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Acoustics — Determination of acoustic properties in impedance tubes — Part 2: Two-microphone technique for normal incidence sound absorption coefficient and normal incidence surface impedance

Acoustique — Détermination des propriétés acoustiques aux tubes d'impédance — Partie 2: Méthode à deux microphones pour le coefficient d'absorption sonore normal et l'impédance de surface normale

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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~~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~~www.iso.org/directives).

~~Attention is drawn~~ISO draws attention to the possibility that ~~some of~~ the ~~elements~~implementation of this document may ~~be~~involve the ~~subject~~use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights~~.~~ in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights. ~~Details of any patent rights identified during the development of the document will be in the Introduction~~

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see ~~www.iso.org/iso/foreword.html~~www.iso.org/iso/foreword.html.

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

~~ISO 10534 currently consists of~~, in collaboration with the ~~following parts:~~

~~— Part 1: Method using standing wave ratio~~

~~— Part 2: 2-microphone technique~~European Committee for ~~normal incidence sound absorption coefficient~~Standardization (CEN) Technical Committee CEN/TC 126, *Acoustics properties of building products* and ~~normal incidence surface impedance~~

~~Annexes A~~*of buildings*, in accordance with the Agreement on technical cooperation between ISO and ~~B form an integral part of this part of ISO 10534. Annexes C to G are for information only.~~CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 10534-2:1998), which has been technically revised.

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The main change of this ISO version is changes are as follows:

— the introduction of the measurement procedure to estimate the characteristic properties of porous materials (characteristic impedance, wavenumber, dynamic mass density, dynamic bulk modulus) in an informative annex. The signal processing techniques have been updated since the first version of this standard, which was published in 1998document.

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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Acoustics — Determination of acoustic properties in impedance tubes — Part 2: Two-microphone technique for normal incidence sound absorption coefficient and normal incidence surface impedance

1 Scope

This test method covers the use of an impedance tube, two microphone locations and a frequency analysis system for the determination of the sound absorption coefficient of sound absorbing materials for normal incidence sound incidence. It can also be applied for the determination of the acoustical surface impedance or surface admittance of sound absorbing materials. As an extension, it can also be used to assess intrinsic properties of homogeneous acoustical materials such as their characteristic impedance, characteristic wavenumber, dynamic mass density and dynamic bulk modulus.

The test method is similar to the test method specified in ISO 10534-1[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 sound 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 and quantities reported in the previous paragraph. The test method is intended to provide an alternative, and generally much faster, measurement technique than that of ISO 10534-1[1].

Normal incidence absorption coefficients coming from impedance tube measurements are not comparable with random incidence absorption coefficients measured in reverberation rooms according to ISO 354~~.~~[2]. The reverberation room method will (under ideal conditions) determine the sound absorption coefficient for diffuse sound incidence. However, the reverberation room method requires test specimens which are rather large. The impedance tube method is limited to studies at normal and plane incidence and 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 only, diffuse incidence sound absorption coefficients can be estimated from measurement results obtained by the impedance tube method (see Annex E).

Through the whole document, a $e^{+j\omega t}$ time convention is used.

2 Normative references

~~The following document is referred to in the text in such a way that some of its content constitutes requirements to this document. The latest edition of the referenced document (including any amendments) applies.~~

~~<std>ISO 266, *Acoustics — Preferred frequencies*</std>~~

There are no normative references in this document.

3 Terms, ~~Definitions~~definitions and symbols

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

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ISO and IEC maintain ~~terminological~~terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at ~~https://www.iso.org/obp~~https://www.iso.org/obp

— IEC Electropedia: available at ~~https://www.electropedia.org/~~ https://www.electropedia.org/

3.1
sound absorption coefficient at normal incidence
α_n
ratio of the sound power dissipated inside the test object to the incident sound power for a plane wave at normal incidence

Note 1 to entry: “Plane wave” here describes a wave whose value, at any moment, is constant over any plane perpendicular to its direction of propagation. “Normal incidence” describes the direction of the longest axis of the impedance tube.

3.2
sound pressure reflection coefficient at normal incidence
r
complex ratio of the reflected wave sound pressure amplitude to that of the incident wave in the reference plane for a plane wave at normal incidence

3.3
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 1 to entry: The reference plane is assumed to be at $x = 0$.

3.4
normal-incidence surface impedance
Z
ratio of the complex sound pressure $p(x = 0)$ to the normal component of the complex sound particle velocity $v(x = 0)$ at an individual frequency in the reference plane defined as $x = 0$

Note 1 to entry: The particle velocity vector has a positive direction pointing towards the interior of the tested object.

Note 2 to entry: *Z* is expressed in newton second per cubic meter (Ns/m^3)

3.5
normal-incidence surface admittance
G
inverse of the normal-incidence surface impedance *Z*

Note 1 to entry: G is expressed in cubic meter per newton per second ($m^3/N/s$)

3.6
wave number in air
k_0
variable, expressed in radian per metre, defined by

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$$k_0 = \omega / c_0 = 2\pi f / c_0 = 2\pi / \lambda_0$$

$$k_0 = \omega / c_0 = 2\pi f / c_0 = 2\pi / \lambda_0$$

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where

ω is the angular frequency,

f is the frequency,

c_0 is the speed of sound in the air,

λ_0 is the wavelength in air.

Note 1 to entry: In general, the wave number is complex, so that $k_0 = k_0' - jk_0''$ where k_0' is the real component and k_0'' is the imaginary component (which is the attenuation constant).

Note 2 to entry: k_0' is expression in radian per metre.

3.7
material characteristic wave number
k_c
variable, expressed in radian per meter, defined by

$$k_c = \omega / c = 2\pi f / c = \omega \sqrt{\rho_{eq} / K_{eq}}$$

$$k_c = \omega / c = 2\pi f / c = \omega \sqrt{\rho_{eq} / K_{eq}}$$

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where

c is the speed of sound inside the material;

ρ_{eq} is the material dynamic mass density (defined in 3.9);

K_{eq} is the material bulk modulus (defined in 3.10)

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3.8
material characteristic impedance
Z_c
variable, expressed in Newton second per cubic metre, defined by

$$Z_c = \sqrt{\rho_{eq} K_{eq}}$$

$$Z_c = \sqrt{\rho_{eq} K_{eq}}$$

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3.9
material dynamic mass density
ρ_{eq}
ρ_{eq}

Field Code Changed

variable describing the visco-inertial dissipation inside the tested material.

Note 1 to entry: The dynamic mass density can differ from the static (volume-averaged) value.

Note 2 to entry: It is expressed in kg/m^3.

3.10
material dynamic bulk modulus
K_{eq}
variable describing the thermal dissipation inside the tested material.

Note 1 to entry: The dynamic bulk modulus can differ from the static (volume-averaged) value.

Note 2 to entry: It is expressed in N/m^2 (or equivalently in pascal).

3.11
complex sound pressure
p
frequency-domain spectrum of the sound pressure time signal

3.12
cross spectrum
S_{12}
product $p_2\, p_1$ *, determined from the complex sound pressures p_1 and p_2 at two microphone positions

Note 1 to entry: * means the complex conjugate.

3.13
cross spectrum
~~S_{21}~~
S_{21}
product $p_1\, p_2$ *, determined from the complex sound pressures p_1 and p_2 at two microphone positions

Field Code Changed

Note 1 to entry: * means the complex conjugate.

3.14
auto spectrum
~~S_{11}~~
S_{11}
product $p_1\, p_1$ *, determined from the complex sound pressure p_1 at microphone position one

Field Code Changed

Note 1 to entry: * means the complex conjugate.

Note 2 to entry: S_{22} denotes the auto spectrum for pressure p_2 at microphone position two.

3.15
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 $[(S_{12} / S_{11})(S_{22} / S_{21})]^{1/2}$

3.16
calibration factor
H_c
factor used to correct for amplitude and phase mismatches between the microphones

Note 1 to entry: See 8.5.2.

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3.17
local reacting material
material for which the pressure and velocity fields at a given point on the surface are independent on the behaviour at other points of the surface is called a locally reacting material

Note 1 to entry: This local reaction behaviour infers specific properties for a material: its surface impedance is independent on the incidence angle of a plane wave impinging the material. Homogeneous honeycomb structures and perforated plates are examples of possible locally reacting materials (see Figure 1, a). For a locally reacting material, its absorption coefficient depends on the angle of incidence as its reflection coefficient does as well

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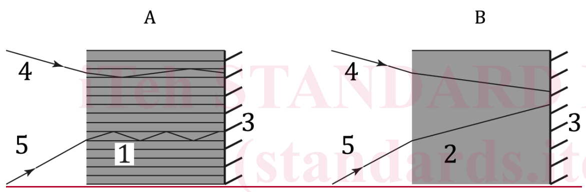

Key

1	locally reacting material sample	4	plane wave impinging the sample
2	~~NON~~non-locally reacting material sample	5	plane wave impinging the sample with a different angle
3	rigid ~~&~~and impervious backing	A	locally reacting material sample
		B	~~NON~~non-locally reacting material sample

Figure 1 — Propagation of plane waves inside a locally reacting material sample and comparison to a non-locally reacting material sample

3.18
bulk or extended reaction material
material for which the reaction does not occur only normal to the surface.

Note 1 to entry: The reaction in each point of the material is hence dependent on the reaction of the neighbouring points. Examples of materials experiencing bulk reactions are foams made of multiple pores and fibrous with fibres not parallel to each other's (see Figure 1~~, ~~b).

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4 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 emitting a signal such as a random noise, pseudo-random sequence, or a deterministic signal such as a chirp signal, 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 coefficient (see Annex C), the normal-incidence absorption coefficient, and the normal incidence surface impedance of the test

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