ANSI S12.18-1994
(ASA 110-1994)

AMERICAN NATIONAL STANDARD

PROCEDURES FOR OUTDOOR MEASUREMENT OF SOUND PRESSURE LEVEL

ANSI S12.18-1994 (ASA 110-1994)

Accredited Standards Committee S12, Noise

Standards Secretariat
Acoustical Society of America
120 Wall Street, 32nd Floor
New York, New York 10005-3993

The American National Standards Institute, Inc. (ANSI) is the national coordinator of voluntary standards development and the clearing house in the U.S. for information on national and international standards.

The Acoustical Society of America (ASA) is an organization of scientists and engineers formed in 1929 to increase and diffuse the knowledge of acoustics and to promote its practical applications.

ANSI S12.18-1994
(ASA 110-1994)

AMERICAN NATIONAL STANDARD

Procedures for Outdoor Measurement of Sound Pressure Level

Secretariat

Acoustical Society of America

Approved 12 May 1994

American National Standards, Inc.

ABSTRACT

This American National Standard describes procedures for the measurement of sound pressure levels in the outdoor environment, considering the effects of the ground, the effects of refraction due to wind and temperature gradients, and the effects due to turbulence. This standard is focused on measurement of sound pressure levels produced by specific sources outdoors. The measured sound pressure levels can be used to calculate sound pressure levels at other distances from the source or to extrapolate to other environmental conditions or to assess compliance with regulation. This standard describes two methods to measure sound pressure levels outdoors. METHOD No. 1: general method, outlines conditions for routine measurements. METHOD No. 2: precision method, describes strict conditions for more accurate measurements. This standard assumes the measurement of A-weighted sound pressure level or time-averaged sound pressure level or octave, 1/3-octave or narrow-band sound pressure level, but does not preclude determination of other sound descriptors.

AMERICAN NATIONAL STANDARDS ON ACOUSTICS

The Acoustical Society of America provides the Secretariat for Accredited Standards Committees S1 on Acoustics, S2 on Mechanical Vibration and Shock, S3 on Bioacoustics, and S12 on Noise. These committees have wide representation from the technical community (manufacturers, consumers, and general-interest representatives). The standards are published by the Acoustical Society of America through the American Institute of Physics as American National Standards after approval by their respective standards committees and the American National Standards Institute.

These standards are developed and published as a public service to provide standards useful to the public, industry, and consumers, and to Federal, State, and local governments.

Each of the accredited standards committees (operating in accordance with procedures approved by ANSI) is responsible for developing, voting upon, and maintaining or revising its own standards. The ASA Standards Secretariat administers committee organization and activity, and provides liaison between the accredited standards committees and ANSI. After the standards have been produced and adopted by the accredited standards committees, and approved as American National Standards by ANSI, the ASA Standards Secretariat arranges for their publication and distribution.

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. Consensus is established when, in the judgement of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made towards their resolution.

The use of an American National Standard is completely voluntary; their existence does not in any respect preclude anyone, whether he has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

CAUTION NOTICE: An American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken periodically to reaffirm, revise, or withdraw a standard.

Standards Secretariat
Acoustical Society of America
120 Wall Street, 32nd Floor
New York, New York 10005-3993

Telephone (212) 248-0373
Telefax (212) 248-0146

Contents

Page

Foreward v

0 Introduction 1

1 Scope, purpose, and applications 2

2 References to other standards 2

3 Definitions 3

4 Environmental requirements 3

4.1 General 3

4.2 Factors influencing sound pressure level measurements 4

4.2.1 Geometrical divergence 4

4.2.2 Atmospheric absorption 4

4.2.3 Effects of the environment 4

4.2.4 Miscellaneous attenuation 4

4.3 Outdoor measurement of sound pressure level 5

4.3.1 Geometrical divergence 5

4.3.2 Atmospheric absorption 5

4.3.3 Environmental measurements 6

4.4 METHOD #1: General method for routine measurements 6

4.4.1 Effects of the environment 6

4.4.1.1 Wind, temperature and cloud cover 6

4.4.1.2 Ground, precipitation and snow 7

4.4.2 Miscellaneous attenuation 7

4.5 METHOD #2: Precision method for accurate measurement 7

4.5.1 Effects of the environment 7

4.5.1.1 Requirements 7

4.5.1.2 Ground categorization 7

4.5.1.3 Ground classification 7

4.5.1.4 Comparison of sound pressure levels 8

Page

4.5.2 Miscellaneous attenuation 8

4.6 Terrain equivalence 8

4.7 Ground equivalence 8

5 Acoustical environment 9

5.1 Types of measurements 9

5.1.1 Ambient sound measurements 9

5.1.2 Source measurements 9

5.2 Classification of the sound source 9

5.2.1 Temporal characteristics 9

5.2.2 Frequency characteristics 9

6 Instruments for measuring sound pressure level outdoors 10

6.1 Sound level motor/analyzer 10

6.2 Microphone 10

6.3 Calibration 10

6.4 Tape recorder 10

6.5 Miscellaneous 10

6.6 Configuration of measuring system 10

6.7 Wind speed and direction 10

6.8 Temperature sensor 11

7 Measurement 11

7.1 Premeasurement planning 11

7.2 Sound descriptor 11

7.3 Source configuration and operation 11

7.3.1 Environmental conditions 11

7.3.2 Configuration and installation of a source at a sound measurement site 11

7.3.2.1 Configuration and installation of the source 11

7.3.2.2 Configuration and installation of auxiliary equipment 11

7.3.2.3 Physical environment in which the source is located 12

7.3.2.4 Specifying the installation of the microphones 12

		Page
7.4	Duration or sample size	12
7.5	Data collection	12
7.5.1	Preliminary verification	12
7.5.2	Calibration	12
7.5.3	Meterological	13
7.5.4	Background sound	13
7.5.5	Sound pressure level at each microphone	13
7.5.6	Repeat	13
7.5.7	Final calibration	13
8	Data reduction	13
8.1	Corrections	13
8.1.1	Calibration	13
8.1.2	Contamination by background sound	13
8.1.3	Normalization to reference atmospheric or environmental conditions	14
8.1.3.1	Temperature/relative humidity	14
8.1.3.2	General meteorological conditions	14
8.1.3.3	Ground terrain	14
8.1.3.4	Miscellaneous effects	14
8.2	Experimental error	14
9	Reporting	15
9.1	Introductory information	15
9.2	Site sketches	15
9.2.1	Plan view	15
9.2.2	Elevation view	15
9.3	Characterization of the source	15
9.4	Documentation of the instrumentation	15
9.5	Meteorological data	15
9.6	Acoustical data	15
9.7	Other observations	15

Page

Annex

A Propagation of sound outdoors

A.1 Geometrical divergence 16

A.2 Atmospheric absorption 16

A.3 Effects of the environment 16

A.3.1 Effect of a level reflecting ground 16

A.3.2 Classification of ground surfaces 17

A.3.3 Refraction due to wind velocity and temperature gradients 17

A.3.4 Atmospheric turbulence 17

A.4 Miscellaneous attenuation 18

A.4.1 Attenuation due to reflections 18

A.4.2 Attenuation due to foliage 18

A.4.3 Attenuation due to barriers 18

A.5 Discussion 18

Tables

1 The two METHODS for outdoor measurement of sound pressure level described in this Standard. 5

2 Suggested measurement durations. 12

3 Adjustment of measured level to account for the effect of background sound.. 13

Figures

1 Direct and reflected ray paths, r_1 and r_2 respectively. The angle ϕ is the grazing angle. 3

2 Curved ray paths in the presence of refraction. (a) downward refraction; (b) upward refraction.. 16

Foreword

[This Foreword is not a part of American National Standard for Outdoor Measurement of Sound Pressure Level, ANSI S12.18-1994 (ASA Catalog No. 110-1994)]

This standard provides guidelines for measuring and reporting sound pressure levels associated with a specific source and observed under different environmental conditions outdoors. This standard presents requirements for the documentation of the procedures and results to permit interpretation and independent evaluation of the results.

This standard has been developed under the jurisdiction of Accredited Standards Committee S12, Noise, using the American National Standards Institute (ANSI) Accredited Standards Committee Procedure. The Acoustical Society of America provides the Secretariat for Accredited Standards Committee S12, Noise.

Accredited Standards Committee S12, Noise, under whose jurisdiction this standard was developed, had the following scope:

> *Standards, specifications, and terminology in the field of acoustical noise pertaining to methods of measurement, evaluation, and control; including biological safety, tolerance, and comfort, and physical acoustics as related to environmental and occupational noise.*

At the time this standard was submitted to Accredited Standards Committee S12, Noise, for approval, the membership was as follows:

D. L. Johnson, *Chair*
P. D. Schomer, *Vice Chair*
A. Brenig, *Secretary*

Acoustical Society of America	D. L. Johnson, W. J. Galloway (*Alt.*)
Acoustical Systems, Inc.	R. Goodwin, R. Seitz (*Alt.*)
Air-Conditioning and Refrigeration Institute	S. Wang, J. Clukey (*Alt.*)
Aluminum Company of America (ALCOA)	S. I. Roth
American Academy of Otolaryngology—Head & Neck Surgery, Inc.	L. A. Michael (*Alt.*)
American College of Occupational Medicine	P. J. Brownson, J. Sataloff (*Alt.*)
American Industrial Hygiene Association	C. D. Bohl
American Otological Society	R. F. Naunton
American Society of Heating, Refrigeration & Air-Conditioning Engineers (ASHRAE)	J. Pei, J. L. Heldenbrand (*Alt.*)
American Speech–Language-Hearing Association	R. F. Burkard
Audio Engineering Society, Inc.	M. R. Chial
Bruel & Kjaer Instruments, Inc.	G. C. Michel
Compressed Air and Gas Institute (CAGI)	J. H. Addington
Computer and Business Equipment Manufacturers Association	L. F. Luttrell
David Taylor Research Center	D. J. Vendittis
Edison Electronic Institute	J. Fox, M. C. Mingoia (*Alt.*)

Fastener Industry Noise Control Research Program	E. H. Toothman, J. C. McMurray (*Alt.*)
U. S. Department of Transportation	A. Konheim
Industrial Safety Equipment Association	A. M. Bovi, R. Campbell (*1st Alt.*), F. E. Wilcher (*2nd Alt.*)
Larson-Davis Laboratories	R. Anderson, L. Davis (*Alt.*)
National Council of Acoustical Consultants	J. Erdreich, R. L. Richards (*Alt.*)
National Electrical Manufacturers Association (NEMA)	D. Rawlings
National Hearing Conservation Association (NHCA)	J. Franks, E. H. Berger (*Alt.*)
Power Tool Institute, Inc.	R. Callahan, D. Keller (*Alt.*)
U. S. Army Aeromedical Research Laboratory	B. Mozo, J. H. Patterson (*Alt.*)
U. S. Army Construction Engineering Laboratory (USA-CERL)	P. D. Schomer, M. White (*Alt.*)
U. S. Department of the Air Force	R. L. McKinley
U. S. Department of the Army, Walter Reed Army Medical Center	R. M. Atack
U. S. Department of the Navy, Bureau of Medicine and Surgery	J. Page, L. Marshall (*Alt.*)

Individual experts of Accredited Standards Committee S12, Noise, were:

P. K. Baade	W. J. Galloway	L. H. Royster
R. G. Bartheld	R. Guernsey	W. R. Thornton
R. W. Benson	R. K. Hillquist	H. E. von Gierke
L. Beranek	D. L. Johnson	L. A. Wilber
E. H. Berger	W. W. Lang	G. E. Winzer
K. M. Eldred	G. C. Maling, Jr.	G. S. K. Wong
R. S. Gales	A. H. Marsh	R. W. Young

Working Group S12/WG27, Outdoor Measurement of Sound Pressure Level, which assisted Accredited Standards Committee S12, Noise, in the development of this standard, had the following membership:

G. A. Daigle, Chair

C. D. Bohl	R. Raspet
S. I. Hayek	J. M. Sabatier
J. S. Lamancusa	L. C. Sutherland
J. Nicolas	D. Thomson
R. J. Peppin	W. L. Willshire
A. D. Pierce	

Suggestions for improvements of this standard will be welcomed. They should be sent to the Accredited Standards Committee S12, at the Standards Secretariat, in care of the Acoustical Society of America, 120 Wall Street, 32nd Floor, New York, New York 10005-3993. Telephone (212) 248-0373; FAX (212) 248-0146.

American National Standard

Outdoor Measurement of Sound Pressure Level

0 Introduction

This Standard is concerned with the measurement of sound pressure levels outdoors under a variety of conditions. The basic purpose of this standard is to establish uniform procedures for obtaining sound pressure level data in the presence of the effects of the ground and meteorology outdoors.

The purpose of sound pressure level measurements fall into two broad categories: sound pressure levels measured in order to characterize a specific source and sound pressure levels measured in order to characterize an ambient environment. Primary interest in this standard is focused on sound pressure levels obtained outdoors from specific sources.

This standard is an application of the fundamental standard ANSI S1.13. Whereas the focus of ANSI S1.13 is the basic requirements for the measurement of sound pressure levels for their own sake, the focus of the current standard is the requirements for sound pressure level measurements undertaken outdoors for the specific purpose of source characterization. The current standard specifies requirements in addition to those given in ANSI S1.13.

The procedures for measurement of long-term environmental sound levels outdoors at one or more locations in a community for such purposes as noise prediction validation, regulation and environmental assessment or compatible land use planning are covered by other American National Standards such as ANSI S12.9. The procedures recommended by ANSI S12.9 sample outdoor sound by accepting the environmental and meteorological conditions "as is" within broad limits, thereby providing a statistical sampling of the environmental levels from a variety of sources and meteorological conditions. The current standard specifically excludes outdoor measurement of total environmental sound in a community. However, guidance is given in this standard to obtain an estimate of the ambient sound levels.

The measurement of sound pressure level may not always suffice for the quantitative characterization of the sound produced by a source. The total acoustic power radiated by a source of sound is usually preferable to provide a better measure of source output. Since acoustic power is usually calculated from measured values of time mean square sound pressure which depend on the acoustic environment, it is necessary to design the measurement environment carefully if the accuracy required for sound ratings and comparisons is to be achieved. All aspects of the determination of sound power of sources are covered by other American National Standards such as ANSI S12.30 through S12.36. The current standard specifically excludes those sound pressure level measurements which are obtained in order to permit calculation of the sound power radiated by a source.

This standard describes procedures to measure sound pressure levels from specific sources outdoors. Sound pressure levels from a specific source outdoors are a function of source height, receiver height, the type of ground, and the local atmospheric conditions. Therefore, measured sound pressure levels do not generally obey the simple inverse square law of a 6 dB decrease in level for each doubling of distance. The application of the procedures recommended by this standard will yield reproducible sound pressure levels from measurements of the same source at the same microphone location on different days. The measurements obtained using this standard could be used to adjust sound pressure levels from the same source obtained at different sites for reliable comparison or could be used to calculate sound pressure levels at other distances from the source or to extrapolate to other environmental conditions or to assess compliance with community noise ordinances.

This standard describes two methods for measuring sound pressure levels outdoors. METHOD #1: general method, outlines conditions for routine measurements. METHOD #2: precision method, describes strict conditions for precise measurements. In planning a series of sound pressure measurements, the purpose of the measurements should be kept clearly in mind.

The two methods for sound pressure level measurements in this standard are summarized in Table 1. The method selected depends upon the required accuracy of the measurements. In many situations, the measurement procedure of the general method may be entirely adequate. The precision method is used when more precise measurements are required or for an analysis of the sound pressure levels in frequency bands from measurements made under prescribed meteorological and ground conditions over an appropriate time interval.

METHOD #1: general method, is for routine measurements and is utilized if meteorological variables fall within broad but predetermined limits. No effort is made to control the acoustical environment; that is, the environment is in an "as is" condition. This method usually will utilize a hand held sound level meter to provide a frequency weighted and time-averaged sound pressure level, but does not preclude instruments for frequency band analysis.

METHOD #2: precision method, is for more reproducible measurement of sound pressure levels if the meterorological and ground conditions fall within strict limits. The acoustical environment may be in an "as is" condition, or guidelines are given to modify or find a controlled acoustical environment for better accuracy. Procedures are suggested to adjust the measured sound pressure levels to reference conditions. The precision method is suited for frequency band analysis, but also provides more accurate frequency weighted sound pressure levels if required.

1 Scope, purpose, and applications

1.1 Scope

This standard describes methods for measuring sound pressure levels in the outdoor environment, taking into account the effects of refraction due to wind and temperature gradients, the effects of atmospheric turbulence, the effects of variable ground impedance, and wind noise.

This standard assumes A-frequency weighting or the use of octave, 1/3-octave, or narrow-band filters, but does not preclude the use of other frequency weighting or other sound descriptors.

This standard prescribes selected meteorological conditions under which sound pressure level measurements shall be made. Certain meteorological conditions are reproducible and correspond to quite stable sound propagation conditions. These optimal conditions yield reproducible measurements and allow the comparison of sound pressure levels measured at different times.

The standard does not prescribe standardized receiver locations. Sound pressure levels may be measured at receiver locations of interest, within certain prescribed limits.

Measurement conditions shall be carefully documented and noted in the report describing the sound pressure level measurements. The measured sound pressure levels shall apply only to the stated conditions and shall not represent the sound pressure levels under other conditions, sites, receiver locations, or sources. In some cases, guidance is provided to adjust the measured sound pressure levels to reference conditions, other sites, or other receiver location.

This standard does not include procedures for measurement of long-term, time-average environmental sound levels in a community for environmental assessment or planning for compatible land uses.

Sound pressure levels measured for determining the sound power radiated by a source are not covered by this standard.

1.2 Purpose

The purpose of this standard is to specify procedures for measuring and reporting sound pressure levels from specific sources outdoors and to specify a set of reproducible atmospheric conditions to obtain reproducible measurements.

1.3 Applications

This standard is applicable to the measurement of sound pressure levels from specific sources outdoors. The measurements take into account the source height, receiver height, the type of ground, and the local atmospheric conditions. A major application of this standard is obtaining reproducible sound pressure levels from the same source at the same microphone location on different days. Another application is to adjust sound pressure levels from the same source measured at different sites or distances for reliable comparison. The sound pressure levels measured using this standard can be used to calculate sound pressure levels at other distances from the source or to extrapolate to other environmental conditions. The measurements can be used in conjunction with other standards and procedures to obtain a more accurate test for compliance with community noise regulations.

2 References to other standards

The following standards contain provisions which, through reference in this document, 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, 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 listed below.

(1) **ANSI S1.4-1983** *American National Standard Specifications for Sound Level Meters*, (ASA 47-1983); and Amendment No. 1 in ANSI S1.4A-1985.

(2) **ANSI S1.11-1986 (R1993)** *American National Standard Specifications for Octave-Band and Fractional-Octave-Band Analog and Digital Filters.*

(3) **ANSI S1.13-1971 (R1986)** *American National Standard Specifications for the Measurements of Sound Pressure Levels.*

(4) **ANSI S1.26-1978 (R1989)** *American National Standard Method for the Calculation of the Absorption of Sound by the Atmosphere*

(5) **ISO 2613-1 (1993)** *Attenuation of sound during propagation outdoors—Part 1: Calculation of the absorption of sound by the atmosphere.*

(6) **ANSI S1.40-1984 (R1990)** *American National Standard Specification for Acoustical Calibrators.*

(7) **ANSI S12.9-1988 (R1993)** *American National Standard Quantities and procedures for description and measurement of environmental sound, Part 1.*

(8) *Integrating-Averaging Sound Level Meters, IEC Standard*, Publication 804, 1984.

(9) *Sound Level Meters*, IEC 651, 1979.

(10) *Description and measurement of environmental noise*, ISO 1996: 1982.

3 Definitions

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.

background sound: All encompassing sound associated with a given environment without contributions from the source or sources of interest.

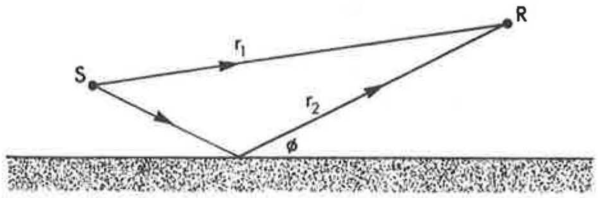

Figure 1

grazing angle: Angle of elevation of the source and receiver when measured from the ground at the point of specular reflection (see Fig. 1).

ground impedance: (A complex function of frequency) the specific acoustic impedance of the ground surface at a frequency; that is, the sound pressure at a frequency divided by the normal component of acoustic particle velocity directed into the surface at the frequency.

sound pressure level: Ten times the logarithm to the base 10 of the square of the ratio of the sound pressure to the reference sound pressure of 20 μPa.

4 Environmental requirements

4.1 General

The sound pressure levels measured in the vicinity of an outdoor source is influenced by the medium through which the sound propagates. Normally occurring variations in meteorological conditions can easily result in sound pressure level variations on the order of 20 dB or more. The presence of the ground, in particular, or other surfaces normally influence the measured sound pressure levels. Small changes in source orientation can also affect measured sound pressure levels when the source exhibits directional radiation characteristics. In order to obtain accurate, reproducible data, it is imperative to understand and consider the influence of environmental variables on the measurement of sound pressure level.

Sound propagating outdoors through the atmosphere generally decreases in level with increasing distance between source and receiver. This attenuation is the result of several mechanisms, most notably geometrical divergence from the sound source, absorption of acoustic energy by the air through which the sound waves propagate, and the effects of the environment. The environmental effects principally arise from propagation close to different ground surfaces in the presence of ambient atmospheric conditions, especially wind and temperature.

In the case of sound from a source radiating equally in all directions in a free field (i.e., far from all reflective or absorptive surfaces), the octave-band sound pressure level L_p, in decibels, at a microphone is given by

$$L_p = L_W - A_{total} - 10.9 \quad (1)$$

where L_W is the sound power level in decibels re 1 pW of the source in that octave band. In Eq. (1) a temperature of 20 °C and an atmospheric pressure of 1 atm has been assumed. In the case of a directional point source the term L_W in Eq. (1) is the sound power level of the source that is effective for radiating sound (in that octave band) in the direction of propagation from source to receiver.

The total attenuation, in decibels, in each octave band shall be approximated by

$$A_{total} = A_{div} + A_{air} + A_{env} + A_{misc} \quad (2)$$

In Eq. (2) the first three terms give the attenuation from three principal effects—geometrical divergence (A_{div}), air absorption (A_{air}), and the environment (A_{env}). The last term (A_{misc}) covers attenuation from additional effects which arise only in specific cases; for example, reflections from buildings, propagation through foliage, and propagation through built-up areas of houses or other low buildings.

4.2 Factors influencing sound pressure level measurements

4.2.1 Geometrical divergence

At large distances from a source in a homogeneous, non-dissipative atmosphere in the absence of a reflecting plane, the sound pressure varies inversely with distance from the source. The attenuation, in decibels, due to divergence, A_{div}, shall be determined from

$$A_{div} = 20 \log (r/r_0) \quad (3)$$

where r is the distance from the point source in meters and r_0 is a reference distance of 1 meter.

The term 20 log (r/r_0) signifies that the sound pressure level will decrease six decibels each time the distance from the acoustic center of the source is doubled, or equivalently, 20 dB for each tenfold increase of distance. If the dimension of the source is large relative to the wavelength of sound it radiates, or the distance from the center of the source is small relative to the overall dimensions of the source, there is an area in the vicinity of the source where pressure maxima and minima may occur, and/or where the decay with distance does not follow the 6 dB/doubling relationship.

4.2.2 Atmospheric absorption

As sound propagates through the atmosphere its energy is gradually absorbed by a number of energy-exchange processes in the air called atmospheric absorption. Details on the amount of absorption affecting individual measurements made at long distances are found in ANSI S1.26.

4.2.3 Effects of the environment

The propagation of sound close to the ground for horizontal distances less than 30 m is essentially independent of meteorological conditions; for this case the atmosphere can be regarded as homogeneous and the ray paths approximated by straight lines. The attenuation due to the effects of the environment (A_{env}) is then that due to the ground alone.

For distances greater than 30 m meteorological conditions usually become a major factor. These factors include refraction by wind and temperature gradients and atmospheric turbulence. The meteorological effects then modify the ground attenuation to produce the total attenuation due to the environment.

Annex A provides a detailed discussion of the individual mechanisms contributing to A_{env}.

4.2.4 Miscellaneous attenuation

The term A_{misc} in Eq. (2) covers contributions to the attenuation from effects not included in the other terms. These contributions are the effect of reflection from the walls of buildings or other near vertical surfaces, the attenuation when propagating through foliage, and any other situations not covered by the above.

Annex A provides a detailed discussion of the individual terms contributing to A_{misc}.

Table 1 – The two Methods for outdoor measurement of sound pressure level described in this Standard.

METHOD #1: General method for routine measurements.

(1) No sound level measurement shall be made when the average wind velocity exceeds 5 m/s when measured at a height of 2±0.2 m above the ground.

(2) If the distance between source and receiver exceeds 30 m and the grazing angle is smaller than 20°, measurements shall only be made with the receiver downwind from the source and when the direction of the wind vector is within an angle of ±45° of the direction connecting the center of the sound source and the center of the specified receiver area.

(3) No sound level measurement shall be made at distances greater than 30 m on a sunny day with little or no cloud cover (sun essentially unobscured by clouds at least 80% of the time) and if the wind speed is less than 1 m/s when measured at a height of 2±0.2 m above the ground.

(4) Alternatively, measurement at any distance in any near horizontal direction can be made if propagation occurs under a well-developed ground-based temperature inversion with winds less than 1 m/s measured at a height of 2±0.2 m.

(5) No measurements shall be made during measurable precipitation or freezing rain.

(6) Measurement during precipitation or when the ground is wet or snow covered is highly discouraged. Measurements in the presence of contributions from miscellaneous effects should be avoided.

METHOD #2: Precision method for accurate measurements.

Measurement shall only be made if:

(1) direction of the wind vector is within an angle of ±45° of the direction connecting the center of the sound source and the center of the specified receiver area, with the wind blowing from the source to the receiver; and,

(2) wind velocity is between approximately 1 and 3 m/s measured at a height of 2±0.2 m above the ground.

Alternatively, measurement in any near horizontal direction can be made if:

(3) propagation occurs under a well-developed ground-based temperature inversion with winds less than 1 m/s measured at a height of 2±0.2 m.

Further, measurement shall only be made if:

(4) the ground can be properly categorized according to the methods in Section 6.5.1.2;

(5) there are no phenomena that contribute to miscellaneous attenuation.

4.3 Outdoor measurement of sound pressure level

The two methods described in this standard are summarized in Table 1. The following specifications apply to the application of both METHOD #1 and METHOD #2.

4.3.1 Geometrical divergence

This standard does not prescribe standardized receiver distances and hence does not impose any specific requirement on the first term in Eq. (2) describing the attenuation due to geometrical divergence.

Eq. (3) can be used to adjust sound level measurements for geometrical divergence.

4.3.2 Atmospheric absorption

This standard does not prescribe standardized atmospheric variables that control atmospheric absorption. Measurements made at long distances shall be adjusted for atmospheric absorption by using ANSI S1.26.

As a rough rule of thumb, for typical broadband noise sources, the attenuation in A-weighted sound levels due to atmospheric absorption will usually exceed about 1 dB for typical weather, at distances greater than about 200 m.

4.3.3 Environmental measurements

Ambient air temperature and relative humidity shall be carefully recorded during the acoustical measurements. The average temperature and relative humidity provided by the nearest meteorological office can be used. If the air temperature is measured on site, the sensor shall be mounted at a height of 2±0.2 m above the ground.

Wind velocity shall be measured at a height of 2±0.2 m above the ground.

The component of wind velocity from source to receiver for a given set of acoustical measurements shall be determined by:

(1) monitoring wind velocity (speed and direction) throughout any period of acoustical measurement;

(2) noting the average speed and direction over the period of any acoustical measurement; and

(3) computing from these averages the vector component of wind velocity in the direction from the source to the receiver; for line sources, this component shall be computed along the normal line between source and receiver; for sources distributed at specified locations, the line between the receiver and center of the sources shall be used.

4.4 METHOD #1: General method for routine measurements

Measurements shall be conducted only if variables that influence the terms in Eq. (2) fall within broad, but precisely predetermined limits. The general method is most suited for the measurement of A-weighted sound pressure level, but does not preclude other measurements such as octave band sound pressure level.

4.4.1 Effects of the environment

The following conditions will yield accurate and reproducible sound pressure level measurements if the noise spectrum is broad and approximately flat, with no discrete tones and when only the A-weighted sound pressure level at the receiver position is of interest. In this case, the attenuation due to the environment is approximately that for 500 Hz. As the spectrum of the noise shifts to higher frequencies, the accuracy of the measurement decreases.

4.4.1.1 Wind, temperature and cloud cover

No sound level measurement shall be made when the average wind velocity exceeds 5 m/s when measured at a height of 2±0.2 m above the ground. No attempt shall be made to adjust measured noise levels based on the wind data.

If the distance between source and receiver exceeds 30 m and the grazing angle (ϕ in Fig. 1) is smaller than 20°, measurements shall only be made with the receiver downwind from the source and the direction of the wind vector is within an angle of ±45° of the direction connecting the center of the sound source and the center of the specified receiver area. At distances beyond 30 m at grazing angles smaller than 20°, measurements made upwind would be in a refractive shadow which alters the spectrum of the received signal and the sound pressure levels significantly because the attenuation provided by the environment, A_{env} in Eq. (2), becomes excessive.

No sound level measurement shall be made at distances greater than 30 m on a sunny day with little or no cloud cover (sun essentially unobscured by clouds at least 80% of the time) and if the wind speed is less than 1 m/s when measured at a height of 2±0.2 m above the ground. At distances beyond 30 m under these conditions, the measurement would be made in a refractive shadow which alters the spectrum of the received signal and sound pressure levels significantly because the attenuation provide by the environment, A_{env} in Eq. (2), becomes excessive.

Alternatively, measurement at any distance in any near horizontal direction can be made if propagation occurs under a well-developed ground-based temperature inversion with winds less than 1 m/s measured at a height of 2±0.2 m. The existence of a temperature inversion shall be carefully documented.

Ambient air temperature and cloud cover shall be noted and recorded during the acoustical measurements in order to ascertain that the above requirements were met. No attempt shall be made to adjust measured noise levels for cloud cover or temperature.

4.4.1.2 Ground, precipitation and snow

This standard does not prescribe standardized ground. The ground surface over which the measurement is made shall be carefully documented to allow for the possibility of future consideration of possible errors introduced by the nature of the terrain. If measurements must be compared, terrain equivalence and ground equivalence can then be obtained.

No measurements shall be made during measurable precipitation or freezing rain. Measurable precipitation almost always influences outdoor sound levels. For example, tires rolling on a paved surface produce higher sound levels when the pavement is wet. Ground that is saturated with water after a heavy rain fall can produce erratic values of A_{env} in Eq. (2). Also, fallen snow on the ground will affect the measured sound level at about any distance from the source by strongly influencing the values of A_{env} in Eq. (2).

Measurement during precipitation or when the ground is wet or snow covered is highly discouraged. If it is necessary to obtain data when the ground is wet or snow covered, the conditions shall be carefully described.

4.4.2 Miscellaneous attenuation

Measurements in the presence of contributions from miscellaneous effects, such as those identified in 6.2.4, should be avoided. If it is not possible to obtain data in the absence of effects that provide contributions to A_{misc} in Eq. (2), the conditions that govern these effects such as a reflecting object, barrier, or other, shall be carefully described.

4.5 METHOD #2: Precision method for accurate measurements

Precise measurements can be made under favorable propagation conditions that are stable and suitable for reproducible measurement. The attenuation due to the environment, A_{env}, here is relatively insensitive to minor changes of atmospheric conditions and is largely controlled by the ground only. The precision method is recommended for obtaining octave, 1/3-octave, or narrow band sound pressure levels outdoors. The method is also suited for obtaining accurate frequency-weighted sound pressure levels directly.

4.5.1 Effects of the environment

4.5.1.1 Requirements

Measurements shall only be made if:

(1) direction of the wind vector is within an angle of ±45° of the direction connecting the center of the sound source and the center of the specified receiver area, with the wind blowing from the source to the receiver; and,

(2) wind velocity is between approximately 1 and 3 m/s measured at a height of 2±0.2 m above the ground.

Alternatively, measurement in any near horizontal direction can be made if:

(3) propagation occurs under a well-developed ground-based temperature inversion with winds less than 1 m/s measured at a height of 2±0.2 m.

The existence of a temperature inversion shall be carefully documented.

Further, measurement shall only be made if:

(4) the ground can be properly categorized according to the methods in Section 4.5.1.2

(5) there are no phenomena that contribute to the miscellaneous attenuation, A_{misc} in Eq. (2).

4.5.1.2 Ground categorization

The ground can be categorized if:

(1) the specific acoustic impedance of the ground is known or can be measured. Although several methods exist to measure this property, there is no standard procedure. If a measurement of ground impedance is made, the method used shall be carefully documented; or,

(2) in the absence of ground impedance data, the ground can be documented as acoustically *hard ground* or *soft ground* according to the physical properties of the surface and the grazing angle.

4.5.1.3 Ground classification

For grazing angles less than 20°, the following descriptions shall be used as a guide to categorize the ground in the absence of ground impedance data:

(1.a) *Hard Ground*—Open water, asphalt or concrete pavement, and other ground surfaces having low porosity tend to be highly reflective, absorbing very little acoustic energy upon reflection. Tamped ground, for example, as often occurs around industrial sites, can be considered as hard ground.

(1.b) *Soft Ground*—Ground covered by grass, shrubs, or other vegetation, and all other porous grounds suitable for the growth of vegetation such as farming land typically cause significant attenuation at low frequencies. New-fallen snow is even more absorptive at low frequencies than grass covered ground as is ground covered in pine needles or similarly loose material. This standard recommends that measurements above snow-covered ground be avoided unless operation of the sound source is intimately tied with this ground condition.

(2) At grazing angles greater than 20°, which can commonly occur at short ranges or in the case of elevated sources, soft ground becomes a good reflector of sound and can be considered *hard ground*.

4.5.1.4 Comparison of sound pressure levels

Valid comparison of sound pressure level measurements made at the same distances and receiver heights can be obtained by establishing terrain and ground equivalence. Alternatively measurements made at different distances or receiver heights can be compared by adjusting the measured sound pressure levels using Eq. (2) for the different distances and receiver heights.

This standard does not prescribe the use of particular prediction methods to compute A_{env} in Eq. (2). Moreover, when predictions are used to adjust sound pressure levels, errors inherent in the chosen prediction method decrease the precision of the measured results.

When prediction methods are used to compute A_{env};

(1) the prediction method shall consider all the effects identified in Section 4.2.3.

(2) documentation shall exist on the field validation or calibration of the prediction method over the relevant topography and type of ground; this documentation shall be referenced in the test report, and the results of this validation must be sufficient to ascribe quantitative error to the predictions.

Any prediction method that meets these requirements may be used. Source and receiver positions must be modeled as precisely as possible relative to the ground within the constraints of the prediction method.

4.5.2 Miscellaneous attenuation

Measurements in the presence of contributions from miscellaneous attenuation effects such as those identified in 6.2.4, shall not be made.

4.6 Terrain equivalence

To permit valid comparisons of sound level measurements, the equivalence of terrain, ground, and atmospheric conditions between measurements must be determined, and must be documented.

The terrain at two sites shall be judged equivalent when:

(1) the same major source-emitting components of the source can be seen at the receiver position of the two sites;

(2) if the terrain is not flat, similar reflection patterns off the ground exist at each site between the receiver and the major source components of the source;

(3) in the case of METHOD #1 only, similar reflective paths that contribute to A_{misc} in Eq. (2) exist from surfaces to the side of, or behind the, receiver position.

A ground profile (elevation view) between source and receiver shall be drawn as described in 9.2.2 to aid in the assessment of terrain equivalence.

4.7 Ground equivalence

The equivalence of the ground at two sites may be determined by measurement of the specific acoustic impedance of the ground. While several methods exist to measure this property, there are no standard procedures available at the time of preparation of this standard.

Therefore, if measurements of ground impedance are not to be made, then the ground shall be categorized (e.g., paved, long grass over loose sand, short grass over packed clay, packed sandy dirt roadway, etc.), and an equivalent site of the same category shall be selected. In this process of categorization, note that only a thin surface layer of soil is relevant, at the very most 5 cm in depth.

Extreme changes in the surface water content should be avoided for equivalence (such after heavy rain), and frozen or snow-covered ground should be avoided because of its variability.

5 Acoustical environment

5.1 Types of measurements

5.1.1 Ambient sound measurements

The observed ambient sound pressure level is usually a superposition of the sound generated by many sources at different locations. The propagation of the sound from each source will be influenced by all or some of the terms in Eq. (2). In this type of measurement, the time-averaged mean squared sound pressure is of interest, rather than the value generated by any of the individual sources operating in the environment. A statistical description of the combined level produced by all of the sources operating simultaneously is frequently of interest.

Only METHOD #1, general method for routine measurements, described under Section 4.3 applies to ambient sound pressure level measurements. For more complete procedures for the measurement of ambient sound pressure levels, see ANSI S12.9 and ANSI S1.13.

5.1.2 Source measurements

This type of measurement is intended to determine the sound pressure level due to a particular source. The source of interest will frequently be operating in the presence of other sources which establish the background sound. Background sound pressure levels during the operation of the source of interest may prevent a true measurement of the source sound pressure level. For a measure of unmasked sound pressure level, the background sound pressure level shall be 10 dB or more below the level from the source of interest. If possible, the background sound pressure level shall be determined in full or 1/3 octaves by shutting down, quieting or removing from the site, the source of interest. Alternately, a measurement in a similar environment or neighborhood without the source may be used as an estimate of the background sound pressure level. If the background level is within 10 dB of the level with the source operating, the procedure described in Section 8.1.2 provides an adjustment to be made to the measured level to obtain a corrected source level for each frequency band. These corrections are to be applied to band levels of frequency bandwidth equal to or less than one full octave. Overall levels can then be calculated by summing over the individual frequency bands. These corrections shall not be applied directly to overall (broadband) weighted or unweighted levels.

Source measurements are made either under METHOD #1, general method for routine measurements (Section 8.4) or under METHOD #2, precision method for accurate measurements (Section 4.5).

NOTE–ANSI S12.9 Part 3 offers more guidance on the elimination of background sound from measurements of a particular source.

5.2 Classification of the sound source

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).

5.2.1 Temporal characteristics

The temporal characteristics of the sound source are broadly classified as *continuous* or *intermittent*. Within each of these categories, and during the time interval that the sound is actually "on" at the measurement point, it may be further classified as either *steady, fluctuating*, or *impulsive*. Guidance on judgment of the temporal nature of the noise may be found in ANSI S1.13 as well as the suggested measurement durations.

In addition to the temporal aspects of the sound field due to the nature of the source, temporal variations due to the atmosphere are superimposed. Guidance on time duration of the measurement are given in Section 7 to ensure that very short term weather effects are averaged out.

5.2.2 Frequency characteristics

The sounds usually encountered in practice may be classified as either *broad-band sounds, narrow band sounds*, or *discrete tones*. The total sound at a given point in space may be a combination of two or all of these. Guidance on judgment of the frequency nature of the noise may be found in ANSI S1.13.

6 Instruments for measuring sound pressure level outdoors

6.1 Sound level meter/analyzer

Sound level meters or measurement systems meeting the Type 1 requirements of ANSI S1.4-1983 should be used. Use of Type 2 equipment, while not precluded, will increase experimental error.

The frequency range shall be 20 Hz to 20 kHz.

The measurement shall be normally made with the sound level meter set to A-weighting; however, for evaluation of sound sources dominated by high frequency impulsive sounds or very low frequency (i.e., infrasonic) sound, C- or another weighting may be more appropriate.

The frequency response of the measurement system shall be calibrated at least annually to conform to the specifications of ANSI S1.4.

Frequency filter sets, if used, shall meet requirements of ANSI S1.11. The particular octave bands to be used should be chosen according to the characteristics of the source being studied. Typically, eight such filters, corresponding to nominal midband frequencies of 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz, shall suffice.

Use of integrating sound level meters is recommended if the chosen descriptor for the study is average sound level or sound exposure level. Such meters should meet the requirements of IEC 804.

Dynamic range of the measurements should be such that attenuator changes are not required unless only the maximum level is required. Otherwise the dynamic range should be 10 dB below the lowest expected or measured and 10 dB above the highest expected or measured sound pressure level.

The instrumentation should be capable of accurate measurements for sounds with a crest factor, resolution and temperature operating range in accordance with ANSI S1.4.

6.2 Microphone

Microphone characteristics shall conform to the requirements of ANSI S1.4 or IEC 651.

The orientation should be in accordance with the characteristics of the microphone so that the frequency response is as flat as possible.

All items used to hold or support microphones shall be oriented so as to produce minimum shielding or reflection of noise from the source to the microphone.

High humidity or temperature can change the sensitivity or damage many types of microphones. The microphone manufacturer's instructions shall be carefully followed to avoid such effects.

6.3 Calibration

A microphone calibrator with an accuracy of ±0.5 dB, meeting the requirements of ANSI S1.40, shall be used.

A calibration check shall be performed at least at the beginning and end of each measurement session.

6.4 Tape recorder

If magnetic tape recorders are to be used, they shall be chosen with regard to the guidelines in ANSI S1.13.

6.5 Miscellaneous

A windscreen meeting microphone manufacturer's recommendations shall be used on each microphone during measurements if the wind exceeds 1 m/s.

For general guidance on all other issues pertaining to instrumentation for the measurement of sound pressure level, see ANSI S1.13.

6.6 Configuration of measuring system

The measuring system, including the operator, shall be positioned in such a way that it does not contribute to miscellaneous attenuation.

The preferred measurement height is 1.2 to 1.8 m above the ground.

6.7 Wind speed and direction

An anemometer or other device for measuring wind speed and direction shall be used. This device shall have an accuracy of ±10% of full scale or better. An averaging time of 10–20 s is desirable. The device shall be supported at a height of 2±0.2 m. For octave or 1/3 octave band measurements, some means of storing the time history of wind speed and direction is recommended (e.g., strip chart recorder or digitized signal). If vertical profiles of wind speed are being measured, a support is needed that can be varied in height from the ground to 10% above the height of the path of sound propagation.

Note–Using more than one sensor will increase the tolerance requirement for individual sensors in order to measure meaningful differences over all changes in height.

6.8 Temperature sensor

A thermometer or other temperature sensor should be used for the measurement of ambient temperature. The device shall have an accuracy of ±2 °C. The temperature shall be measured at a height of 2±0.2 m. A variable height support device will be needed if temperature profiles are being taken.

7 Measurement

For outdoor measurements, background sound pressure levels, together with temperature, wind speed and direction, and relative humidity need to be monitored, and the measurement shall be conducted only if these variables fall within the predetermined limits.

7.1 Premeasurement planning

Prior to making the measurement, the following items should be addressed:

(1) selection of measurement site and receiver positions;

(2) selection of source and its operational parameters;

(3) selection of sound descriptor, measurement duration, number of measurement repetitions, and sample size;

(4) selection of measurement method and admissible ground and atmospheric conditions.

7.2 Sound descriptor

The recommended descriptor to be measured is the A-weighted average sound pressure level or octave or 1/3-octave band sound pressure levels. Measurements may also be made with narrow band or other frequency filters. Use of other descriptors pertinent to the objectives of the study is not precluded, such as C-weighted sound pressure levels.

7.3 Source configuration and operation

The configuration, installation and operation of the source shall be such that it will permit measurement of its sound emission consistent with the intended objective of the measurement.

All source operating parameters that could have a significant effect on the test results shall be identified (e.g., electrical power input, speed and rotation if applicable).

During the acoustical measurements, the source shall be operated in a manner typical of normal use in a field installation. The following operational conditions may be appropriate:

(1) device under normal load;

(2) device under full load [if different from (1)];

(3) device under no-load (idling).

Other operational conditions that significantly affect the sound output of the source should also be measured and controlled or varied.

7.3.1 Environmental conditions

To the extent practical and consistent with the purpose of this standard, environmental conditions that significantly affect the sound output of the source should be measured and controlled within appropriate limits or taken into account by adjustments.

7.3.2 Configuration and installation of a source at a sound measurement site

The directivity index of the source indicates how many decibels the sound pressure level of the sound source in the direction of propagation under consideration exceeds that of a non-directional point source of the same power at the same distance. Small changes in orientation of the source may result in appreciable changes in the sound pressure level.

In the case of measurement of sound emitted by a source at a measurement site of interest, the following items should be considered:

7.3.2.1 Configuration and installation of the source

Whenever a typical condition of mounting exists for the source, that condition shall be used or simulated, if practicable.

7.3.2.2 Configuration and installation of auxiliary equipment

Sources may normally be used with certain standard components, and auxiliary equipment. Auxiliary equipment may act as an additional source of sound or may also act to reduce the level of the sound produced by the source. To ensure meaning-

Table 2 – Suggested measurement durations.

Temporal nature	Greatest anticipated range 10 dB	10–30 dB	30 dB
Steady continuous	2 min	Not applicable	Not applicable
Fluctuating continuous	5 min	15 min	30 min
Impulsive continuous	5 min	15 min	30 min
Steady intermittent	For at least ten events	For at least ten events	For at least ten events
Fluctuating intermittent	For at least ten events	For at least ten events	For at least ten events
Impulsive intermittent	For at least ten events	For at least ten events	For at least ten events

ful measurements, installation and operation of auxiliary equipment shall be specified in order to separate their effects from the effects of the environment.

7.3.2.3 Physical environment in which the source is located.

When a source is mounted near one or more reflecting planes, its radiation may differ appreciably from that of free space. If such a mounting is typical of field installations, the reflecting plane shall be considered to be a part of the source and not part of a contribution to miscellaneous attenuation.

7.3.2.4 Specifying the installation of the microphones.

Microphone positions shall be selected so that an adequate sampling is obtained of the sound field in the ambient environment or in the vicinity of a sound source. The number of microphone positions selected shall be adequate to describe the ambient environment or specify the characteristics of the source. The preferred height of the microphone above the ground for outdoor measurements is 1.2 to 1.8 m. Other heights may be used if they prove to be more practicable or if they are specified in other pertinent standards.

7.4 Duration or sample size

Different sources or sound descriptors may require different measurement durations or sample sizes. For example, ANSI S12.9–Part 3 describes detailed procedures to acquire average sound level data from a source in such a way as to exclude short periods of excessive background sound. Choice of a duration shall consider:

(1) Temporal variation of the noise;

(2) sound descriptor being measured;

(3) range in sound pressure level.

If the user is interested in many source conditions, then a duration long enough to average over all source conditions is needed.

Guidance on judgment of the temporal nature of the noise shall be found in ANSI S1.13. Suggested measurement durations based on the temporal nature of the sound and the range in sound level pressure fluctuations are given in Table 2.

Repeated measurements at a receiver position are required to assess the repeatability of the measurement results; these repetitions are then incorporated into the error analysis. The number of measurement repetitions to be made at a receiver position affects the experimental error that must be computed and reported. A minimum of three repetitions under equivalent conditions is recommended.

7.5 Data collection

7.5.1 Preliminary verification

Make a preliminary verification that source, ground, and atmospheric parameters are as desired; begin collection of needed information for test report.

7.5.2 Calibration

Calibrate equipment according to manufacturers' instruction, with all cabling to be used in the measurement in the circuits for calibration and electrical interference checks.

Table 3 – Adjustments of measured level to account for the effect of background sound.

Difference between measured level and background level (dB)	Adjustment to be made to measured level (dB) to obtain corrected source level
4	−2.2
5	−1.7
6	−1.3
7	−1.0
8	−0.8
9	−0.6
10	−0.4
Greater than 10	0

7.5.3 Meteorological

Wind sensors shall be located at an exposed position and at a height of 2±0.2 m. Temperature sensors shall be shielded from direct solar radiation and mounted at a height of 2±0.2 m. Obtain the relative humidity from an on-site sensor or from the nearest meteorological office.

7.5.4 Background sound

Sample the background sound pressure level at each microphone including the reference microphone with the source quieted, shut down, stopped operation or removed from the site. The suggested samples sizes in Table 2 shall be used. Simultaneously sample meteorological conditions, recording the average wind speed and direction over the period of the acoustical measurement.

If the study source cannot be quieted, shut down, stopped operation or removed for a background sound measurement, determine an upper limit for the background level at a site removed from the study source.

7.5.5 Sound pressure level at each microphone

Sample the sound pressure level at each microphone including the reference microphone with the study source in operation. Simultaneously sample meteorological conditions and any desired source operational parameters.

7.5.6 Repeat

Repeat 9.5.4 and 9.5.5 for the number of repetitions suggested in 9.4 for each source-receiver pair to be studied.

7.5.7 Final calibration

Perform a final calibration check for all microphones. Changes in calibration exceeding 1 dB are unacceptable. In such cases, equipment should be checked, and measurements made at microphones showing such a shift shall be discarded and repeated. Changes in calibration of less than 1 dB are acceptable, see Sect. 8.1.1.

8 Data reduction

This section discusses factors relative to measurements and data reduction.

8.1 Corrections

8.1.1 Calibration

If the final calibration level for a sound measuring system differs from the initial calibration level by 1 dB or less, all measurements made with that system shall be adjusted by one-half of the difference (e.g., if the final level is lower than the correct value, then increase the measured levels).

8.1.2 Contamination by background sound

If the increase in the sound pressure level in any given band, with the source operating, compared to the background sound pressure level alone is 10 decibels or more, the sound pressure level due to both the source and background sound is essentially the sound pressure level due to the source alone. This is the preferred condition, but is frequently unattainable in the field.

If the increase in sound pressure level in any given band, with the sound source operating, compared to the background sound pressure level is 3 decibels or less, the sound pressure level due to the sound source is equal to or less than the background sound pressure level, and the two contributions cannot be properly separated with the measuring techniques described in this standard.

If the increase in sound pressure level in any given band, with the sound source operating, compared to the background sound pressure level, is between 4 and 10 decibels, the sound pressure level due to the sound source alone may be approximated. Subtract the background level from the measured level at each receiver position; use Table 3 with each of these differences to adjust each level accordingly to obtain a corrected sound level.

For those cases where the difference is less than 4.0 dB, the unadjusted source level is to be reported and identified as "masked" by the background level.

8.1.3 Normalization to reference atmospheric or environmental conditions

In the case of octave, 1/3-octave or narrow-band sound pressure level measurements, the levels in each individual band measured under a set of well defined atmospheric and environmental conditions can be adjusted to estimate the level that would have been measured under other conditions. The calculation can also be used to normalize measurements made under different environmental conditions in order to obtain levels that can be compared directly.

8.1.3.1 Temperature/relative humidity

These variables mainly determine the term A_{air}. In order to correct the measurements to other conditions of temperature and relative humidity, or to other distances they shall be corrected by the amount given in ANSI S1.26.

8.1.3.2 General meteorological conditions

If the meteorological conditions such as wind speed and direction do not fall within the specifications for either METHOD #1 or METHOD #2 as specified in Section 5, measurements do not conform with the requirements of this standard. No attempt shall be made to correct measured sound pressure levels based on wind or temperature data except for the adjustment for A_{air} for temperature as specified in 8.1.3.1.

8.1.3.3 Ground terrain

When measurements are made following the procedure outlined under METHOD #2–precision method for accurate measurements, the attenuation due to the environment is largely controlled by the ground, especially at shorter distances. Measurements made over well defined ground conditions can be corrected to other grounds if the ground can be properly categorized.

8.1.3.4 Miscellaneous effects

There is no general procedure to calculate the attenuation (A_{misc}) due to the various miscellaneous mechanisms (other than A_{div}, A_{air}, and A_{env}) that affect the sound pressure level measurements outdoors. However, in the case of METHOD #1–general method for routine measurements, where it is not possible to obtain measurements in the absence of effects that provide contributions to A_{misc}, an estimate of A_{misc} can sometimes be obtained.

8.2 Experimental Error

The experimental error is a cumulation of random and bias errors.

Random errors include:

(1) instrumentation error (meter/analyzer);

(2) variation in levels due to changes in wind velocity within the allowable range for a set of measurements;

(3) variation in levels within a given cloud cover, or due to temperature changes within the prescribed limits;

(4) variation in levels due to changes in source characteristics within the allowable ranges.

Random errors are estimated by the repetition of the measurements for each source-receiver pair and the resultant computation of a variance for the measurements.

Bias errors include:

(1) calibrator bias within its stated accuracy range;

(2) site bias;

(3) error inherent in prediction model if one is used to adjust levels.

9 Reporting

9.1 Introductory information

Documentation shall be sufficiently complete to permit independent repetition of the sound pressure level measurement. This will take into account changes in environmental conditions or corrections to reference environmental and ground conditions.

The introductory information shall state the objectives behind the measurements, and the method, type of source, and sound descriptor that were used, as well as any points of exception to this standard. Definition of the descriptor shall be referenced to the appropriate standard, or shall be given if not standardized.

9.2 Site sketches

Site sketches shall be used to identify sound sources, their locations, other significant factors such as background sound sources and the location where the measurements were made.

9.2.1 Plan view

The plan view shall include source positions, receiver positions, and outlines of significant reflecting objects such as buildings and clusters of trees. When practical, the plan view should be extended 50 m in all directions beyond the outermost receiver and source positions. Distances from each receiver and each source shall be indicated. The magnitude and direction of any ground slope shall be indicated.

9.2.2 Elevation view

An elevation view shall be prepared for each source-receiver pair and should extend at least 50 m beyond each. For linear sources, such as streams of highway traffic, this view should be along the normal line between source and receiver. Each elevation view shall show the peaks of all terrain and structural features either rising above or approaching within 2 m of the line of sight between the source and receiver. Elevations of the source and the receiver shall be indicated. Changes in terrain and type of ground conditions shall be marked. Ground slope magnitudes along the elevation view shall be indicated to the nearest degree.

9.3 Characterization of the source

The make, model, and where appropriate, serial number of all the equipment shall be reported. If the sound sources are motors or engines and used to drive significant sound sources, then the power rating of the prime mover should be recorded. The acoustical spectra of the source may be recorded and reported.

9.4 Documentation of the instrumentation

The manufacturer, type, and serial number of all microphones, meters, analyzers, calibrators, and meteorological sensors shall be reported and keyed to specific measurement points. Settings of controllable instrument parameters such as amplifier gains, recording speeds, recorder gains, field calibration levels, and calibration signal levels and spectra should be provided. Documentation of field calibration shall be included. When data reduction is done away from the site (such as in analyzing tape recordings), documentation of the instrumentation and procedures shall be provided.

9.5 Meteorological data

Data from meteorological sensors shall be reported in sufficient detail to document calculation of the component of average wind velocity from source to receiver, the average temperature, and humidity. The cloud cover class shall also be specified, with a brief statement as to existing weather conditions.

9.6 Acoustical data

The results of the sound pressure level survey will be reported. Data of particular interest would be background sound measurement without the source if possible. All results may be reported either graphically or numerically as appropriate. Data and time of day of the measurement shall be included.

Data obtained from measurements made according to the requirements of this standard can be compared with other acoustical data if the conditions under which the two sets of data were obtained were as nearly identical as is practicable. Otherwise, one or both sets of data must be adjusted to the same acoustical conditions.

Any adjustment shall only be done if the measurements were obtained using METHOD #2–precision method for accurate measurements.

9.7 Other observations

A discussion of any unforeseen events during the measurements that could relate to the source emission, sound propagation or background sound should be included. Any situations that suggest modifications to the experiment for improved results should be documented. Any relevant subjective judgments or interpretations may appear in this section of the measurement report.

Annex A
(informative)
Propagation of sound outdoors

(This annex is not part of American National Standard Outdoor Measurement of Sound Pressure Level, ANSI S12.18-1994, but is included for information purposes only.)

The measurement of sound pressure levels outdoors requires an understanding of the mechanisms that cause attenuation, especially the combined effects of the ground surface and atmospheric refraction for different height and frequency sources. These mechanisms include attenuation due to geometrical divergence, attenuation from air absorption, attenuation resulting from the environment (especially from the effects of the ground and refraction), and miscellaneous attenuation from additional effects which arise only in specific cases. These mechanisms are discussed in more detail in this Appendix.

A.1. Geometrical divergence

At large distances from a source in a homogeneous, non-dissipative atmosphere in the absence of a reflecting plane, the sound pressure varies inversely with distance from the source. The attenuation in decibels due to divergence, A_{div}, is therefore approximated by

$$A_{div}=20 \log (r/r_0)\ (dB) \qquad \text{(A1)}$$

where r is the distance from the point source in meters and r_0 is a reference distance of 1 meters.

A.2 Air absorption

As sound propagates through the atmosphere its energy is gradually absorbed by a number of energy-exchange processes in the air. The amount of absorption depends strongly on frequency and relative humidity, and less strongly on temperature. It also depends slightly on the ambient pressure, sufficiently to require consideration with large changes of altitude (thousands of meters), but not with changes of the weather.

In most conditions, dry air can produce high attenuation of sound at high frequencies. Therefore, in the case of a predominantly high-frequency source, measurements made under dry conditions can differ considerably from measurements made under more humid conditions.

Details on attenuation by air absorption are given in ANSI S1.26.

A.3 Effects of the environment

The propagation of sound close to the ground for horizontal distances less than a few tens of meters is essentially independent of meteorological conditions; for this case the atmosphere can be regarded as homogeneous and the ray paths (see Fig. 2) approximated by straight lines. The attenuation due to the effects of the environment (A_{env}) is then that due to the ground alone. For greater distances meteorological conditions usually become a major factor. These factors are refraction by wind and temperature gradients and atmospheric turbulence. The meteorlogical effects then modify the ground attenuation to produce the total attenuation due to the environment.

A.3.1 Effect of a level reflecting ground

When the sound source is located near a perfectly reflecting ground, sound waves which reflect from the plane will constructively or destructively interfere with those propagating directly from the source (see Fig. 1). Destructive interference occurs at frequencies where the direct and reflected wave propagation distances differ by multiples of one-half wavelength. For the more realistic case when the sound

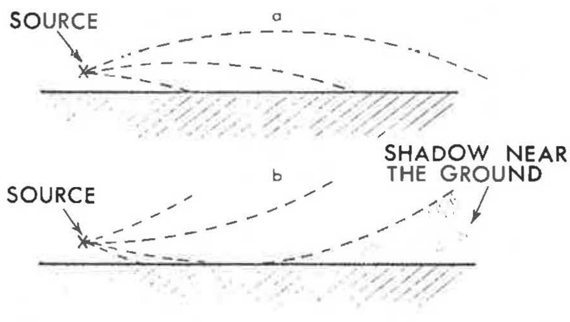

Figure 2

source is located near a partially reflecting ground, the reflected wave is also modified in amplitude and phase by its interaction with the ground surface. The amount of attenuation attributable to this ground interaction, and its variation with frequency depends on the surface type and the source/receiver heights and their separation.

A.3.2 Classification of ground surfaces

The surface of the ground may be classified according to its acoustical properties for the case of grazing angles less than 20° as follows:

(1) *Hard ground*—Open water, asphalt or concrete pavement, and other ground surfaces having very low porosity tend to be highly reflective, absorbing very little acoustic energy upon reflection. Tamped ground, for example, as often occurs around industrial sites, or adjacent to highways or other roadways or railways, can be considered as hard ground.

(2) *Soft ground*—Ground covered by grass, shrubs, or other vegetation, and all other porous grounds suitable for the growth of vegetation such as farming land typically cause significant attenuation at low frequencies.

(3) *Very soft ground*—New-fallen snow is even more absorptive at low frequencies than grass covered ground as is ground covered in pine needles or similarly loose material. Measurements of sound pressure levels above snow-covered ground should be avoided unless operation of the sound source is intimately tied with this ground condition.

(4) *Mixed ground*—a ground surface which includes both hard and soft areas.

(5) *At grazing angles greater than 20°*, which can commonly occur at short ranges or in the case of elevated sources, soft ground becomes a good reflector of sound and can be considered *hard ground*. Very soft ground is less predictable and measurements of sound pressure levels above very soft ground should be avoided.

A.3.3 Refraction due to wind velocity and temperature gradients

The main effect of meteorological conditions is refraction, a change in direction of the sound waves, produced by vertical gradients of wind and temperature.

Sound refracts (bends) upward, as shown in Fig. 2, when the propagation is upwind. Refraction upward often produces a shadow zone near the ground, as shown in the figure, resulting in an excessive attenuation that typically reaches 20 dB or more. Sound pressure level measurements from specific sources will not be reproducible under these conditions. Sound refracts downward, as shown in Fig. 1, when the propagation is downwind. Such downward refracting conditions are favorable for propagation, producing a minimum of attenuation due to the effects of the environment and can represent a preferred source level measurement condition.

During the late morning and afternoon, the air temperature usually decreases steadily with increasing height above the ground, a condition known as temperature lapse; sound refracts upward resulting in a shadow zone near the ground [Fig. 2]. In contrast, at night the temperature often decreases with decreasing height (due to radiation cooling of the ground surface), a condition known as temperature inversion, which may extend to one hundred meters or more above the ground late at night; sound refracts downward, producing a minimum of attenuation due to the environment and therefore represents another condition favorable for propagation.

A.3.4 Atmospheric turbulence

The atmosphere is an unsteady medium with random variations in temperature, wind velocity, pressure, and density. In practice only the temperature and wind velocity variations significantly affect sound waves over a short time period. When sound waves propagate through the atmosphere, atmospheric turbulence scatters the sound energy resulting in random fluctuations in amplitude and phase of the sound waves.

Atmospheric turbulence often causes fluctuations in the measured sound pressure levels from relatively distant sources such as aircraft. However, the fluctuations in sound pressure level which initially increase with increasing distance, quickly reach a limiting value. For example when the noise from an aircraft propagates under clearly line-of-sight conditions over distances of a few kilometers, the measured sound pressure levels fluctuate about their mean value with a standard deviation of no more than about 6 dB. Under other propagation conditions there may be greater fluctuations due to multipath interference, such as in the case of propagation from aircraft flying at heights of several kilometres.

An effect of atmospheric turbulence is the effective attenuation of sound in the direction of maximum radiation for highly directional sound fields. However, for a spherically expanding non-directional source the root-mean-square sound pressure in an unsteady atmosphere is the same as it would be in the absence of turbulence. Other acoustical phenomena are most strongly and directly affected by atmospheric turbulence. For example the interference of direct and ground-reflected discrete-frequency sound waves depends critically on the exact phase relationship that exists between them. In the extreme, turbulence can completely eradicate the interference spectrum at higher frequencies. Another example of the degradation of an acoustical field is the increased sound pressure levels within a refractive shadow [see Fig. 2].

A.4 Miscellaneous attenuation

The term A_{misc} in Eq. (2) covers contributions to the attenuation from effects not included in the other terms. These contributions are the effect of reflection from the walls of buildings or other near vertical surfaces, the attenuation when propagating through foliage, and any other situations not covered by the above.

A.4.1 Attenuation due to reflections

The sound pressure signal that arrives at the receiver by reflection from a more or less vertical surface such as the exterior wall of a building enhances the sound pressure that propagates directly from source to receiver (see Fig. 1).

A.4.2 Attenuation due to foliage

Trees and bushes are very poor sound barriers; they provide very little attenuation as a result of shielding. Their roots do provide some ground attenuation by keeping the soil porous. Therefore, the principal contribution of foliage is not to barrier attenuation but instead to ground attenuation which is inherent in the calculation for A_{env}. However, if the foliage is dense enough to completely obstruct the view, and if it also intercepts the path of sound propagation, there may be some additional attenuation caused by propagation through the foliage. A hedge, a row of bushes, a strip of vegetation left to grow naturally, or a forest may all be examples of dense foliage. There is little or no attenuation from bare branches or trunks of trees at frequencies of interest.

A.4.3 Attenuation due to barriers

A barrier is any solid obstacle that is relatively opaque to sound and which blocks the line-of-sight from the sound source to receiver. Barriers can be erected specifically to reduce noise, or they may occur naturally such as buildings or walls.

A.5 Discussion

In cases where refraction can be neglected above a soft ground surface, the effects of the ground are largest for intermediate frequencies (500 Hz) when the source is above the ground (1 m or more). If the source is close to the ground all frequencies above 500 Hz display large attenuations. This attenuation is discussed in References A1 and A2. Extra care in ground characterization and equivalence should be used for sources at all heights at intermediate frequencies and for sources low to the ground at intermediate and high frequencies.

Refraction has a small effect on sound pressure levels out to approximately 30 m. Beyond this distance, shadow zones become important for upward refraction and the sound pressure levels drop dramatically. A more complete discussion of this large attenuation is found in References A3 and A4. The effects of refraction are usually largest over a hard surface and can often lead to anomalous measurements. More restrictive conditions are needed to produce reproducible measurements over a hard surface.

References

A1 J. E. Piercy, T. F. W. Embleton, and L. C. Sutherland, "Review of noise propagation in the atmosphere," *J. Acoust. Soc. Am.* **61**, 1403–1418 (1977).

A2 T. F. W. Embleton, "Sound propagation outdoors—Improved predictions schemes for the 80's," *Noise Control Eng. J.* **18**, 30–39 (1982).

A3 S. W. Lee, N. Bong, W. F. Richards, and R. Raspet, "Impedance formulation of the fast-field program for acoustic wave propagation in the atmosphere," *J. Acoust. Soc. Am.* **79**, 628–634 (1986).

A4 M. J. White and K. E. Gilbert, "Application of the parabolic equation to the outdoor propagation of sound," *Appl. Acoust.* **27**, 227–238 (1989).

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 (ASA 111)** American National Standard Acoustical Terminology
- **ANSI S1.4-1983 (ASA 47)** American National Standard Specification for Sound Level Meters
- **ANSI S1.4A-1985** Amendment to S1.4-1983
- **ANSI S1.6-1984 (R 1990) (ASA 53)** American National Standard Preferred Frequencies, Frequency Levels, and Band Numbers for Acoustical Measurements
- **ANSI S1.8-1989 (ASA 84)** American National Standard Reference Quantities for Acoustical Levels
- **ANSI S1.10-1966 (R 1986)** American National Standard Method for the Calibration of Microphones
- **ANSI S1.11-1986 (R 1993) (ASA 65)** American National Standard Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters
- **ANSI S1.12-1967 (R 1986)** American National Standard Specification for Laboratory Standard Microphones
- **ANSI S1.13-1971 (R 1986)** American National Standard Methods for the Measurement of Sound Pressure Levels
- **ANSI S1.20-1988 (R 1993) (ASA 75)** American National Standard Procedures for Calibration of Underwater Electroacoustic Transducers
- **ANSI S1.22-1992 (ASA 100)** American National Standard Scales and Sizes for Frequency Characteristics and Polar Diagrams in Acoustics
- **ANSI S1.25-1991 (ASA 98)** American National Standard Specification for Personal Noise Dosimeters (Revision of ANSI S1.25-1978)
- **ANSI S1.26-1978 (R 1989) (ASA 23)** American National Standard Method for the Calculation of the Absorption of Sound by the Atmosphere
- **ANSI S1.40-1984 (R 1990) (ASA 40)** American National Standard Specification for Acoustical Calibrators
- **ANSI S1.42-1986 (R 1992) (ASA 64)** American National Standard Design Response of Weighting Networks for Acoustical Measurements

S2 STANDARDS ON MECHANICAL VIBRATION AND SHOCK

- **ANSI S2.2-1959 (R 1990)** American National Standard Methods for the Calibration of Shock and Vibration Pickups
- **ANSI S2.3-1964 (R 1990)** American National Standard Specifications for a High-Impact Shock Machine for Electronic Devices
- **ANSI S2.4-1976 (R 1990) (ASA 8)** American National Standard Method for Specifying the Characteristics of Auxiliary Analog Equipment for Shock and Vibration Measurements
- **ANSI S2.5-1962 (R 1990)** American National Standard Recommendations for Specifying the Performance of Vibration Machines
- **ANSI S2.7-1982 (R 1986) (ASA 42)** American National Standard Balancing Terminology
- **ANSI S2.8-1972 (R 1990)** American National Standard for Describing the Characteristics of Resilient Mountings
- **ANSI S2.9-1976 (R 1990) (ASA 6)** American National Standard Nomenclature for Specifying Damping Properties of Materials
- **ANSI S2.10-1971 (R 1990)** American National Standard Methods for Analysis and Presentation of Shock and Vibration Data
- **ANSI S2.11-1969 (R 1986)** American National Standard for the Selection of Calibrations and Tests for Electrical Transducers used for Measuring Shock and Vibration
- **ANSI S2.14-1973 (R 1986)** American National Standard for Specifying the Performance of Shock Machines
- **ANSI S2.15-1972 (R 1986)** American National Standard Specification for the Design, Construction, and Operation of Class HI (High-Impact) Shock-Testing Machine for Lightweight Equipment
- **ANSI S2.17-1980 (R 1986) (ASA 24)** American National Standard Techniques of Machinery Vibration Measurement
- **ANSI S2.19-1989 (ASA 86)** American National Standard Mechanical Vibration–Balance Quality Requirements of Rigid Rotors, Part 1: Determination of Permissible Residual Unbalance
- **ANSI S2.20-1983 (R 1989) (ASA 20)** 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 1986) (ASA 31)** American National Standard Method for the Experimental Determination of Mechanical Mobility. Part I: Basic Definitions and Transducers
- **ANSI S2.32-1982 (R 1990) (ASA 32)** American National Standard Methods for the Experimental Determination of Mechanical Mobility. Part II: Measurements Using Single-Point Translation Excitation
- **ANSI S2.34-1984 (R 1990) (ASA 34)** American National Standard Guide to the Experimental Determination of Rotation Mobility Properties and the Complete Mobility Matrix
- **ANSI S2.38-1982 (R 1990) (ASA 44)** American National Standard Field Balancing Equipment—Description and Evaluation
- **ANSI S2.40-1984 (R 1990) (ASA 50)** American National Standard Mechanical Vibration of Rotating and Reciprocating Machinery—Requirements for Instruments for Measuring Vibration Severity
- **ANSI S2.41-1985 (R 1990) (ASA 56)** 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 1990) (ASA 46)** American National Standard Procedures for Balancing Flexible Rotors
- **ANSI S2.43-1984 (R 1990) (ASA 54)** American National Standard Criteria for Evaluating Flexible Rotor Balance
- **ANSI S2.45-1983 (R 1990) (ASA 51)** American National Standard Electrodynamic Test Equipment for Generating Vibration—Methods of Describing Equipment Characteristics
- **ANSI S2.46-1989 (ASA 82)** American National Standard Characteristics to be Specified for Seismic Transducers
- **ANSI S2.47-1990 (ASA 95)** American National Standard Vibration of Buildings—Guidelines for the Measurement of Vibrations and Evaluation of Their Effects on Buildings
- **ANSI S2.48-1993 (ASA 108)** American National Standard Servo-Hydraulic Test Equipment for Generating Vibration—Methods of Describing Characteristics
- **ANSI S2.58-1983 (R 1990) (ASA 52)** American National Standard Auxiliary Tables for Vibration Generators—Methods of Describing Equipment Characteristics
- **ANSI S2.60-1987 (ASA 68)** American National Standard Balancing Machines—Enclosures and Other Safety Measures

• **ANSI S2.61-1989 (ASA 78)** American National Standard Guide to the Mechanical Mounting of Accelerometers

• **ANSI Z24.21-1957 (R 1989)** American National Standard Method for Specifying the Characteristics of Shock and Vibration Measurement

S3 STANDARDS ON BIOACOUSTICS

• **ANSI S3.1-1991 (ASA 99)** American National Standard Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms

• **ANSI S3.2-1989 (ASA 85)** American National Standard Method for Measuring the Intelligibility of Speech Over Communication Systems

• **ANSI S3.3-1960 (R 1990)** American National Standard Methods for Measurement of Electroacoustical Characteristics of Hearing Aids

• **ANSI S3.4-1980 (R 1992) (ASA 37)** American National Standard Procedure for the Computation of Loudness of Noise

• **ANSI S3.5-1969 (R 1986)** American National Standard Methods for the Calculation of the Articulation Index

• **ANSI S3.6-1989 (ASA 81)** American National Standard Specification for Audiometers

• **ANSI S3.7-1973 (R 1986)** American National Standard Method for Coupler Calibration of Earphones

• **ANSI S3.13-1987 (R 1993) (ASA 74)** American National Standard Mechanical Coupler For Measurement of Bone Vibrators

• **ANSI S3.14-1977 (R 1986) (ASA 21)** American National Standard for Rating Noise with Respect to Speech Interference

• **ANSI S3.18-1979 (R 1993) (ASA 38)** American National Standard Guide for the Evaluation of Human Exposure to Whole-Body Vibration

• **ANSI S3.19-1974 (R 1990) (ASA 1)** American National Standard Method for the Measurement of Real-Ear Protection of Hearing Protectors and Physical Attenuation of Earmuffs

• **ANSI S3.20-1973 (R 1986)** American National Standard Psychoacoustical Terminology

• **ANSI S3.21-1978 (R 1992) (ASA 19)** American National Standard Method for Manual Pure-Tone Threshold Audiometry

• **ANSI S3.22-1987 (ASA 70)** American National Standard Specification of Hearing Aid Characteristics

• **ANSI S3.25-1989 (ASA 80)** American National Standard for an Occluded Ear Simulator

• **DRAFT ANSI S3.28-1986 (ASA 66)** Draft American National Standard Methods for the Evaluation of the Potential Effect on Human Hearing of Sounds with Peak A-Weighted Sound Pressure Levels Above 120 Decibels and Peak C-Weighted Sound Pressure Levels Below 140 Decibels

• **ANSI S3.29-1983 (R 1990) (ASA 48)** American National Standard Guide to the Evaluation of Human Exposure to Vibration in Buildings

• **ANSI S3.32-1982 (R 1990) (ASA 43)** American National Standard Mechanical Vibration and Shock Affecting Man—Vocabulary

• **ANSI S3.34-1986 (R 1992) (ASA 67)** American National Standard Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand

• **ANSI S3.35-1985 (R 1990) (ASA 59)** American National Standard Method of Measurement of Performance Characteristics of Hearing Aids Under Stimulated *in-situ* Working Conditions

• **ANSI S3.36-1985 (R 1990) (ASA 58)** American National Standard Specification for a Manikin for Simulated *in situ* Airborne Acoustic Measurements

• **ANSI S3.37-1987 (R 1992) (ASA 69)** American National Standard Preferred Earhook Nozzle Thread for Postauricular Hearing Aids

• **ANSI S3.39-1987 (ASA 71)** American National Standard Specifications for Instruments to Measure Aural Acoustic Impedance and Admittance (Aural Acoustic Immittance)

• **ANSI S3.40-1989 (ASA 79)** 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 (ASA 96)** American National Standard Audible Emergency Evacuation Signal

• **ANSI S3.42-1992 (ASA 103)** American National Standard Testing Hearing Aids with a Broad-Band Noise Signal

• **ANSI S3.43-1992 (ASA 102)** American National Standard Standard Reference Zero for the Calibration of Pure-Tone Bone-Conduction Audiometers

S12 STANDARDS ON NOISE

• **ANSI S12.1-1983 (R 1990) (ASA 49)** American National Standard Guidelines for the Preparation of Standard Procedures for the Determination of Noise Emission from Sources

• **ANSI S12.3-1985 (R 1990) (ASA 57)** American National Standard Statistical Methods for Determining and Verifying Stated Noise Emission Values of Machinery and Equipment

• **ANSI S12.4-1986 (R 1993) (ASA 63)** American National Standard Method for Assessment of High-Energy Impulsive Sounds with Respect to Residential Communities

• **ANSI S12.5-1985 (R 1990) (ASA 87)** American National Standard Requirements for the Performance and Calibration of Reference Sound Sources

• **ANSI S12.6-1984 (R 1990) (ASA 55)** American National Standard Method for the Measurement of the Real-Ear Attenuation of Hearing Protectors

• **ANSI S12.7-1986 (R 1993) (ASA 62)** American National Standard Methods for Measurements of Impulse Noise

• **ANSI S12.8-1987 (ASA 73)** American National Standard Methods for Determination of Insertion Loss of Outdoor Noise Barriers

• **ANSI S12.9-1988/Part 1 (R 1993) (ASA 76)** American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound. Part 1

• **ANSI S12.9-1992/Part 2 (ASA 105)** 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 (ASA 109)** American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 3: Short-Term Measurements with an Observer Present

• **ANSI S12.10-1985 (R 1990) (ASA 61)** 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 1993) (ASA 72)** American National Standard Methods for the Measurement of Noise Emitted by Small Air-Moving Devices

• **ANSI S12.12-1992 (ASA 104)** American National Standard Engineering Method for the Determination of Sound Power Levels of Noise Sources Using Sound Intensity

• **DRAFT ANSI S12.13-1991 (ASA 97)** Draft American National Standard Evaluating the Effectiveness of Hearing Conservation Programs

• **ANSI S12.14-1992 (ASA 101)** 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 (ASA 106)** 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 (ASA 107)** American National Standard Guidelines for the Specification of Noise of New Machinery
- **ANSI S12.18-1994 (ASA 110)** American National Standard Procedures for Outdoor Measurement of sound Pressure Level
- **ANSI S12.23-1989 (ASA 83)** American National Standard Method for the Designation of Sound Power Emitted by Machinery and Equipment
- **ANSI S12.30-1990 (ASA 94)** 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 (ASA 93)** 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 (ASA 92)** 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 (ASA 91)** 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 1993) (ASA 77)** American National Standard Engineering Methods for the Determination of Sound Power Levels of Noise Sources for Essentially Free-Field Conditions over a Reflecting Plane (Revision of ANSI S1.34-1980)
- **ANSI S12.35-1990 (ASA 90)** 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 (ASA 89)** American National Standard Survey Methods for the Determination of Sound Power Levels of Noise Sources (Revision of ANSI S1.36-1979)
- **ANSI S12.40-1990 (ASA 88)** American National Standard Sound Level Descriptors for Determination of Compatible Land Use (Revision of ANSI S3.23-1980)

For ordering information, please contact:

Standards Secretariat
Acoustical Society of America
120 Wall Street, 32nd Floor
New York, New York 10005-3993

Telephone: (212) 248-0373
Telefax: (212) 248-0146

NOTES

NOTES

STANDARDS SECRETARIAT
ACOUSTICAL SOCIETY OF AMERICA

The Standards Publication Program of the Acoustical Society of America (ASA) is the responsibility of the ASA Committee on Standards (ASACOS) and the ASA Standards Secretariat, headed by its Standards Manager.

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/TC94/SC12 Hearing Protection. S3 is the 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 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; and ISO/TC 108/SC5 Condition Monitoring and Diagnostics of Machines.

ASACOS and the ASA Standards Secretariat provide the Secretariat for the U.S. Technical Advisory Groups listed above and administer the international Secretariat for ISO/TC 108 Mechanical Vibration and Shock, ISO/TC 108/SC1 Balancing Machines, and ISO/TC 108/SC5 Condition Monitoring and Diagnostics of Machines.

Standards are produced in four broad areas: physical acoustics, mechanical shock and vibration, bioacoustics, and noise, and are reaffirmed or revised every five years. The latest information on current ANSI standards as well as those under preparation is available from the ASA Standards Secretariat. For information, please contact A. Brenig, Standards Manager, Acoustical Society of America, 120 Wall Street, 32nd Floor, New York, NY 10005-3993. Telephone (212) 248-0373, Telefax (212) 248-0146.