

ANSI S1.13-2005
(Revision of ANSI S1.13-1995)

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AMERICAN NATIONAL STANDARD

Measurement of Sound Pressure Levels in Air

ANSI S1.13-2005

Accredited Standards Committee S1, Acoustics

Standards Secretariat
Acoustical Society of America
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Secretariat:
Acoustical Society of America

Approved by American National Standards Institute, Inc.
25 July 2005

Abstract

This standard specifies requirements and describes procedures for the measurement of sound pressure levels in air at a single point in space. These requirements and procedures apply primarily to measurements performed indoors but may be utilized in outdoor measurements under specified conditions. This is a fundamental standard applicable to a wide range of measurements and to sounds that may differ widely in temporal and spectral characteristics; more specific American National Standards complement its requirements. A classification is given of the types of sound generally encountered, and the preferred descriptor for each type is identified. This standard is intended to be used by practitioners in the field, as well as by members of the general public who have little or no special technical training in areas relating to acoustics. This is a replacement for a previous version of ANSI S1.13.

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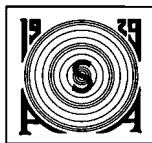
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Contents

Foreword.....	iii
Introduction.....	v
1 Scope.....	1
2 Purpose.....	1
3 Applications.....	2
4 Normative references	2
5 Definitions	3
6 Types of sound	6
6.1 Temporal characteristics	7
6.2 Frequency characteristics	8
6.3 Spatial characteristics	9
7 Types of acoustical environment	10
7.1 Ideal acoustical environments.....	10
7.2 Practical acoustical environment	10
8 Instrumentation for measuring sound pressure levels.....	11
8.1 General requirements	11
8.2 Sound level meters	11
8.3 Component systems	12
8.4 Frequency weightings	12
8.5 Octave-band and one-third octave-band analyzers.....	12
8.6 Data-logging and data-sampling instruments	12
8.7 Equipment for recording and storing data.....	13
9 Measurement of sound pressure level at a point in space	14
9.1 Planning and preparation for the measurements.....	14
9.2 Set-up for the measurements.....	15
9.3 Precision of measurements (measurement uncertainty)	18
9.4 Measurement procedures	18
9.5 Spatial aspects	22
10 Documentation of measurements—measurement record.....	22
10.1 General information	22
10.2 Description of sound of interest	23
10.3 Description of acoustical environment.....	23
10.4 Instrumentation	23
10.5 Acoustical data.....	24
11 Reporting of measurement results—measurement report	24

Annex A (informative) Identification and evaluation of prominent discrete tones	25
A.1 Field of application	25
A.2 Background	25
A.3 Microphone position	25
A.4 Instrumentation	26
A.5 Audibility requirement	26
A.6 Critical bandwidths	27
A.7 Tone-to-noise ratio method	28
A.8 Prominence ratio method	31
A.9 Information to be recorded for prominent discrete tones	36
A.10 References	37
Annex B (informative) Identification and evaluation of impulsive sound	39
B.1 Definition: Time-averaged A1-weighted sound level	39
B.2 Measurement position	39
B.3 Instrumentation	39
B.4 Measurements	40

Figures

Figure A.1 — Tone-to-noise ratio method applied to a single tone in a critical band	32
Figure A.2 — Tone-to-noise ratio method applied to multiple tones in a critical band	32
Figure A.3 — Illustration of the prominence ratio method for prominent tone identification	36
Figure A.4 — Criteria for prominence for both tone-to-noise ratio (A.7.5) and prominence ratio (A.8.6) as a function of frequency	37

Foreword

[This Foreword is for information only, and is not a part of the American National Standard ANSI S1.13 – 2005 American National Standard Measurement of Sound Pressure Levels in Air].

This standard comprises a part of a group of definitions, standards, and specifications for use in acoustics. It was developed and approved by Accredited Standards Committee S1 Acoustics, under its approved operating procedures. Those procedures have been accredited by the American National Standards Institute (ANSI). The Scope of Accredited Standards Committee S1 is as follows:

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

This standard is a limited revision of ANSI S1.13-1995, which has been technically revised by updating the references in the body and replacing Annex A in its entirety.

This standard is not comparable to any existing ISO Standard.

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

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Suggestions for improvements of this standard will be welcomed. They should be sent to Accredited Standards Committee S1, Acoustics, in care of the Standards Secretariat of the Acoustical Society of America, 35 Pinelawn Road, Suite 114E, Melville, New York 11747-3177. Telephone: 631-390-0215; FAX: 631-390-0217; E-mail: asastds@aip.org

Introduction

Sound is a pressure fluctuation in the air. In general, the greater the amplitude of the pressure fluctuation, the "louder" the sound will be perceived by people. But loudness is a *subjective* measure of the amplitude that varies from one person to the next and will depend on many parameters, some of which are nonphysical. The need often arises for an *objective* measure of the amplitude of the pressure fluctuations, a measure that depends solely on physical parameters and that is not subject to interpretation or opinion. Sound pressure level is this objective measure. This standard gives requirements and guidelines for measuring the sound pressure level in air at a single point in space.

The total ambient sound that exists at a given point in space is usually due to a composite of many different sounds with different strengths and frequency content. The composite sound may be a combination of background noise and sound from a single identifiable source; it may be a combination from several individual sources; and it may include reflections from room surfaces or reflecting objects. This standard is primarily concerned with the measurement of the level of the composite sound at a given point or in measuring changes in that level caused by a certain sound of interest.

This standard (ANSI S1.13-2005, Measurement of Sound Pressure Levels in Air) is a fundamental standard giving basic information and requirements for a wide range of measurements. Other American National Standards provide more specialized information and requirements.

The way in which the sound pressure level varies with time (temporal pattern), how it varies over frequency (frequency content), and how it varies from one physical point to another (spatial distribution) are often important. The desire to quantify these aspects has led, unfortunately, to a preponderance of metrics and descriptors in use today, some quite complicated and some limited to very specific applications. Fortunately, the advent of modern digital instruments of relatively low cost and wide availability and the efforts by standardization bodies have led to a general consensus on only a small number of descriptors. This standard identifies the time-average A-weighted sound level and the A-weighted sound exposure level as preferred descriptors for the various types of sounds defined in the text.

There are many reasons for measuring sound pressure levels. These include regulatory purposes, quantifying noise emissions of products, assessing hearing-damage risk, designing acoustical spaces, monitoring the condition of a machine, evaluating the performance of sound sources such as loudspeakers or emergency sirens, evaluating hearing protectors, absorptive materials, or barriers, and assessing various subjective responses such as loudness, noisiness, speech-interference level, and articulation index. However, most purposes for sound pressure level measurements fall into two groups: sound pressure levels measured in order to characterize a source, and sound pressure levels measured in order to characterize an environment. Regardless of the reasons, or whether one is trying to characterize a source or an environment, the process will involve individual measurements of the sound pressure level at one or more specific points in space. This is the focus of this standard. The particular reasons or applications for the measurements are dealt with only superficially.

This standard is intended to be used by practitioners in the field as well as by members of the general public who have little or no special technical training in areas relating to acoustics. One of the goals of publishing this standard is to make the practice of making an accurate sound pressure level measurement more widespread and comfortable.

It is anticipated that standards, test codes, government regulations, purchase specifications, design specifications, or similar documents requiring the measurement of sound pressure levels will refer to this standard in a form such as "... (at the specified point or points) the (specified type of) sound pressure level shall be measured in accordance with ANSI S1.13-2005."

American National Standard

Measurement of Sound Pressure Levels In Air

1 Scope

This standard specifies requirements and procedures for the measurement of sound pressure levels in air. These requirements and procedures apply primarily to measurements performed under normal, relatively quiescent meteorological conditions. Nearly all measurements made indoors will fall under such conditions, but outdoor measurements may also be made, and may remain in conformance with this standard provided the ranges of certain environmental variables are restricted, as described herein.

The requirements in this standard (identified by the use of the word *shall*) are to be understood as conditions on the measurements that must be met in order to state that such measurements have been made in conformance with this American National Standard. The guidelines and recommendations (identified by the use of the word *should*) are to be understood as conditions that will generally improve the accuracy, validity, applicability, documentation, and reporting of the measurement data but that are not mandatory for conformance.

The type of sounds considered by this standard may differ widely in temporal and spectral characteristics. The sound to be measured may be continuous or intermittent; it may be steady, fluctuating, or impulsive; and it may be essentially broad band or contain discrete tones or narrow bands of noise.

The frequency range covered by the requirements of this standard depends on the specific type of sound level meter or instrumentation being used, but, in general, the frequency content of the sound being measured should be contained within the range covered by the octave bands having center frequencies from 31.5 Hz to 16.0 kHz. The sound pressure levels of sounds whose energy is concentrated outside of this range may not be measured accurately according to the procedures of this standard.

The sound pressure level descriptors primarily used in this standard are the time-average A-weighted sound level (also called the equivalent-continuous A-weighted sound pressure level) and the A-weighted sound exposure level. The choice of descriptor and the measurement procedures to follow depend on the type of sound, and this standard gives requirements and guidelines governing this choice.

The nature of the sound that is being measured by the procedures of this standard may be considered as either *desirable* (e.g., music from a symphony orchestra or a signal from an alarm device) or *undesirable* (e.g., noise from a busy highway or household vacuum cleaner). There is no differentiation as far as the procedures in this standard are concerned.

This standard does not address the measurement of sound pressure levels in environments other than air (such as other gases, liquids, or solids), the measurement of infrasonic or ultrasonic sounds, or (generally) the measurement of sound pressure levels outdoors in nonquiescent conditions.

2 Purpose

This standard has a number of purposes, equally important. They are as follows:

- a) To establish uniform procedures for measuring the sound pressure level in air at a single point in space.
- b) To provide a classification of the types of sounds that can occur.

- c) To facilitate the drafting of test codes, regulations, and the like by standardizing the basic requirements of sound pressure level measurements common to most of these documents. Rather than reiterating these requirements, the test codes and similar documents may simply refer to ANSI S1.13-2005 for the essential requirements.
- d) To help make the procedures of acoustical measurements more accessible to regulatory personnel and the general public through clearly defining the steps and types of instrumentation necessary.

3 Applications

Since this is a fundamental standard, as opposed to a specialized standard or test code, it is applicable to the acquisition of sound pressure level data by a wide range of interested parties for a wide range of purposes. To illustrate just a few possible applications, this standard may be used:

- By an individual who wishes to know the sound pressure level at a certain point in or around the home, at a concert, or at a work environment.
- To assess the change in sound pressure level at a certain point due to the switching on or off of a particular sound source.
- To assess whether or not a certain acoustical space, such as an office, conference room, or concert hall, meets a particular background noise specification.
- In conjunction with other standards and procedures, to assess hearing-damage risk caused by noise exposure.
- By law-enforcement agents, usually in conjunction with another standard or procedural document, to assess compliance with noise regulations.
- By manufacturers, in conjunction with applicable noise emission standards or test codes, to determine the sound power level of a product.
- By testing laboratories, in conjunction with other standards, to check whether or not stated noise emission levels are verified.
- To evaluate the performance of loudspeakers, musical instruments, or other sound sources.

4 Normative references

The following Standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI S1.4-1983 (R 2001), *American National Standard Specification for Sound Level Meters*. Includes S1.4A-1985 (R 2001), *American National Standard Specification for Sound Level Meters (Amendment)*.

ANSI S1.11-2004, *American National Standard Specifications for Octave-Band and Fractional Octave-Band Analog and Digital Filters*.

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

ANSI S1.42-2001 *American National Standard Design Response of Weighting Networks for Acoustical Measurements.*

ANSI S1.43-1997 (R 2002), *American National Standard Specifications for Integrating-Averaging Sound Level Meters.*

ANSI S12.7-1986 (R 1998), *American National Standard Methods for Measurement of Impulse Noise.*

ANSI S12.9-1988/Part 1 (R 2003), *American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 1.*

ANSI S12.9-1992/Part 2 (R 2003) *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 (R 2003), *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 (R 2001), *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 (R 2003), *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 S12.9-2000/Part 6, *American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 6: Methods for Estimation of Awakenings Associated with Aircraft Noise Events Heard in Homes.*

ANSI S12.18-1994 (R2004), *American National Standard Procedures for Outdoor Measurement of Sound Pressure Level.*

5 Definitions

5.1

ambient sound

The all-encompassing sound existing at a specified point and time associated with a given environment. The ambient sound is usually a composite of sounds from several sources, near and far.

NOTE 1 In general, the ambient sound may include sounds from individually identifiable sources that operate continuously. The sound from such a source at a specified point and time in the given environment is sometimes referred to as the specific sound.

NOTE 2 The ambient sound may be reduced in level by eliminating one or more of the individually identifiable sources. When all such sources can be eliminated, the resulting sound at a specified point and time in the given environment is sometimes referred to as the residual sound.

NOTE 3 If sounds from intermittent sources contribute to the overall ambient sound at a given point in an environment (such as the low-level sounds of passing cars on a distant roadway), the level of the ambient sound should be taken as the level in the absence of such intermittent events, if practical.

5.2

sound of interest

The sound existing at a specified point in a given environment that is intended to be characterized (by the methods of this standard). The sound of interest may be the ambient sound itself, or it may be a sound

that is clearly distinguishable from the ambient sound. The source or sources of the sound of interest may or may not be identifiable.

NOTE Examples of sounds of interest are the sound inside a classroom next to a highway, the sound existing at a residential property line when a nearby fire station siren goes off, the sound of a passing vehicle at a certain distance from the roadway, and the sound in the center of a concert hall during a symphony.

5.3

observation period

The time period during which the sound of interest is observed, measured, recorded, or otherwise assessed for the purposes of classifying the type of sound in regard to its temporal or spectral characteristics.

5.4

measurement time interval

The time interval over which the squared instantaneous sound pressure is integrated to compute the time-averaged sound pressure or the sound exposure (i.e., the time interval during which data are actually measured).

5.5

instantaneous sound pressure

The sound pressure (i.e., the difference between the total pressure and the atmospheric static pressure) that exists at a given point in space, at a particular instant in time, in a stated frequency band. Unit: pascal (Pa); symbol: $p(t)$.

NOTE The instantaneous sound pressure may be frequency-weighted by a standardized frequency-weighting characteristic (e.g., A or C, see ANSI S1.4-1983 and ANSI S1.4A-1985). Example: A-weighted instantaneous sound pressure; symbol: $p_A(t)$.

5.6

peak sound pressure

At a point in space, the highest absolute value of the instantaneous sound pressure occurring during a specified time interval. Unit: pascal (Pa); symbol: P_{pk} .

NOTE The peak sound pressure may be frequency-weighted by a standardized frequency-weighting characteristic (e.g., A or C; see ANSI S1.4-1983 and ANSI S1.4A-1985). Example: A-weighted peak sound pressure; symbol: p_{Apk} .

5.7

peak sound pressure level

Ten times the common logarithm of the square of the ratio of the peak sound pressure to the reference sound pressure of 20 micropascals. Unit: decibel (dB); symbol: L_{pk} .

5.8

sound pressure

At a point in space, the root mean square determined over a specified time interval of the instantaneous sound pressure. Unit: pascal (Pa); symbol: p .

NOTE The term *sound pressure* is also used generically to mean the fluctuating pressure that is superimposed on the atmospheric static pressure due to the presence of a sound wave. However, in this standard, it has the restricted meaning, noted above.

5.9

sound pressure level

Ten times the common logarithm of the square of the ratio of the sound pressure to the reference sound pressure of 20 micropascals. Unit: decibel (dB); symbol: L_p .

Sound pressure level is given by the formula

$$L_p = 10 \log_{10} \left(\frac{p}{p_0} \right)^2,$$

where

p is the sound pressure,

p_0 is the reference sound pressure of 20 μPa .

5.10

time-averaged A-weighted sound pressure

Square root of the time integral of squared A-weighted instantaneous sound pressure divided by the time period of integration in seconds. Unit: pascal (Pa); symbol: $\overline{p_A}$.

The time period of the integration (averaging time) shall be specified. The time-averaged A-weighted sound pressure is given by the formula

$$\overline{p_A} = \left(\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} p_A^2(t) dt \right)^{1/2},$$

where

$\overline{p_A}$ is the time-averaged A-weighted sound pressure,

$p_A^2(t)$ is the squared A-weighted instantaneous sound pressure.

NOTE 1 The frequency weighting should always be stated. If a frequency weighting besides A-weighting is used (e.g., C-weighting), it should be stated explicitly in the title (e.g., time-averaged C-weighted sound pressure; symbol: $\overline{p_C}$).

NOTE 2 If no frequency weighting is used and the time-averaged sound level is measured in a frequency band (such as an octave band or one-third octave band), the frequency band should be specified.

5.11

time-averaged A-weighted sound level

Ten times the common logarithm of the square of the ratio of time-averaged A-weighted sound pressure to the reference sound pressure of 20 micro-pascals. Unit: decibel (dB), symbol: $L_{A,T}$.

NOTE 1 The time-averaged A-weighted sound level is the primary quantity measured by many commercially available sound level meters. Performance requirements for sound level meters are specified in ANSI S1.4-1983 and ANSI S1.4A-1985.

NOTE 2 The time-averaged A-weighted sound level is also termed the equivalent continuous A-weighted sound pressure level.

NOTE 3 The frequency weighting should always be stated. If a frequency weighting besides A-weighting is used (e.g., C-weighting), it should be stated explicitly in the title (e.g., time-averaged C-weighted sound level; symbol: $L_{C,T}$). If no frequency weighting is used and the time-averaged sound level is measured in a frequency band (such as an octave band or one-third octave band), the frequency band should be specified.

NOTE 4 Long-term, cumulative average sound pressure level descriptors for rating environmental sound and determining compatible land use are given in ANSI S12.9.

5.12

A-weighted sound exposure

Time integral of the squared instantaneous A-weighted sound pressure over a given time interval. Unit: pascal-squared second (Pa^2s); symbol: E_A . The A-weighted sound exposure is given by the formula

$$E_A = \int_{t_1}^{t_2} p_A^2(t) dt,$$

where

E_A is the A-weighted sound exposure determined over a time interval (t_2-t_1),

$p_A^2(t)$ is the squared A-weighted instantaneous sound pressure.

NOTE 1 The frequency weighting should always be stated. If a frequency weighting besides A-weighting is used (e.g., C-weighting), it should be stated explicitly in the title (e.g., C-weighted sound exposure; symbol: E_C).

NOTE 2 If no frequency weighting is used and the time-averaged sound exposure is measured in a frequency band (such as an octave band or one-third octave band), the frequency band should be specified.

5.13

A-weighted sound exposure level

Ten times the common logarithm of the ratio of the A-weighted sound exposure to the reference sound exposure (symbol: E_0) of 400 micropascal-squared seconds ($400 \mu\text{Pa}^2 \text{s}$). Unit: decibel (dB); symbol: L_{AE} .

NOTE 1 The sound exposure level is capable of being measured directly by many commercially available sound level meters.

NOTE 2 For a single-event sound, such as an aircraft flyover, the integration time interval should encompass all significant sound associated with the event.

NOTE 3 The frequency weighting should always be stated. If a frequency weighting besides A-weighting is used (e.g., C-weighting), it should be stated explicitly in the title (e.g., C-weighted sound exposure level; symbol: L_{CE}). If no frequency weighting is used and the time-averaged sound exposure is measured in a frequency band (such as an octave band or one-third octave band), the frequency band should be specified.

NOTE 4 Long-term, cumulative sound exposure level descriptors for rating environmental sound and determining compatible land use are given in ANSI S12.9.

5.14

impulse

A transient excursion in sound pressure amplitude such that (i) the duration of the excursion is less than 1 s, (ii) the peak sound pressure level during the excursion is at least 10 dB above the sound pressure level of the ambient sound, and (iii) either the rise time or fall time, or both, from the peak level to the ambient level is less than 250 ms. The ambient level is taken as the sound pressure level that would exist in the absence of the impulse, and the duration of the impulse is taken as either (i) the time interval that the instantaneous sound pressure of the impulse exceeds that of the ambient or (ii) the time interval between the points on the rising and trailing edges of the impulse that are 20 dB below the peak level, whichever time interval is shorter.

6 Types of sound

The type of sound that exists at a point in a sound field can be classified according to its temporal characteristics (how it varies with time) and its spectral characteristics (how it varies over frequency). The