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Acoustics — Determination of acoustic properties in impedance tubes —

Part 2: Two-microphone technique for normal sound absorption coefficient and normal 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

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This document was prepared by Technical Committee ISO/TC 43 *Acoustics*, Subcommittee SC 2, *Building acoustics,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 126, *Acoustics properties of building products and of buildings,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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

The main 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 document.

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.

Acoustics — Determination of acoustic properties in impedance tubes —

Part 2:
Two-microphone technique for normal sound absorption coefficient and normal 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

There are no normative references in this document.

3 Terms, definitions and symbols

For the purposes of this document, the following terms and definitions 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/

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

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

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 radians per metre.

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

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

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)

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

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

3.9
material dynamic mass density
ρ_{eq}
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.

