

AS/NZS 1935.1:1998

ISO 10534-1:1996

Reconfirmed 2016

Australian/New Zealand Standard™

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

**Part 1: Method using standing wave
ratio**

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Australian Building Codes Board
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Australian Defence Force Academy
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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

RECONFIRMATION

OF

AS/NZS 1935.1:1998

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

Part 1: Method using standing wave ratio

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University of Auckland (New Zealand)
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NOTES

Australian/New Zealand Standard™

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Part 1: Method using standing wave ratio

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee AV/4, Acoustics, Architectural, to supersede AS 1935—1976, *Method for measurement of normal incidence sound absorption coefficient and specific normal acoustic impedance of acoustic materials by the tube method*.

The objective of this Standard is to provide a method for the determination of the sound absorption coefficient reflection factor and surface impedance or surface admittance of materials and objects.

This Standard is technically equivalent to and has been reproduced from ISO 10534-1:1996 *Acoustics—Determination of sound absorption coefficient and impedance in impedance tubes Part 1: Method using standing wave ratio*.

Appendix ZZ lists the Australian and New Zealand variations to ISO 10534.1:1996. The changes are indicated with a marginal bar against the relevant clause, note, table or figure.

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<i>Reference to International Standard or other publication</i>		<i>Australian/New Zealand Standard</i>	
ISO		AS	
266	Acoustics—Preferred frequencies	2533	Acoustics—Preferred frequencies for measurements
354	Acoustics—Measurement of sound absorption in a reverberation room	1045	Acoustics—Measurement of sound absorption in a reverberation room

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CONTENTS

	<i>Page</i>
1 Scope	1
2 Normative references	1
3 Definitions	2
4 Principle	3
5 Fundamentals	3
6 Test equipment	5
7 Preliminary tests and measurements	10
8 Mounting of the test sample	10
9 Test methods	10
10 Transformation of reflection factor and impedance	11
11 Test report	12
 Annexes	
A Preliminary measurements	14
B Verification of the test equipment	17
C Pressure-release termination of test sample	19
D Determination of diffuse sound absorption coefficient α_{st} of locally reacting absorbers	20
Appendix ZZ List of variations between this Standard and ISO 10534-1	21

NOTES

AUSTRALIAN/NEW ZEALAND STANDARD

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

Part 1: Method using standing wave ratio

1 Scope

1.1 This part of ISO 10534 specifies a method for the determination of the sound absorption coefficient, reflection factor and surface impedance or surface admittance of materials and objects. The values are determined for normal sound incidence by evaluation of the standing wave pattern of a plane wave in a tube, which is generated by the superposition of an incident sinusoidal plane wave with the plane wave reflected from the test object.

This method can be used for the determination of the sound absorption coefficient of sound absorbers for normal sound incidence. It can further be used for the determination of the acoustical surface impedance or surface admittance of sound-absorbing materials. It is well suited for parameter studies and for the design of sound absorbers, because only small samples of the absorber material are needed.

1.2 There are some characteristic differences between this method and the measurement of sound absorption in a reverberation room (see ISO 354).

The impedance tube method can be used for the determination of the reflection factor and also the impedance or admittance. The sound is incident normally on the object surface. The reverberation room method will (under idealized conditions) determine the sound absorption coefficient for random sound incidence.

The impedance tube method relies on the existence of a plane incident sound wave and gives exact values under this condition (measuring and mounting errors excluded). The evaluation of the sound absorption coefficient in a reverberation room is based on a number of simplifying and approximate assumptions concerning the sound field and the size

of the absorber. Sound absorption coefficients exceeding the value 1 are therefore sometimes obtained.

The impedance tube method requires samples of the test object which are the size of the cross-sectional area of the impedance tube. The reverberation room method requires test objects which are rather large and can also be applied to test objects with pronounced structures in the lateral and/or normal directions. Measurements with such objects in the impedance tube must be interpreted with care (see 9.1).

For the computational transformation of the test results from the impedance tube method (normal incidence) to the situation of diffuse sound incidence, see annex D.

1.3 This part of ISO 10534 gives preference to numerical methods of evaluation instead of graphical methods, because computers which can perform these computations are assumed to be available. Some of the quantities in the formulae are complex. The arguments of trigonometric functions are in radians.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 10534. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 10534 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 266:—¹⁾, *Acoustics — Preferred frequencies*.

ISO 354:1985, *Acoustics — Measurement of sound absorption in a reverberation room*.

3 Definitions

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

3.1 sound absorption coefficient, α : Ratio of the sound power entering the surface of the test object (without return) to the incident sound power for a plane wave at normal incidence.

3.2 sound pressure reflection factor at normal incidence, r : Complex ratio of the pressure amplitude of the reflected wave to 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 flattest objects. It is assumed to be at $x = 0$.

3.4 field impedance, $Z(x)$: Ratio of the sound pressure $p(x)$ to the particle velocity $v(x)$ (directed into the test object) at a point x in the sound field.

3.5 impedance in the reference plane, ${}_r Z$: Ratio at the reference plane of the sound pressure p to the sound particle velocity v :

$$Z_r = p/v$$

3.6 surface impedance, Z : Complex ratio of the sound pressure $p(0)$ to the normal component of the sound particle velocity $v(0)$ at the reference plane.

3.7 surface admittance, G : Complex ratio of the normal component of the sound particle velocity $v(0)$ to the sound pressure $p(0)$ in the reference plane.

3.8 surface admittance, G_s : Admittance component at, and normal to, the surface of the test object.

3.9 characteristic impedance, Z_0 : Field impedance (in the direction of propagation) in a single plane wave:

$$Z_0 = \rho_0 c_0$$

where

ρ_0 is the density of the medium (air);
 c_0 is the speed of sound in the medium.

3.10 normalized impedance, z : Ratio of the impedance Z to the characteristic impedance Z_0 :

$$z = Z/Z_0$$

3.11 normalized admittance, g : Product of the admittance G and the characteristic impedance Z_0 :

$$g = Z_0 G$$

3.12 standing wave ratio, s : Ratio of the sound pressure amplitude at a pressure maximum, $|p_{\max}|$, to that at an adjacent pressure minimum, $|p_{\min}|$ (if necessary after correction for varying values at the minima due to sound attenuation in the impedance tube):

$$s = |p_{\max}| / |p_{\min}|$$

3.13 standing wave ratio with attenuation, s_n : Standing wave ratio of the n^{th} maximum to the n^{th} minimum.

3.14 free-field wave number, k_0 :

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

where

ω is the angular frequency;

f is the frequency;

c_0 is the speed of sound.

In general the wave number is complex, so

$$k_0 = k_0' - jk_0''$$

where

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

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

3.15 phase of reflection (factor), Φ : Results from the representation of the complex reflection factor by magnitude and phase:

$$r = r' + jr'' = |r| \cdot e^{j\Phi} = |r| (\cos \Phi + j \sin \Phi)$$

$$|r| = \sqrt{r'^2 + r''^2}$$

$$\Phi = \arctan \frac{r''}{r'}$$

$$r' = |r| \cos \Phi$$

$$r'' = |r| \sin \Phi$$

1) To be published. (Revision of ISO 266:1975)