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SIST EN ISO 10534-2:2002

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Akustika - Ugotavljanje koeficienta absorpcije in impedance zvoka v Kundtovi cevi – 2. del: Metoda s prenosno funkcijo (ISO 10534-2:1998)

Acoustics - Determination of sound absorption coefficient and impedance in impedances tubes - Part 2: Transfer-function method (ISO 10534-2:1998)

Akustik - Bestimmung des Schallabsorptionsgrades und der Impedanz in Impedanzrohren - Teil 2: Verfahren mit Übertragungsfunktion (ISO 10534-2:1998)

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Acoustique - Détermination du facteur d'absorption acoustique et de l'impédance des tubes d'impédance - Partie 2: Méthode de la fonction de transfert (ISO 10534-2:1998)

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English version

Acoustics - Determination of sound absorption coefficient and impedance in impedances tubes - Part 2: Transfer-function method (ISO 10534-2:1998)

Acoustique - Détermination du facteur d'absorption acoustique et de l'impédance des tubes d'impédance - Partie 2: Méthode de la fonction de transfert (ISO 10534-2:1998)

Bauakustik - Bestimmung des Schallabsorptionsgrades und der Impedanz in Impedanzrohren - Teil 2: Verfahren mit Übertragungsfunktion (ISO 10534-2:1998)

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Foreword

The text of the International Standard from Technical Committee ISO/TC 43 "Acoustics" of the International Organization for Standardization (ISO) has been taken over as an European Standard by Technical Committee CEN/TC 126 " Acoustic properties of building products and of buildings", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2001, and conflicting national standards shall be withdrawn at the latest by December 2001.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of the International Standard ISO 10534-2:1998 has been approved by CEN as a European Standard without any modification.

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Acoustics — Determination of sound absorption coefficient and impedance in impedance tubes —

Part 2:
Transfer-function method

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Acoustique — Détermination du facteur d'absorption acoustique et de l'impédance des tubes d'impédance —

Partie 2: Méthode de la fonction de transfert

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SIST EN ISO 10534-2:2002

Contents

Page

iTeh STANDARD PREVIEW
(standards.iteh.ai)
SIST EN ISO 10534-2:2002
https://standards.iteh.ai/catalog/standards/sist/2dc4f9a9-902a-4d08-9764-c92d28d4427b/sist-en-iso-10534-2-2002

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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.

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.

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International Standard ISO 10534-2 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics.*

ISO 10534 consists of the following parts, under the general title *Acoustics — Determination of sound absorption coefficient and impedance in impedance tubes*:

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— *Part 1: Method using standing wave ratio*

— *Part 2: Transfer-function method*

Annnexes A to C form an integral part of this part of ISO 10534. Annexes D to G are for information only.

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Acoustics — Determination of sound absorption coefficient and impedance in impedance tubes —

Part 2:
Transfer-function method

1 Scope

This test method covers the use of an impedance tube, two microphone locations and a digital frequency analysis system for the determination of the sound absorption coefficient of sound absorbers for normal sound incidence. It can also be applied for the determination of the acoustical surface impedance or surface admittance of sound absorbing materials. Since the impedance ratios of a sound absorptive material are related to its physical properties, such as airflow resistance, porosity, elasticity and density, measurements described in this test method are useful in basic research and product development.

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The test method is similar to the test method specified in ISO 10534-1 in that it uses an impedance tube with a sound source connected to one end and the test sample mounted in the tube at the other end. However, the measurement technique is different. In this test method, plane waves are generated in a tube by a noise source, and the decomposition of the interference field is achieved by the measurement of acoustic pressures at two fixed locations using wall-mounted microphones or an in-tube traversing microphone, and subsequent calculation of the complex acoustic transfer function, the normal incidence absorption and the impedance ratios of the acoustic material. The test method is intended to provide an alternative, and generally much faster, measurement technique than that of ISO 10534-1.

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Compared with the measurement of the sound absorption in a reverberation room according to the method specified in ISO 354, there are some characteristic differences. The reverberation room method will (under ideal conditions) determine the sound absorption coefficient for diffuse sound incidence, and the method can be used for testing of materials with pronounced structures in the lateral and normal directions. However, the reverberation room method requires test specimens which are rather large, so it is not convenient for research and development work, where only small samples of the absorber are available. The impedance tube method is limited to parametric studies at normal incidence but requires samples of the test object which are of the same size as the cross-section of the impedance tube. For materials that are locally reacting, diffuse incidence sound absorption coefficients can be estimated from measurement results obtained by the impedance tube method. For transformation of the test results from the impedance tube method (normal incidence) to diffuse sound incidence, see annex F.

2 Definitions and symbols

For the purposes of this part of ISO 10534 the following definitions apply.

2.1
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

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2.2
sound pressure reflection factor at normal incidence
r
complex ratio of the amplitude of the reflected wave to that of the incident wave in the reference plane for a plane wave at normal incidence

2.3
reference plane
cross-section of the impedance tube for which the reflection factor r or the impedance Z or the admittance G are determined and which is usually the surface of the test object, if flat

NOTE The reference plane is assumed to be at $x = 0$.

2.4
normal surface impedance
Z
ratio of the complex sound pressure $p(0)$ to the normal component of the complex sound particle velocity $v(0)$ at an individual frequency in the reference plane

2.5
normal surface admittance
G
inverse of the normal surface impedance Z

2.6
wave number
k_0
variable defined by

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SIST EN ISO 10534-2:2002
https://standards.iteh.ai/catalog/standards/sist/2dc4f9a9-902a-4d08-9764-c92d28d4427b/sist-en-iso-10534-2-2002

$$k_0 = \omega / c_0 = 2\pi f / c_0$$

where

ω is the angular frequency;

f is the frequency;

c_0 is the speed of sound.

NOTE In general the wave number is complex, so

$$k_0 = k_0' - j k_0''$$

where

k_0' is the real component ($k_0' = 2\pi/\lambda_0$);

λ_0 is the wavelength;

k_0'' is the imaginary component which is the attenuation constant, in nepers per metre.

2.7
complex sound pressure
p
Fourier Transform of the temporal acoustic pressure

2.8
cross spectrum
S_{12}
product $p_2 \cdot p_1^*$, determined from the complex sound pressures p_1 and p_2 at two microphone positions

NOTE * means the complex conjugate.

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2.9
auto spectrum
S_{11}
product $p_1 \cdot p_1{}^*$, determined from the complex sound pressure p_1 at microphone position one

NOTE * means the complex conjugate.

2.10
transfer function
H_{12}
transfer function from microphone position one to two, defined by the complex ratio $p_2/p_1 = S_{12}/S_{11}$ or S_{22}/S_{21}, or $[(S_{12}/S_{11})(S_{22}/S_{21})]^{1/2}$

2.11
calibration factor
H_c
factor used to correct for amplitude and phase mismatches between the microphones

NOTE See 7.5.2.

3 Principle

The test sample is mounted at one end of a straight, rigid, smooth and airtight impedance tube. Plane waves are generated in the tube by a sound source (random, pseudo-random sequence, or chirp), and the sound pressures are measured at two locations near to the sample. The complex acoustic transfer function of the two microphone signals is determined and used to compute the normal-incidence complex reflection factor (see annex C), the normal-incidence absorption coefficient, and the impedance ratio of the test material.

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The quantities are determined as functions of the frequency with a frequency resolution which is determined from the sampling frequency and the record length of the digital frequency analysis system used for the measurements. The usable frequency range depends on the width of the tube and the spacing between the microphone positions. An extended frequency range may be obtained from the combination of measurements with different widths and spacings.

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The measurements may be performed by employing one of two techniques:

1: two-microphone method (using two microphones in fixed locations);
2: one-microphone method (using one microphone successively in two locations).

Technique 1 requires a pre-test or in-test correction procedure to minimize the amplitude and phase difference characteristics between the microphones; however, it combines speed, high accuracy, and ease of implementation. Technique 1 is recommended for general test purposes.

Technique 2 has particular signal generation and processing requirements and may require more time; however, it eliminates phase mismatch between microphones and allows the selection of optimal microphone locations for any frequency. Technique 2 is recommended for the assessment of tuned resonators and/or precision, and its requirements are described in more detail in annex B.

4 Test equipment

4.1 Construction of the impedance tube

The apparatus is essentially a tube with a test sample holder at one end and a sound source at the other. Microphone ports are usually located at two or three locations along the wall of the tube, but variations involving a centre mounted microphone or probe microphone are possible.

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The impedance tube shall be straight with a uniform cross-section (diameter or cross dimension within ± 0,2 %) and with rigid, smooth, non-porous walls without holes or slits (except for the microphone positions) in the test section. The walls shall be heavy and thick enough so that they are not excited to vibrations by the sound signal and show no vibration resonances in the working frequency range of the tube. For metal walls, a thickness of about 5 % of the diameter is recommended for circular tubes. For rectangular tubes the corners shall be made rigid enough to prevent distortion of the side wall plates. It is recommended that the side wall thickness be about 10 % of the cross dimension of the tube. Tube walls made of concrete shall be sealed by a smooth adhesive finish to ensure air tightness. The same holds for tube walls made of wood; these should be reinforced and damped by an external coating of steel or lead sheets.

The shape of the cross-section of the tube is arbitrary, in principle. Circular or rectangular (if rectangular, then preferably square) cross-sections are recommended.

If rectangular tubes are composed of plates, care shall be taken that there are no air leaks (e.g. by sealing with adhesives or with a finish). Tubes should be sound and vibration isolated against external noise or vibration.

4.2 Working frequency range

The working frequency range is

$$f_l < f < f_u \quad (1)$$

where

- f_l is the lower working frequency of the tube;
- f is the operating frequency;
- f_u is the upper working frequency of the tube.

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f_l is limited by the accuracy of the signal processing equipment.

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f_u is chosen to avoid the occurrence of non-plane wave mode propagation.

The condition for f_u is:

$$d < 0{,}58\ \lambda_u ; \quad f_u \cdot d < 0{,}58\ c_0 \quad (2)$$

for circular tubes with the inside diameter d in metres and f_u in hertz.

$$d < 0{,}5\ \lambda_u ; \quad f_u \cdot d < 0{,}50\ c_0 \quad (3)$$

for rectangular tubes with the maximum side length d in metres; c_0 is the speed of sound in metres per second given by equation (5).

The spacing s in metres between the microphones shall be chosen so that

$$f_u \cdot s < 0{,}45\ c_0 \quad (4)$$

The lower frequency limit is dependent on the spacing between the microphones and the accuracy of the analysis system but, as a general guide, the microphone spacing should exceed 5 % of the wavelength corresponding to the lower frequency of interest, provided that the requirements of equation (4) are satisfied. A larger spacing between the microphones enhances the accuracy of the measurements.

4.3 Length of the impedance tube

The tube should be long enough to cause plane wave development between the source and the sample. Microphone measurement points shall be in the plane wave field.