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335 East 45th Street
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**AMERICAN NATIONAL STANDARD
Specifications for Instruments to Measure
Aural Acoustic Impedance and Admittance
(Aural Acoustic Immittance)**

ABSTRACT

This standard provides specifications for instruments designed to measure acoustic impedance, acoustic admittance, or both quantities, within the human external ear canal. Terms that apply to these instruments and to related measurements are defined. Four types of instruments are classified. Characteristics, specifications, and recommended calibration procedures then are provided. Material within this standard is intended both for users and for manufacturers of instruments that measure aural acoustic impedance and admittance.

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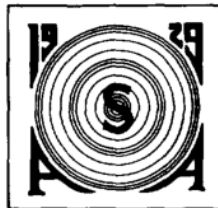
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FOREWORD

[This Foreword is not a part of American National Standard Specifications for Instruments to Measure Aural Acoustic Impedance and Admittance (Aural Acoustic Immittance), S3.39-1987 (ASA Catalog No. 71-1987).]

This standard provides specifications for instruments designed to measure acoustic impedance, acoustic admittance, or both quantities, within the human external ear canal. Terms that apply to these instruments and to related measurements are defined. Four types of instruments are classified. Characteristics, specifications, and recommended calibration procedures then are provided. Material within this standard is intended both for users and for manufacturers of instruments that measure aural acoustic impedance and admittance.

This standard is similar in most respects to an IEC draft document, *Aural Impedance/Admittance Instruments*, developed by Working Group 14 of IEC Technical Committee No. 29 Electroacoustics, of the International Electrotechnical Commission (IEC/TC 29/WG14).

This standard was developed under the jurisdiction of Accredited Standards Committee S3, Bioacoustics, using the American National Standards Institute (ANSI) Accredited Standards Committee Procedure. The Acoustical Society of America holds the Secretariat for Accredited Standards Committee S3, Bioacoustics.

Accredited Standards Committee S3, Bioacoustics, under whose jurisdiction this standard was developed, has the following scope:

Standards, specifications, methods of measurement and test, and terminology in the fields of psychological and physiological acoustics, including aspects of general acoustics, shock, and vibration which pertain to biological safety, tolerance, and comfort.

At the time this standard was submitted to Accredited Standards Committee S3, Bioacoustics, for approval, the membership was as follows:

L. A. Wilber, *Chairman*
H. Silbiger, *Vice-Chairman*
A. Brenig, *Secretary*

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U.S. Department of the Air Force • H. E. von Gierke, C. Nixon (*Alt*)
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Individual experts of the Accredited Standards Committee S3 were:

L. Batchelder	W. J. Galloway	D. Johnson	H. E. von Gierke
R. W. Benson	R. Guernsey	H. Levitt	L. Wilber
K. M. Eldred	J. C. Guignard	S. F. Lybarger	W. Yost
R. S. Gales	K. D. Kryter	W. Melnick	R. W. Young

Working Group S3-60, Measurement of Acoustic Impedance and Admittance of the Ear, which assisted Accredited Standards Committee S3, Bioacoustics, in the development of this standard, has the following membership:

D. J. Lilly, *Chairman*

M. Burkhard	R. F. Sullivan
R. L. Grason	L. A. Wilber
P. B. Madsen	

Suggestions for improvements in this standard will be welcomed. They should be sent to the Standards Manager, Standards Secretariat, Acoustical Society of America, 335 East 45th Street, New York, NY 10017-3483.

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American National Standard Specifications for Instruments to Measure Aural Acoustic Impedance and Admittance (Aural Acoustic Immittance)

1 SCOPE

The instruments covered by this standard are designed primarily for the measurement of acoustic impedance, acoustic admittance, or both quantities, within the human external auditory meatus. The standard is concerned with the parameters and tolerances of instruments used for measurement of aural acoustic impedance and aural acoustic admittance when the probe-tone frequency is 226 Hz. It is not within the scope of this standard to establish normative values for human ears.

Within this standard four types of instruments are classified according to the types of measurements that they can perform and according to their features, tolerances, and ranges.

2 PURPOSE

The purpose of this standard is to ensure that acoustic-impedance or acoustic-admittance measurements will be substantially the same for a given ear when these measurements are obtained with any instruments that meet the specifications and tolerances outlined in this standard, and when comparable test conditions prevail. This standard is not intended to inhibit development, to restrict incorporation of new features (such as probe frequencies other than 226 Hz), or to discourage other improvements that may become useful in the measurement of aural acoustic impedance or acoustic admittance.

3 APPLICATIONS

This standard applies to instruments that are used primarily to measure or to monitor aural acoustic impedance or acoustic admittance within the external auditory meatus.

4 REFERENCES TO OTHER STANDARDS

4.1 American National Standards

When the following American National Standards are superseded by a revision approved by the Ameri-

can National Standards Institute, Inc., the revision shall apply.

(1) American National Standard Acoustical Terminology (Including Mechanical Shock and Vibration), ANSI S1.1-1960 (R 1976).

(2) American National Standard Specification for Audiometers, ANSI S3.6-1969 (R 1986).

(3) American National Standard for Coupler Calibration of Earphones, ANSI S3.7-1979.

(4) American National Standard Letter Symbols and Abbreviations for Quantities Used in Acoustics, ANSI Y10.11-1984.

4.2 Other National Standards

(1) IEEE Standard Pulse Terms and Definitions, ANSI/IEEE Std. 181-1977.

(2) Safe Current Limits for Electromedical Apparatus, ANSI/AAMI SCL 12/78.

5 DEFINITIONS

Traditionally, acoustic-impedance data have been reported with units (cgs) acoustic ohms. The units in this standard, however, conform to the International System of Units (SI). Table 1 provides an outline of some quantities used in this standard, standard symbols, names that traditionally have been used for the units, cgs units, and SI units. For analysis purposes, the impedance-type analogy is used throughout this standard.

5.1 acoustic immittance: refers collectively to acoustic impedance, to acoustic admittance, or to both quantities.

5.2 acoustic impedance: at a given surface, the complex ratio of effective sound pressure averaged over the surface to effective volume velocity through it. The symbol is Z_a and the unit is pascal second per meter to the third power ($\text{Pa}\cdot\text{s}/\text{m}^3$).

5.3 acoustic resistance: the real component of complex acoustic impedance. The symbol is R_a and the unit is pascal second per meter to the third power ($\text{Pa}\cdot\text{s}/\text{m}^3$).

TABLE 1. Summary of quantities used for measurement of aural acoustic impedance and acoustic admittance.

Quantity	Symbol	SI units	Derived units used for measurements	Traditional units ^a	Conversion cgs to SI
Acoustic impedance	Z_a				
Acoustic resistance	R_a	$\text{Pa} \cdot \text{s} / \text{m}^3$	$10^8 \text{Pa} \cdot \text{s} / \text{m}^3$	Acoustic ohm (cgs units implied)	$10^3 \frac{\text{dyn} \cdot \text{s}}{\text{cm}^3} = 10^8 \frac{\text{Pa} \cdot \text{s}}{\text{m}^3}$
Acoustic reactance	X_a				
Impedance phase angle	ϕ_z	Radian	$2\pi/360 \text{ rad} = 1 \text{ deg}$	Degree	Not applicable
Acoustic admittance	Y_a				
Acoustic conductance	G_a	$\text{m}^3 / \text{Pa} \cdot \text{s}$	$10^{-8} \text{m}^3 / \text{Pa} \cdot \text{s}$	Acoustic mmho (cgs units implied)	$10^3 \frac{\text{cm}^3}{\text{dyn} \cdot \text{s}} = 10^8 \frac{\text{m}^3}{\text{Pa} \cdot \text{s}}$
Acoustic susceptance	B_a				
Admittance phase angle	ϕ_y	Radian	$2\pi/360 \text{ rad} = 1 \text{ deg}$	Degree	Not applicable
Acoustic mass (Inertance)	M_a	$\text{Pa} \cdot \text{s}^2 / \text{m}^3$	None	None	$\frac{\text{dyn} \cdot \text{s}^2}{\text{cm}^3} = 10^5 \frac{\text{Pa} \cdot \text{s}^2}{\text{m}^3}$
Acoustic stiffness	K_a	Pa / m^3	None	None	$\frac{\text{dyn}}{\text{cm}^3} = 10^5 \frac{\text{Pa}}{\text{m}^3}$
Acoustic compliance (capacitance)	C_a	m^3 / Pa	None	None	$\frac{\text{cm}^3}{\text{dyn}} = 10^5 \frac{\text{m}^3}{\text{Pa}}$
Acoustic equivalent volume	V_{ea}	m^3	$10^{-6} \text{m}^3 = 1 \text{ cm}^3$	cm^3	$1 \text{ cm}^3 = 10^{-6} \text{m}^3$
Air pressure (excess)	p	Pa	$10 \text{ Pa} = 1 \text{ daPa}$	mm H ₂ O	$1 \text{ mm H}_2\text{O} = 9.806 65 \text{ Pa}$

^aTraditional units in this table evolved as a result of common practice and by analogy to electric-circuit elements. It is the intent of groups writing standards on units and terminology to provide names for the units that will be unique to acoustical and mechanical systems. Reference should be made to appropriate ANSI and IEC documents for preferred names. The appropriate ANSI document is Y10.11 as revised.

5.4 acoustic reactance: the imaginary component of complex acoustic impedance. The symbol is X_a and the unit is pascal second per meter to the third power ($\text{Pa} \cdot \text{s} / \text{m}^3$).

5.5 acoustic admittance: at a given surface, the complex ratio of the effective volume velocity through the surface to the effective sound pressure averaged over the surface. Thus acoustic admittance at a surface is the reciprocal of acoustic impedance at the same sur-

face. The symbol is Y_a and the unit is meter to the third power per pascal second ($\text{m}^3 / \text{Pa} \cdot \text{s}$).

5.6 acoustic conductance: the real component of complex acoustic admittance. The symbol is G_a and the unit is meter to the third power per pascal second ($\text{m}^3 / \text{Pa} \cdot \text{s}$).

5.7 acoustic susceptance: the imaginary component of complex acoustic admittance. The symbol is B_a and