ANSI S1.15-1997/Part 1

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AMERICAN NATIONAL STANDARD

MEASUREMENT MICROPHONES — PART 1: SPECIFICATIONS FOR LABORATORY STANDARD MICROPHONES

ANSI S1.15-1997/Part 1

Accredited Standards Committee S1, Acoustics

Standards Secretariat
Acoustical Society of America
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ANSI S1.15-1997/Part 1

American National Standard

Measurement Microphones — Part 1: Specifications for Laboratory Standard Microphones

Secretariat

Acoustical Society of America

Approved 6 June 1997

American National Standards Institute, Inc.

Abstract

This Standard specifies mechanical dimensions and certain electroacoustical characteristics for capacitor (condenser) microphones used as laboratory standards for sound pressure measurements of the highest attainable accuracy. The specifications are intended to ensure that primary calibration by the reciprocity method can be readily carried out. This Standard establishes a system to classify laboratory standard microphones into a number of types according to their dimensions and properties. This American National Standard is comparable to International Standard IEC 61094-1:1992, ‘‘Measurement microphones — Part 1: Specifications for laboratory standard microphones.’’

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Foreword

[This Foreword is for information only and is not an integral part of American National Standard Measurement Microphones — *Part 1:* Specifications for Laboratory Standard Microphones, ANSI S1.15-1997/Part 1.]

This American National Standard is comparable to International Standard IEC 61094-1:1992, ''Measurement microphones — *Part 1:* Specifications for laboratory standard microphones.''

This Standard is *Part 1* of a series of standards related to measurement microphones.

Part 2 of this series covers the primary method for pressure calibration of laboratory standard microphones by the reciprocity technique. *Part 3* covers the primary method for free-field calibration of laboratory standard microphones by the reciprocity technique. *Part 4* provides specifications for working standard microphones.

This Standard was developed under the jurisdiction of Accredited Standards Committee S1, Acoustics, which has the following scope:

> *Standards, specifications, methods of measurement and test, and terminology, in the fields of physical acoustics including architectural acoustics, electroacoustics, sonics and ultrasonics, and underwater sound, but excluding those aspects which pertain to safety, tolerance, and comfort.*

At the time this standard was submitted to Accredited Standards Committee S1, Acoustics, for final approval, the membership was as follows:

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E. E. Gross, Jr.	G. C. Maling, Jr.	R. W. Young

Working Group S1/WG1, Standard Microphones and their Calibration, of Accredited Standards Committee S1 provided comments and recommendations during the development of the IEC 61094 series of International Standards for measurement microphones. The composition of S1/WG1 was:

V. Nedzelnitsky, Chair

J. R. Arrington	D. J. Evans	E. E. Gross
E. D. Burnett	E. Frederiksen	G. S. K. Wong

The *ad hoc* Working Group, that assisted Accredited Standards Committee S1, Acoustics, in the preparation of this Standard, had the following membership:

A. H. Marsh   V. Nedzelnitsky   P. D. Schomer   G. S. K. Wong

Suggestions for improvement of this Standard will be welcomed. They should be made in writing to Accredited Standards Committee S1, Acoustics, in care of the ASA Standards Secretariat, 120 Wall Street, 32nd floor, New York, New York 10005-3993, USA. Telephone +1 212 248 0373; FAX: +1 212 248 0146, E-mail asastds@aip.org.

American National Standard

Measurement Microphones—Part 1: Specifications for Laboratory Standard Microphones

1 Scope

This Part 1:

— specifies mechanical dimensions and certain electroacoustic characteristics for condenser microphones used as laboratory standards for sound pressure measurements of the highest attainable accuracy. The specifications are intended to ensure that primary calibration by the reciprocity method can be readily carried out for the purpose of traceability to national standards.

— establishes a system for classifying laboratory standard condenser microphones into a number of types according to their dimensions and properties in order to facilitate the specification of calibration methods, the conduct of inter-laboratory comparisons involving the calibration of the same microphones in different laboratories, and the interchangeability of microphones in a given calibration system.

2 Normative references

The following Standards contain provisions that, through reference in this text, constitute provisions of this American National Standard. At the time of approval by the American National Standards Institute, Inc. (ANSI), the editions indicated were valid. All standards are subject to revision. Parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the Standards listed below. Information on the most recent editions is available from the ASA Standards Secretariat.

[1] ANSI S1.1-1994, *American National Standard Acoustical Terminology*.

[2] IEC 50(801): 1994, *International Electrotechnical Vocabulary—Chapter 801: Acoustics and electroacoustics. First edition.*

[3] ASME B1.1:1989, *Unified inch screw threads (UN and UNR thread form)*.

3 Definitions

For the purposes of this Part 1, the following definitions apply. Definitions for related quantities are given in ANSI S1.1 and in IEC 50(801). Boldface symbols represent complex quantities.

3.1 capacitor (condenser) microphone. Microphone that consists of a capacitor and whose operation depends upon interaction between its electric field and the change of its electrostatic capacitance when exposed to the pressure of a sound wave [8.25 of ANSI S1.1-1994 and IEV 801-06-13].

NOTE – This Standard only considers capacitor (condenser) microphones operating by a virtually constant charge obtained from an external polarizing voltage applied from a source of suitably high internal resistance.

3.2 laboratory standard microphone. Capacitor microphone capable of being calibrated to a very high accuracy by a primary method such as the closed coupler reciprocity method, and meeting certain severe requirements on mechanical dimensions and electroacoustical characteristics, especially with respect to stability in time and dependence on environmental conditions.

3.3 open-circuit voltage. Alternating voltage appearing at the electrical output terminals of a microphone as measured by the insert voltage technique when the microphone is attached to the ground-shield configuration specified in 7.2, but is otherwise unloaded. Unit, volt (V).

NOTE – Owing to the capacitive nature of the microphone, the voltage at the electrical terminals depends on the electrical load presented by the mechanical and electrical attachment of the microphone to a preamplifier. For this reason, preamplifiers used for measuring the open-circuit voltage of a microphone should fulfill the requirements of 7.2.

3.4 pressure sensitivity of a microphone. For a sinusoidal signal of given frequency and for given environmental conditions, quotient of the root-mean-square, open-circuit voltage of the microphone by the root-mean-square sound pressure acting over the exposed surface of the diaphragm (i.e., at the acoustical terminals of the microphone), the sound pressure being uniformly applied over the surface of the diaphragm. This quotient is a complex quantity. When phase information is of no interest, the pressure sensitivity may denote its modulus only. Unit, volt per pascal (V/Pa).

3.5 pressure sensitivity level of a microphone. Logarithm of the ratio of the modulus of the pressure sensitivity $|\mathbf{M}_p|$ to a reference sensitivity. Pressure sensitivity level in decibels is 20 $\lg(|\mathbf{M}_p|/M_R)$, where the reference sensitivity M_R is 1 V/Pa. Unit, decibel (dB).

3.6 free-field sensitivity of a microphone. For a sinusoidal plane progressive wave of given frequency, for a specified direction of sound incidence, and for given environmental conditions, quotient of the root-mean-square, open-circuit output voltage of the microphone by the root-mean-square sound pressure that would exist at the position of the acoustic center of the microphone in the absence of the microphone. This quotient is a complex quantity. When phase information is of no interest, the free-field sensitivity may denote its modulus only. Unit, volt per pascal (V/Pa).

NOTES

1 At frequencies sufficiently low for the disturbance of the sound field by the microphone to be negligible, the free-field sensitivity approaches the pressure sensitivity; see 6.10 for practical limitations.

2 The position of the acoustic center is a function of frequency.

3.7 free-field sensitivity level of a microphone. Logarithm of the ratio of the modulus of the free-field sensitivity $|\mathbf{M}_f|$ to a reference sensitivity. Free-field sensitivity level in decibels is 20 $\lg(|\mathbf{M}_f|/M_R)$, where the reference sensitivity M_R is 1 V/Pa. Unit, decibel (dB).

3.8 diffuse-field sensitivity of a microphone. For a sinusoidal signal of specified frequency and for given environmental conditions, quotient of the root-mean-square, open-circuit output voltage of the microphone as a result of sound waves arriving more-or-less simultaneously with equal probability from all directions, by the root-mean-square sound pressure, from the same sound waves, at the position of the acoustic center of the microphone in the absence of the microphone. Unit, volt per pascal (V/Pa).

NOTES

1 At frequencies sufficiently low for the disturbance of the sound field by the microphone to be negligible, the diffuse-field sensitivity approaches the pressure sensitivity; see 6.10 for practical limitations.

2 The position of the acoustic center is a function of frequency

3.9 diffuse-field sensitivity level of a microphone. Logarithm of the ratio of the modulus of the diffuse-field sensitivity $|\mathbf{M}_d|$ to a reference sensitivity. Diffuse-field sensitivity level in decibels is 20 $\lg(|\mathbf{M}_d|/M_R)$, where the reference sensitivity M_R is 1 V/Pa. Unit, decibel (dB).

3.10 random-incidence sensitivity of a microphone. For a sinusoidal signal of specified frequency and for given environmental conditions, at a specified location, quotient of the root-mean-square, open-circuit output voltage of the microphone as a result of a succession of sound waves incident with equal probability from all directions, by the root-mean-square sound pressure at the position of the acoustic center of the microphone from a single free sound wave in the absence of the microphone. Unit, volt per pascal (V/Pa).

3.11 random-incidence sensitivity level of a microphone. Logarithm of the ratio of the modulus of the random-incidence sensitivity $|\mathbf{M}_{ri}|$ to a reference sensitivity. Random-incidence sensitivity level in decibels is 20 $\lg(|\mathbf{M}_{ri}|/M_R)$, where the reference sensitivity M_R is 1 V/Pa. Unit, decibel (dB).

NOTE – From the best of the available experimental evidence, taken under nearly ideal conditions in a given laboratory, for a given microphone, diffuse-field and random-incidence sensitivity levels, at frequencies as high as 12.5 kHz, agreed within approximately 0.1 dB or by an amount comparable to the uncertainty of the measurements. The two sensitivity levels are used equivalently for the purposes of this Standard.

3.12 electrical impedance of a microphone. For a sinusoidal signal of given frequency, complex quotient of the voltage applied across the microphone's electrical terminals by the resulting current through those terminals. The microphone shall be connected to the ground-shield configuration specified in 7.2. Unit, ohm (Ω).

NOTE – Electrical impedance of a microphone is a function of the acoustical load on the diaphragm.

3.13 acoustic impedance of a microphone. For a sinusoidal signal of given frequency, complex quotient of the sound pressure by the volume velocity at the diaphragm, the sound pressure being uniformly distributed over the surface of the diaphragm and the electrical terminals being loaded with an infinite impedance. Unit, pascal per (cubic metre per second) [Pa/(m^3/s)].

3.14 equivalent volume of a microphone. For a given frequency, complex volume $\mathbf{V}_e$ of a gas enclosed in a rigid cavity and undergoing an adiabatic compression and expansion such that the acoustic impedance of this complex volume of gas and the acoustic impedance of the microphone are equal. Unit, cubic metre (m^3).

NOTE – Unless explicitly stated otherwise, the equivalent volume is understood to be expressed as a volume of air.

3.15 static pressure coefficient of microphone pressure sensitivity level. For a given frequency, quotient of the incremental change of pressure sensitivity level by the incremental change in static pressure producing the change in sensitivity. Unit, decibel per pascal (dB/Pa).

NOTE – The static pressure coefficient is a function of frequency as well as static pressure.

3.16 temperature coefficient of microphone pressure sensitivity level. For a given frequency, quotient of the incremental change of pressure sensitivity level by the incremental change in temperature producing the change in sensitivity. Unit, decibel per kelvin (dB/K).

NOTE – The temperature coefficient is a function of frequency as well as temperature.

3.17 relative humidity coefficient of microphone pressure sensitivity level. For the reference temperature and static pressure, quotient of the incremental change of pressure sensitivity level by the incremental change in relative humidity producing the change in sensitivity. Unit: decibel per percent relative humidity (dB/%).

3.18 stability coefficient of microphone pressure sensitivity level. Rate of change in pressure sensitivity level over a stated period of time, when the microphone is stored under typical laboratory conditions. Stability coefficient is represented by two quantities. Long term stability coefficient (systematic drift) is expressed by the slope of the regression line obtained from a least-squares fit to the sensitivity levels measured at various times over a period of one year. Unit, decibel per year (dB/year). Short-term stability coefficient (reversible changes) is expressed by the standard deviation of residuals obtained from sensitivity levels measured at various times over a period of 10 days, unit, decibel (dB).

4 Reference environmental conditions

Reference environmental conditions are:

air temperature: 23 °C;
static pressure: 101.325 kPa; and
relative humidity: 50 %.

5 Classification of laboratory standard microphones

5.1 General

The sound pressure in a given sound field will generally depend on position and should ideally be measured at a point with a transducer of infinitesimally small dimensions and infinitely high acoustic impedance. However, the finite dimensions and acoustic impedance of a real microphone, and the mounting of this microphone, cause practical measurements of sound pressure to depart from this ideal.

The effect of diffraction is accounted for by defining different sensitivities of a microphone each referring to idealized sound fields, for example, pressure, free-field, and diffuse-field (random-incidence) sensitivities. A microphone is usually so constructed that one of the above sensitivities is essentially independent of frequency in the widest possible frequency range.

5.2 Type designation

Laboratory standard microphones are designated by a mnemonic system consisting of the letters LS (for Laboratory Standard) followed by a number representing the mechanical configuration and a third letter representing the electroacoustical characteristic. The third letter may be either P or F representing, respectively, microphones having a pressure or free-field sensitivity, which is approximately independent of frequency in the widest possible frequency range. The designation LS2P thus refers to a laboratory standard microphone of mechanical configuration 2 having a nearly constant pressure sensitivity as a function of frequency.

The type designation does not prevent the use of these microphones under other conditions, such as pressure, free-field, or diffuse field (random-incidence) conditions after proper calibration.

NOTE – Specifications for microphones having a nearly constant diffuse-field (random-incidence) sensitivity are not included in this edition of this Standard.

6 Characteristics of laboratory standard microphones

6.1 Sensitivity

Primary methods for determining the sensitivity of laboratory standard microphones as a function of frequency using the reciprocity principle are given in Part 2 of this series of Standards.

Microphones are often supplied with a protective grid to prevent accidental damage to the diaphragm. When laboratory standard microphones are calibrated or used for the most accurate measurements of sound pressure levels, this protective grid may need to be removed.

6.2 Acoustic impedance

The finite acoustic impedance of the microphone should generally be taken into account when measuring the sound pressure in standing waves or in small enclosures. When performing a reciprocity calibration using a small coupler, the acoustic impedance of the microphone is an important part of the total acoustic transfer impedance.

The acoustic impedance shall be specified as a function of frequency at least for the applicable range given under item 2 of table 3.

NOTE – The acoustic impedance of a microphone may be specified by the lumped parameters of an equivalent single-degree-of-freedom system having the same resonance frequency and low-frequency impedance. The lumped parameters are acoustic compliance, mass, and resistance but may also be expressed in terms of equivalent volume at low frequencies, resonance frequency, and loss factor. The resonance frequency is to be understood as the frequency at which the imaginary part of the acoustic impedance is zero.

6.3 Equivalent volume

The acoustic impedance of a microphone (3.13) is often expressed in terms of the corresponding complex equivalent volume. Both the acoustic impedance of the microphone and its equivalent volume are essentially independent of the environmental conditions.

The equivalent volume $\mathbf{V}_e$ of a microphone is related to the acoustic impedance of the microphone by the following equation. The numerator terms on the right-hand side are at reference environmental conditions to provide an unambiguous relationship.

$$\mathbf{V}_e = \frac{\kappa_R p_{sR}}{j\omega \mathbf{Z}_a} \qquad (1)$$

where

κ_R is the ratio of the specific heat capacities under reference environmental conditions;

p_{sR} is the reference static pressure in pascals;

ω is the angular frequency in radians per second; and

$\mathbf{Z}_a$ is the acoustic impedance of the microphone in pascal per (cubic metre per second).

6.4 Upper limit of the dynamic range

The upper limit of the dynamic range for a laboratory standard microphone shall be stated in terms of the sound pressure level, in decibels, which, at low frequencies, in the stiffness controlled frequency range of the microphone, results in a total harmonic distortion of 1%.

NOTE – The upper limit of the dynamic range may be influenced by the characteristics of the preamplifier connected to the microphone.

6.5 Static pressure dependence of microphone sensitivity

The sensitivity of the microphone will depend slightly on the static pressure, which influences the compliance of the air enclosed in the cavity behind the diaphragm.

The static pressure coefficient shall be stated as a function of frequency at least for the static pressure range from 90 kPa to 110 kPa and at least for the applicable frequency range stated under item 2 in table 3.

6.6 Temperature dependence of microphone sensitivity

Small and slow temperature variations will usually result in a reversible change in sensitivity but large or rapid temperature changes (temperature shock) may lead to a permanent change of microphone sensitivity.

The temperature coefficient shall be stated as a function of frequency at least for the temperature range from 18 °C to 25 °C and at least for the applicable frequency range stated under item 2 in table 3.

6.7 Humidity dependence of microphone sensitivity

The sensitivity of the microphone may depend slightly on relative humidity. The relative humidity coefficient shall be stated at the reference temperature and reference static pressure, at least for the range of relative humidity from 25% to 80%.

6.8 Electrical insulation resistance

Electrical insulation resistance shall be stated as the minimum resistance at the reference temperature and a relative humidity of 80% after being exposed to those conditions for 24 h at a static pressure in the range from 90 kPa to 110 kPa.

NOTE – During calibration, the requirements given in item 9 of table 3 apply to the environmental conditions under which the calibration is performed.

6.9 Stability of microphone sensitivity

The sensitivity of a microphone can change over a period of time even when stored under typical climatic conditions.

Stability coefficients shall be stated for reference environmental conditions at a frequency in the range from 200 Hz to 1 kHz, preferably 500 Hz.

6.10 Pressure equalization and microphone sensitivity

The cavity behind the diaphragm is normally fitted with a narrow pressure-equalizing tube to permit the static pressure to be the same on both sides of the diaphragm. However, at very low frequencies, a partial equalization of sound pressure across the diaphragm occurs when both the microphone diaphragm and the exterior opening of this tube are exposed to the sound pressure in a free field, or in a diffuse field. During calibration of pressure sensitivity in acoustical couplers which do not expose this opening to the sound field, such partial equalization does not occur. Consequently, at very low frequencies, the free-field sensitivity and diffuse-field (random-incidence) sensitivity will be significantly less than the pressure sensitivity.

The pressure equalization shall be described either in terms of the time constant for the equalizing tube and back-cavity system or in terms of the lower limiting frequency. The lower limiting frequency is that frequency at which the free-field sensitivity level is 3 dB less than the pressure sensitivity level at 250 Hz.

7 Specifications

7.1 Mechanical dimensions

Mechanical configurations of laboratory standard microphones are given in figure 1. The corresponding nominal dimensions and tolerances are listed in table 1.

The diameter of the diaphragm shall be approximately the same as the diameter d_3 of the front cavity and shall be stated by the manufacturer.

The maximum force that can be applied to the central electrical contact of the microphone without noticeable change in the actual electroacoustical performance shall be stated by the manufacturer.

7.2 Ground-shield reference configuration

According to 3.3, the open-circuit voltage shall be measured at the electrical terminals of the microphone when it is attached to a specified ground-shield configuration. The ground-shield reference configuration for the mechanical attachment to the microphones is shown in figure 2. The corresponding nominal dimensions and tolerances are listed in table 2.

7.3 Electroacoustical specifications

Electroacoustical specifications are given in table 3. The microphone shall be attached to the ground-shield reference configuration; see 7.2. The polarizing voltage shall be 200 V. When determining the equivalent volume, the value of κ_R shall be taken as 1.40. The manufacturer shall provide design specifications for all characteristics listed except for item 12, together with individual data for items 1 and 2. The sensitivity level shall be given with a resolution of 0.01 dB together with a statement of the measurement uncertainty.

A type LS1P microphone is intended for use at low and mid-frequencies where a very high calibration accuracy can be achieved. A type LS1P microphone should not be used above 8 kHz where performance degradation becomes significant. Degradation also will occur for measurements under free-field or diffuse-field (random-incidence) conditions owing to pronounced directional properties at high frequencies.

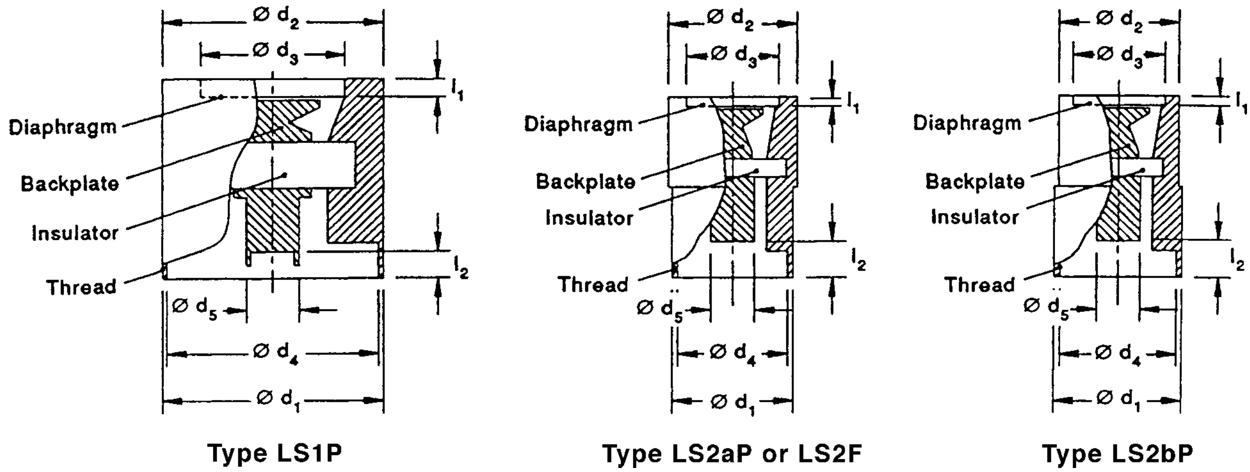

Figure 1 — Mechanical configurations of microphones.
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Table 1 — Nominal mechanical dimensions and tolerance limits for the laboratory standard microphones of figure 1; dimensions in millimetres.

Dimension symbol	Type LS1P	Type LS2aP or LS2F	Type LS2bP
$\varnothing\ d_1$	23.77±0.05	12.7±0.03	12.7±0.03
$\varnothing\ d_2$	23.77±0.05	13.2±0.03	12.15±0.03
$\varnothing\ d_3$	18.60±0.03	9.3±0.03	9.8±0.03
$\varnothing\ d_4$	23.11	11.70	11.70
$\varnothing\ d_5$	<6.0	<5.0	<5.0
l_1	1.95±0.1	0.50±0.05	0.70±0.03
l_2	3.3	3.6	3.2
thread $\varnothing\ d_4$	60 UNS-2B	60 UNS-2B	60 UNS-2B

NOTES

1 LS2aP and LS2bP denote microphones of slightly different mechanical construction having the same electroacoustical specifications as given in table 3 for LS2P microphones.

2 For some microphones, the mechanical configuration is obtained by applying a special adaptor, in which case the tolerances on the outer dimension d_2 are doubled.

3 Dimension d_4 is the major diameter for class-2 internal thread dimensions from ASME B1.1.

4 For type LS1P, an internal thread is usually applied to the front cavity and the dimension given for the diameter d_3 is then the pitch diameter. When a thread is applied, the thread characteristics shall be according to the designation 60 UNS-2B per ASME B1.1, and the tolerances on d_3 are increased to ±0.1 mm.

5 The values given for l_2 are recommended nominal values. There may be substantial departures from these nominal values for existing microphones.

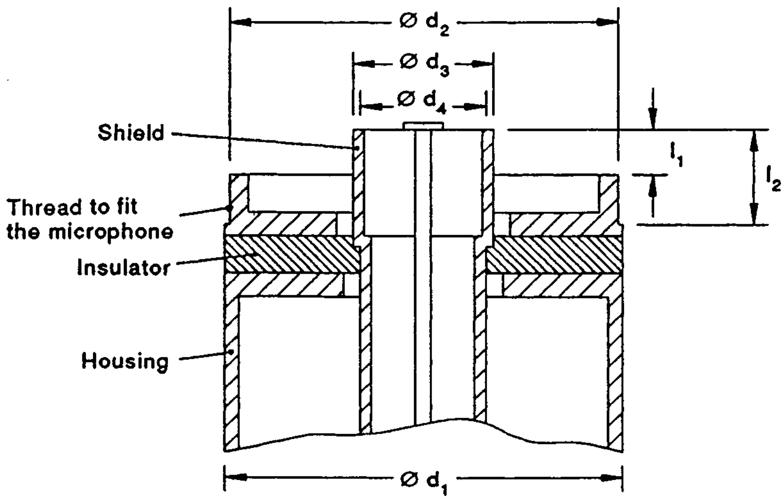

Figure 2 — Mechanical attachment to a microphone showing the ground-shield reference configuration.
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Types LS2P and LS2F microphones extend the frequency range to about 20 kHz, but with lower sensitivity than is available from a type LS1P microphone.

7.4 Identification markings

Each laboratory standard microphone shall be inscribed with the manufacturer's model designation and individual serial number.

Table 2 — Nominal mechanical dimensions and tolerance limits for the ground-shield reference configuration of figure 2; dimensions in millimetres.

Dimension symbol	Type LS1P	Type LS2P or LS2F
$\varnothing$ d_1	23.77±0.05	12.7±0.05
$\varnothing$ d_2	23.11	11.70
$\varnothing$ d_3	11.0±0.1	7.0±0.07
$\varnothing$ d_4	9.0±0.1	6.5±0.07
l_1	2.5	3.0
l_2	5.0±0.15	5.0±0.15
thread $\varnothing$ d_2	60 UNS-2A	60 UNS-2A

NOTE – Dimension d_2 is the major diameter for class-2 external thread dimensions from ASME B1.1.

Table 3 — Electroacoustical specifications for laboratory standard microphones.

Item	Characteristics	Remarks	Microphone type LS1Pn[a)]	LS1Po[a)]	LS2P	LS2F	Unit
1	Sensitivity level (re 1 V/Pa)	at 200 Hz to 500 Hz	−26±2	−30±5	−37±3	−38±2	dB
2	Frequency response[b)]	within 2 dB[c)]	10 to 8000	10 to 7000	10 to 20,000	10 to 20,000	Hz
3	Modulus of equivalent volume	at 200 Hz to 500 Hz	150±30	95±55	10±5	9±3	mm^3
4	Resonance frequency		>8	>7	>20	>20	kHz
5	Upper limit of dynamic range (re 20 μPa)	for 1% total distortion	>130	>124	>145	>145	dB
6	Static pressure coefficient	see 6.5	−0.02 to +0.02	−0.02 to +0.02	−0.025 to +0.025	−0.05 to +0.05	dB/kPa
7	Temperature coefficient	see 6.6	−0.02 to +0.02	−0.02 to +0.02	−0.02 to +0.02	−0.035 +0.035	dB/K
8	Relative humidity coefficient	see 6.7	<0.0004	···	<0.0004	<0.0004	dB/%
9	Electrical insulation resistance	minimum d.c. value	$>10^{13}$	$>2\times10^{10}$	$>10^{13}$	$>10^{13}$	Ω
10	Pressure equalizing time constant[d)]		>0.05	>0.05	>0.05	>0.05	s
11	Long-term stability coefficient	15 °C to 25 °C 250 Hz to 1 kHz	<0.02	<0.02	<0.02	<0.02	dB/year
12	Short-term stability coefficient[e)]	15 °C to 25 °C 250 Hz to 1 kHz	<0.02	<0.02	<0.02	<0.02	dB

[a)]Microphones according to specifications of the columns marked LS1Pn and LS1Po represent ''new'' and ''old'' designs for LS1P microphones, respectively.
[b)]Frequency response refers to the pressure or free-field sensitivity level according to the type designation.
[c)]The response limit stated is the maximum difference between the greatest and the smallest sensitivity level within the required frequency interval.
[d)]Unless required for specific purposes, the time constant should be not larger than 1 s, otherwise the requirements on short-term stability may not be met.
[e)]The figures shall be derived from at least five measurements taken over a period of 10 days and with an interval of not less than 24 h.

OTHER ACOUSTICAL STANDARDS AVAILABLE FROM THE STANDARDS SECRETARIAT OF THE ACOUSTICAL SOCIETY OF AMERICA

• **ASA NOISE STDS INDEX 3-1985** Index to Noise Standards

S1 STANDARDS ON ACOUSTICS

• **ANSI S1.1-1994** American National Standard Acoustical Terminology

• **ANSI S1.4-1983** (**R 1997**) American National Standard Specification for Sound Level Meters

• **ANSI S1.4A-1985** Amendment to S1.4-1983

• **ANSI S1.6-1984** (**R 1997**) American National Standard Preferred Frequencies, Frequency Levels, and Band Numbers for Acoustical Measurements

• **ANSI S1.8-1989** (**R 1997**) American National Standard Reference Quantities for Acoustical Levels

• **ANSI S1.9-1996** American National Standard Instruments for the Measurement of Sound Intensity

• **ANSI S1.10-1966** (**R 1997**) American National Standard Method for the Calibration of Microphones

• **ANSI S1.11-1986** (**R 1993**) American National Standard Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters

• **ANSI S1.12-1967** (**R 1997**) American National Standard Specification for Laboratory Standard Microphones

• **ANSI S1.13-1995** American National Standard Measurement of Sound Pressure Levels in Air

• **ANSI S1.14-1998** American National Standard Recommendations for Specifying and Testing the Susceptibility of Acoustical Instruments to Radiated Radio-frequency Electromagnetic Fields, 25 MHz to 1 GHz

• **ANSI S1.15-1997/Part 1** American National Standard Measurement Microphones, Part 1: Specifications for Laboratory Standard Microphones

• **ANSI S1.20-1988** (**R 1993**) American National Standard Procedures for Calibration of Underwater Electroacoustic Transducers

• **ANSI S1.22-1992** (**R 1997**) American National Standard Scales and Sizes for Frequency Characteristics and Polar Diagrams in Acoustics

• **ANSI S1.25-1991** (**R 1997**)American National Standard Specification for Personal Noise Dosimeters (Revision of ANSI S1.25-1978)

• **ANSI S1.26-1995** American National Standard Method for the Calculation of the Absorption of Sound by the Atmosphere

• **ANSI S1.40-1984** (**R 1997**) American National Standard Specification for Acoustical Calibrators

• **ANSI S1.42-1986** (**R 1992**) American National Standard Design Response of Weighting Networks for Acoustical Measurements

• **ANSI S1.43-1997** American National Standard Specifications for Integrating-Averaging Sound Level Meters

S2 STANDARDS ON MECHANICAL VIBRATION AND SHOCK

• **ANSI S2.2-1959** (**R 1997**) American National Standard Methods for the Calibration of Shock and Vibration Pickups

• **ANSI S2.3-1964** (**R 1997**) American National Standard Specifications for a High-Impact Shock Machine for Electronic Devices

• **ANSI S2.4-1976** (**R 1997**) American National Standard Method for Specifying the Characteristics of Auxiliary Analog Equipment for Shock and Vibration Measurements

• **ANSI S2.5-1962** (**R 1997**) American National Standard Recommendations for Specifying the Performance of Vibration Machines

• **ANSI S2.7-1982** (**R 1997**) American National Standard Balancing Terminology

• **ANSI S2.8-1972** (**R 1997**) American National Standard for Describing the Characteristics of Resilient Mountings

• **ANSI S2.9-1976** (**R 1997**) American National Standard Nomenclature for Specifying Damping Properties of Materials

• **ANSI S2.10-1971** (**R 1997**) American National Standard Methods for Analysis and Presentation of Shock and Vibration Data

• **ANSI S2.11-1969** (**R 1997**) American National Standard for the Selection of Calibrations and Tests for Electrical Transducers used for Measuring Shock and Vibration

• **ANSI S2.13-1996/Part 1** American National Standard Mechanical Vibration of Non-Reciprocating Machines—Measurements on Rotating Shafts and Evaluation—Part 1: General Guidelines

• **ANSI S2.14-1973** (**R 1997**) American National Standard for Specifying the Performance of Shock Machines

• **ANSI S2.15-1972** (**R 1997**) American National Standard Specification for the Design, Construction, and Operation of Class HI (High-Impact) Shock-Testing Machine for Lightweight Equipment

• **ANSI S2.16-1997** American National Standard Vibratory Noise Measurements and Acceptance Criteria for Shipboard Equipment

• **ANSI S2.17-1980** (**R 1997**) American National Standard Techniques of Machinery Vibration Measurement

• **ANSI S2.19-1989** (**R 1997**) American National Standard Mechanical Vibration−Balance Quality Requirements of Rigid Rotors, Part 1: Determination of Permissible Residual Unbalance

• **ANSI S2.20-1983** (**R 1997**) American National Standard for Estimating Airblast Characteristics for Single Point Explosions in Air, With a Guide to Evaluation of Atmospheric Propagation and Effects

• **ANSI S2.31-1979** (**R 1997**) American National Standard Method for the Experimental Determination of Mechanical Mobility. Part I: Basic Definitions and Transducers

• **ANSI S2.32-1982** (**R 1997**) American National Standard Methods for the Experimental Determination of Mechanical Mobility. Part II: Measurements Using Single-Point Translation Excitation

• **ANSI S2.34-1984** (**R 1997**) American National Standard Guide to the Experimental Determination of Rotation Mobility Properties and the Complete Mobility Matrix

• **ANSI S2.38-1982** (**R 1997**) American National Standard Field Balancing Equipment—Description and Evaluation

• **ANSI S2.40-1984** (**R 1997**) American National Standard Mechanical Vibration of Rotating and Reciprocating Machinery—Requirements for Instruments for Measuring Vibration Severity

• **ANSI S2.41-1985** (**R 1997**) American National Standard Mechanical Vibration of Large Rotating Machines With Speed Range from 10 to 200 rev/s—Measurement and Evaluation of Vibration Severity *in situ*

• **ANSI S2.42-1982** (**R 1997**) American National Standard Procedures for Balancing Flexible Rotors

• **ANSI S2.43-1984** (**R 1997**) American National Standard Criteria for Evaluating Flexible Rotor Balance

• **ANSI S2.45-1983** (**R 1997**) American National Standard Electrodynamic Test Equipment for Generating Vibration—Methods of Describing Equipment Characteristics
• **ANSI S2.46-1989** (**R 1997**) American National Standard Characteristics to be Specified for Seismic Transducers
• **ANSI S2.47-1990** (**R 1997**) American National Standard Vibration of Buildings—Guidelines for the Measurement of Vibrations and Evaluation of Their Effects on Buildings
• **ANSI S2.48-1993** (**R 1997**) American National Standard Servo-Hydraulic Test Equipment for Generating Vibration—Methods of Describing Characteristics
• **ANSI S2.58-1983** (**R 1997**) American National Standard Auxiliary Tables for Vibration Generators—Methods of Describing Equipment Characteristics
• **ANSI S2.60-1987** (**R 1997**) American National Standard Balancing Machines—Enclosures and Other Safety Measures
• **ANSI S2.61-1989** (**R 1997**) American National Standard Guide to the Mechanical Mounting of Accelerometers

S3 STANDARDS ON BIOACOUSTICS

• **ANSI S3.1-1991** American National Standard Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms
• **ANSI S3.2-1989** (**R 1995**) American National Standard Method for Measuring the Intelligibility of Speech Over Communication Systems
• **ANSI S3.4-1980** (**R 1997**) American National Standard Procedure for the Computation of Loudness of Noise
• **ANSI S3.5-1997** American National Standard Methods for Calculation of the Speech Intelligibility Index
• **ANSI S3.6-1996** American National Standard Specification for Audiometers
• **ANSI S3.7-1995** American National Standard Method for Coupler Calibration of Earphones
• **ANSI S3.13-1987** (**R 1997**) American National Standard Mechanical Coupler for Measurement of Bone Vibrators
• **ANSI S3.14-1977** (**R 1997**) American National Standard for Rating Noise with Respect to Speech Interference
• **ANSI S3.18-1979** (**R 1993**) American National Standard Guide for the Evaluation of Human Exposure to Whole-Body Vibration
• **ANSI S3.20-1995** American National Standard Bioacoustical Terminology
• **ANSI S3.21-1978** (**R 1997**) American National Standard Method for Manual Pure-Tone Threshold Audiometry
• **ANSI S3.22-1996** American National Standard Specification of Hearing Aid Characteristics
• **ANSI S3.25-1989** (**R 1995**) American National Standard for an Occluded Ear Simulator
• **ANSI S3.29-1983** (**R 1996**) American National Standard Guide to the Evaluation of Human Exposure to Vibration in Buildings
• **ANSI S3.32-1982** (**R 1995**) American National Standard Mechanical Vibration and Shock Affecting Man—Vocabulary
• **ANSI S3.34-1986** (**R 1997**) American National Standard Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand
• **ANSI S3.35-1985** (**R 1997**) American National Standard Methods of Measurement of Performance Characteristics of Hearing Aids Under Simulated *in-situ* Working Conditions
• **ANSI S3.36-1985** (**R 1996**) American National Standard Specification for a Manikin for Simulated *in situ* Airborne Acoustic Measurements
• **ANSI S3.37-1987** (**R 1997**) American National Standard Preferred Earhook Nozzle Thread for Postauricular Hearing Aids
• **ANSI S3.39-1987** (**R 1996**) American National Standard Specifications for Instruments to Measure Aural Acoustic Impedance and Admittance (Aural Acoustic Immittance)
• **ANSI S3.40-1989** (**R 1995**) American National Standard Guide for the Measurement and Evaluation of Gloves Which are Used to Reduce Exposure to Vibration Transmitted to the Hand
• **ANSI S3.41-1990** (**R 1996**) American National Standard Audible Emergency Evacuation Signal
• **ANSI S3.42-1992** (**R 1997**) American National Standard Testing Hearing Aids with a Broad-Band Noise Signal
• **ANSI S3.44-1996** American National Standard Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment
• **ANSI S3.46-1997** American National Standard Methods of Measurement of Real-Ear Performance Characteristics of Hearing Aids

S12 STANDARDS ON NOISE

• **ANSI S12.1-1983** (**R 1996**) American National Standard Guidelines for the Preparation of Standard Procedures for the Determination of Noise Emission from Sources
• **ANSI S12.2-1995** American National Standard Criteria for Evaluating Room Noise
• **ANSI S12.3-1985** (**R 1996**) American National Standard Statistical Methods for Determining and Verifying Stated Noise Emission Values of Machinery and Equipment
• **ANSI S12.5-1990** (**R 1997**) American National Standard Requirements for the Performance and Calibration of Reference Sound Sources
• **ANSI S12.6-1997** American National Standard Method for the Measurement of the Real-Ear Attenuation of Hearing Protectors (Revision of ANSI S12.6-1984)
• **ANSI S12.7-1986** (**R 1993**) American National Standard Methods for Measurements of Impulse Noise
• **ANSI S12.8-1987** American National Standard Methods for Determination of Insertion Loss of Outdoor Noise Barriers
• **ANSI S12.9-1988/Part 1** (**R 1993**) American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 1
• **ANSI S12.9-1992/Part 2** American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 2: Measurement of Long-Term, Wide-Area Sound
• **ANSI S12.9-1993/Part 3** American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 3: Short-Term Measurements with an Observer Present
• **ANSI S12.9-1996/Part 4** American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 4: Noise Assessment and Prediction of Long-Term Community Response
• **ANSI S12.9-1998/Part 5** American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 5: Sound Level Descriptors for Determination of Compatible Land Use
• **ANSI S12.10-1985** (**R 1997**) American National Standard Methods for the Measurement and Designation of Noise Emitted by Computer and Business Equipment (Revision of ANSI S1.29-1979)
• **ANSI S12.11-1987** (**R 1997**) American National Standard Methods for the Measurement of Noise Emitted by Small Air-Moving Devices

• **ANSI S12.12-1992** (**R 1997**) American National Standard Engineering Method for the Determination of Sound Power Levels of Noise Sources Using Sound Intensity

• **DRAFT ANSI S12.13-1991** Draft American National Standard Evaluating the Effectiveness of Hearing Conservation Programs

• **ANSI S12.14-1992** (**R 1997**) American National Standard Methods for the Field Measurement of the Sound Output of Audible Public Warning Devices Installed at Fixed Locations Outdoors

• **ANSI S12.15-1992** (**R 1997**) American National Standard for Acoustics—Portable Electric Power Tools, Stationary and Fixed Electric Tools, and Gardening Appliances—Measurement of Sound Emitted

• **ANSI S12.16-1992** (**R 1997**) American National Standard Guidelines for the Specification of Noise of New Machinery

• **ANSI S12.17-1996** American National Standard Impulse Sound Propagation for Environmental Noise Assessment

• **ANSI S12.18-1994** American National Standard Procedures for Outdoor Measurement of Sound Pressure Level

• **ANSI S12.19-1996** American National Standard Measurement of Occupational Noise Exposure

• **ANSI S12.23-1989** (**R 1996**) American National Standard Method for the Designation of Sound Power Emitted by Machinery and Equipment

• **ANSI S12.30-1990** (**R 1997**) American National Standard Guidelines for the Use of Sound Power Standards and for the Preparation of Noise Test Codes (Revision of ANSI S1.30-1979)

• **ANSI S12.31-1990** (**R 1996**) American National Standard Precision Methods for the Determination of Sound Power Levels of Broad-Band Noise Sources in Reverberation Rooms (Revision of ANSI S1.31-1980)

• **ANSI S12.32-1990** (**R 1996**) American National Standard Precision Methods for the Determination of Sound Power Levels of Discrete-Frequency and Narrow-Band Noise Sources in Reverberation Rooms (Revision of ANSI S1.32-1980)

• **ANSI S12.33-1990** (**R 1997**) American National Standard Engineering Methods for the Determination of Sound Power Levels of Noise Sources in a Special Reverberation Test Room (Revision of ANSI S1.33-1982)

• **ANSI S12.34-1988** (**R 1997**) American National Standard Engineering Methods for the Determination of Sound Power Levelsof Noise Sources for Essentially Free-Field Conditions over a Reflecting Plane (Revision of ANSI S1.34-1980)

• **ANSI S12.35-1990** (**R 1996**) American National Standard Precision Methods for the Determination of Sound Power Levels of Noise Sources in Anechoic and Hemi-Anechoic Rooms (Revision of ANSI S1.35-1979)

• **ANSI S12.36-1990** (**R 1997**) American National Standard Survey Methods for the Determination of Sound Power Levels of Noise Sources (Revision of ANSI S1.36-1979)

• **ANSI S12.42-1995** American National Standard Microphone-in-Real-Ear and Acoustic Test Fixture Methods for the Measurement of Insertion Loss of Circumaural Hearing Protection Devices

• **ANSI S12.43-1997** American National Standard Methods for Measurement of Sound Emitted by Machinery and Equipment at Workstations and Other Specified Positions

• **ANSI S12.44-1997** American National Standard Methods for Calculation of Sound Emitted by Machinery and Equipment at Workstations and Other Specified Positions from Sound Power Level

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The Acoustical Society of America provides the Secretariat for four Accredited Standards Committees of the American National Standards Institute (ANSI): S1 on Acoustics, S2 on Mechanical Vibration and Shock, S3 on Bioacoustics, and S12 on Noise.

These four Accredited Standards Committees also provide the United States input to various international committees (IEC and ISO). Standards Committees S1 Acoustics and S3 Bioacoustics provide the United States input to ISO/TC 43 Acoustics, and IEC/TC 29 Electroacoustics, as the Technical Advisory Groups. S12 on Noise serves as the U.S. Technical Advisory Group for ISO/TC 43/SC1 Noise, and for ISO/TC 94/SC12 Hearing Protection. S3 is the U.S. Technical Advisory Group for ISO/TC 108/SC4 Human Exposure to Mechanical Vibration and Shock. S2 serves as the U.S. Technical Advisory Group for ISO/TC 108, Mechanical Vibration and Shock; ISO/TC 108/SC1, Balancing, including Balancing Machines, ISO/TC 108/SC2 Measurement and Evaluation of Mechanical Vibration and Shock as Applied to Machines, Vehicles, and Structures; ISO/TC 108/SC3 Use and Calibration of Vibration and Shock Measuring Instruments; ISO/TC 108/SC5 Condition Monitoring and Diagnostics of Machines; and ISO/TC 108/SC6 Vibration and Shock Generating Systems.

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