods are also applicable to acoustic materials other than road surfaces.

The measurement results of this method are comparable to the results of the impedance tube method, performed on bore cores taken from the surface in accordance with documents such as ISO 10534-1[4], ISO 10534-2 and ASTM E1050[7].

The measurement results obtained with this method are in general not comparable to the results of the reverberation room method (ISO 354[1]), because the method described in this part of ISO 13472 uses a plane progressive wave at perpendicular incidence, while the reverberation room method uses a diffuse sound field.

Acoustics — Measurement of sound absorption properties of road surfaces *in situ* —

Part 2:
Spot method for reflective surfaces

1 Scope

This part of ISO 13472 specifies a test method for measuring *in situ* the sound absorption coefficient of road surfaces for the one-third-octave-band frequencies ranging from 250 Hz to 1 600 Hz under normal incidence conditions. For special purposes, the frequency range can be changed by modifying the dimensions of the system.

The test method is intended for:

a) determination of the sound absorption coefficient of semi-dense to dense road surfaces (and, if of interest, also the complex acoustical impedance);

b) determination of the sound absorption properties of test tracks in accordance with standards such as ISO 10844 and test surfaces defined in national and international type approval regulations for road vehicles and vehicle tyres;

c) verification of the compliance of the sound absorption coefficient of a road surface with design specifications or other requirements.

2 Normative references

The following referenced documents are indispensable for the application 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 10534-2:1998, *Acoustics — Determination of sound absorption coefficient and impedance in impedance tubes — Part 2: Transfer-function method*

ISO 10844, *Acoustics — Specification of test tracks for measuring noise emitted by road vehicles and their tyres*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement* (*GUM:1995*)

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

3 Terms and definitions

For the purposes of this document, the following definitions apply.

3.1
frequency range
frequency interval in which measurements are valid specified in one-third-octave bands in accordance with IEC 61260

NOTE The frequency range is specified in one-third-octave bands. This means that its lower limit is the lower limit of the lowest one-third-octave band specified and its upper limit is the upper limit of the highest one-third-octave band specified. The frequency range specified in one-third-octave bands of 250 Hz to 1 600 Hz centre frequency implies a frequency range specified in narrow bands of 220 Hz to 1 800 Hz.

3.2
sound absorption coefficient at normal incidence
α
ratio of sound power entering the surface of the test object (without return) to the incident sound power for a plane wave at normal incidence

[ISO 10534-2:1998, 2.1]

3.3
sound pressure reflection factor at normal incidence
r
complex ratio of the pressure of the reflected wave to the pressure of the incident wave at the surface of the test object for a plane wave at normal incidence

3.4
plane of reference for the road surface
hypothetical plane defined by the underside of the sealing device at which the sound pressure reflection factor is calculated

3.5
signal-to-noise ratio level
difference, in decibels, between the level of the useful signal and the level of the background noise

3.6
normal surface impedance
Z
ratio of the complex sound pressure to the normal component of the complex sound particle velocity at an individual frequency in the reference plane

NOTE 1 Adapted from ISO 10534-2:1998, 2.4.

NOTE 2 Although not used in specifications of road surfaces, calculating propagation over such a surface requires a complex acoustic impedance.

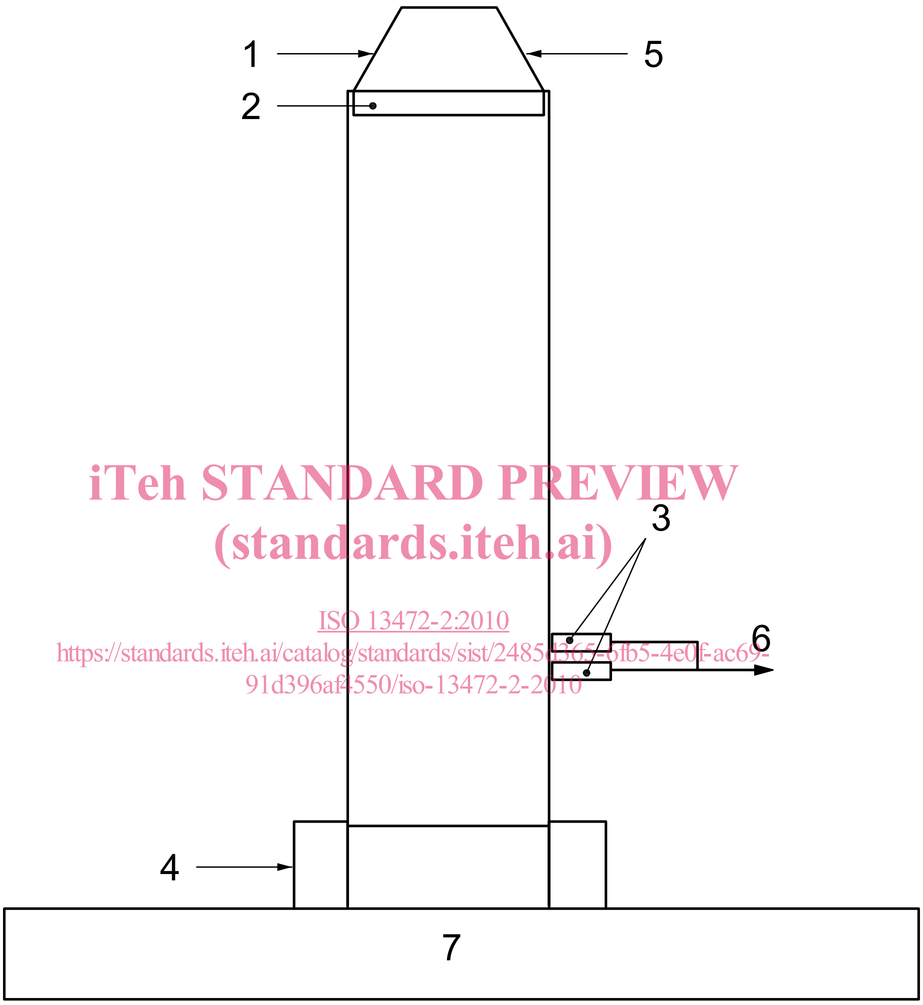
4 Principle

The two microphone impedance tube method (see ISO 10534-2 or ASTM E1050[7]) is adapted to a portable apparatus that enables the normal incidence sound absorption coefficient of plane surfaces to be rapidly measured over a broad frequency range without distortion of the surface. The procedure enables a single skilled operator to perform such measurements. There is no need for a calibration for microphones as required in typical acoustic measurements, but it does require a specific verification of the two microphone apparatus for amplitude and phase relationship between microphones at the time of the measurement and a determination of the internal energy loss of the system based on measurements on a totally reflecting plane.

The apparatus is a standard impedance tube utilizing the two microphone arrangement. A sound signal from a loudspeaker located at one end propagates through the tube. The open end of the tube is placed on the surface to be measured. The complex acoustic transfer function of the two microphone signals is determined and used to compute the normal incidence sound absorption coefficient and related quantities.

The absorption coefficient covers the one-third-octave-band frequency range from 250 Hz to 1 600 Hz.

Figure 1 illustrates the system set-up.



Key

1 loudspeaker
2 vibration isolation
3 microphones
4 *in-situ* test fixture
5 sound source and amplifier
6 frequency analyser
7 surface under test

Figure 1 — Configuration of the measuring device and related equipment

The signal processing is described in ISO 10534-2 and ASTM E1050[7] and consists basically of the measurement of the complex transfer function between the two microphones in the presence of the sample under test. This is then processed to obtain the complex pressure reflection factor from which the acoustic absorption can be calculated. The procedure described in ISO 10534-2 and ASTM E1050[7] includes the calibration of amplitude and phase properties of the two microphones.

In this method, the test sample holder specified in ISO 10534-2 is replaced by an *in-situ* test fixture that enables an airtight connection between the inside of the test tube and the surface of the road under test. The test tube and the fixture can be either integrated into a single piece or connected by some kind of fixing device and an airtight seal such as a rubber O-ring.

On the underside of the *in-situ* test fixture, a ring of deformable material forms an airtight seal with the surface texture of the road surface on one hand and with the fixture on the other. Sealing is improved with a small groove made in the fixture (see Figures C.1 and C.2).

The sound absorption coefficient is determined in accordance with the procedure specified in ISO 10534-2.

5 Test equipment

5.1 Components of the test system

The test equipment comprises a signal generator, a sound source, a tube, two microphones mounted flush with the inside wall of the tube at the specified positions, an *in-situ* test fixture device to maintain an airtight fit to the surface, and a signal-processing unit capable of doing complex Fourier transforms in two channels simultaneously.

Any measurement system that provides the characteristics and meets the criteria specified in ISO 10534-2 is acceptable.

5.2 Sound source

The sound source shall meet the requirements defined in ISO 10534-2. It:

a) is sealed to and vibration isolated from the tube to minimize structure-borne sound excitation of the tube;

b) has a uniform power response over the frequency range of interest.

5.3 Test signal

The test signal shall be broad band with a uniform spectral density over the frequency range of interest.

A signal generator capable of producing a compatible test signal is often incorporated in a frequency analysis system. When employing alternative signals, it is recommended that the time blocks in the frequency analysis be synchronized with repetitions in the test signal pattern.

5.4 Impedance tube

5.4.1 Tube diameter

The diameter of the tube shall be (100 ± 1) mm. The tube shall have a circular cross-section, be straight with a uniform cross-section (variations in diameter no greater than 0,2 %) and with smooth, non-porous walls, without holes or slits and rigid so as to prevent unwanted loss of sound energy.

NOTE 1 Not meeting the diameter requirement affects the frequency range. The upper frequency at a given diameter, f_u, is given by the equation:

$$f_u = 0,58 \frac{c_0}{d}$$

where

c_0 is the speed of sound, in metres per second;

d is the diameter, in metres, of the tube.

NOTE 2 Loss of energy due to vibrations of the walls is generally prevented by using a metal tube with a thickness of at least 5 % of the tube diameter.

The tube shall have a small ventilation hole in the vicinity of the loudspeaker so as to prevent build-up of static pressure inside the tube.

5.4.2 Tube length and microphone positions

The length shall be sufficient to make a plane wave develop between the source and the position of the microphone. This requirement is met when the microphones are at a distance not less than $3d$, where d is the tube diameter, from the sound source. Non-plane waves from the sample are generally suppressed within one tube diameter. In the case of flat road surfaces and a tube diameter of 100 mm, this is realized by a tube with a minimum length of 480 mm and with the lowest microphone mounted 100 mm from the plane of reference.

Microphones shall be mounted flush with the inner side wall. When a single pair of microphone positions is used, the spacing shall be (81 ± 4) mm.

NOTE The minimum and maximum value of the microphones spacing, s, is defined by the upper and lower frequency of interest as follows.

The maximum spacing is slightly less than half of the shortest wavelength and is given by the inequality:

$$s_{max} < 0,45 \frac{c_0}{f_{max}}$$

A maximum frequency of 1 800 Hz implies a maximum spacing of 85 mm.

The minimum spacing is larger than 5 % of the longest wavelength and is given by the inequality:

$$s_{min} > 0,05 \frac{c_0}{f_{min}}$$

A minimum frequency of 220 Hz implies a minimum spacing of 77 mm.

Reflective test objects cause at certain frequencies destructive interference at the position of the microphones that jeopardizes the signal-to-noise ratio. The test result can be improved by using different microphone positions and spacing. Several systems allow for three choices of microphone positioning to allow a wider spacing for the lower frequency range and a narrow spacing for the higher frequency range.

The spacing shall be known within ± 0,5 mm.