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AMERICAN NATIONAL STANDARD
Specification for Personal Noise Dosimeters

ACCREDITED STANDARDS COMMITTEE S1, ACOUSTICS

ABSTRACT

This Standard contains specifications for performance characteristics of personal noise dosimeters which measure the percentage criterion sound exposure. The Standard makes provision for three exchange rates: 3 dB, 4 dB, and 5 dB per doubling of exposure time. The Standard provides tolerances for the entire instrument including frequency response, exponential averaging (employing SLOW and FAST), threshold, dynamic range, and other characteristics. It specifies that these tolerances be attained by the instrument in a random incidence sound field without the presence of a person wearing the instrument.

CORRECTION NOTICE FOR ANSI S1.25-1991

PLEASE NOTE THAT 1991 IS THE APPROVAL YEAR FOR ANSI S1.25-1991 (AND NOT 1992 AS IS LISTED ON THE TOP OF SOME PAGES IN THE STANDARD). ADDITIONALLY, PARAGRAPH 8.1, PAGE 10, IN THE STANDARD SHOULD BE CORRECTED TO READ "...COMPLIES WITH ANSI S1.25-1991" INSTEAD OF "1992".

AMERICAN NATIONAL STANDARDS ON ACOUSTICS

The Acoustical Society of America provides the Secretariat for Accredited Standards Committees S1 on Acoustics, S2 on Mechanical Shock and Vibration, 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.

This standard was approved by the American National Standards Institute as ANSI S1.25-1991 on 24 October 1991.

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. An American National Standard is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of an American National Standard does not in any respect preclude anyone, whether he has approved the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard. American National Standards are subject to periodic review and users are cautioned to obtain the latest editions.

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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.

Published by the Acoustical Society of America through the American Institute of Physics

FOREWORD

(This Foreword is for information only, and is not a part of American National Standard Specification for Personal Noise Dosimeters, ANSI S1.25-1991, ASA Catalog No. 98-1991, [A revision of ANSI S1.25-1978].)

The initial standard, Specification for Personal Noise Dosimeters, ANSI S1.25-1978 (ASA 25-1978) contained a significant constraint, "This standard is not intended to specify a dosimeter suitable for measurement of noise that is predominantly impulsive." Developments in the state of the art responsive to requirements of regulatory agencies and contemporary practice in industrial hygiene necessitated revision of the standard to remove the constraint.

Accredited Standards Committee S1, Acoustics, has the following scope:

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

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

G. S. K. Wong, *Chair*
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Individual experts of the Accredited Standards Committee S1, Acoustics, were:

J. Erdreich	R. K. Hillquist	L. W. Sepmeyer
K. M. Eldred	D. L. Johnson	W. R. Thornton
D. R. Flynn	W. W. Lang	H. E. von Gierke
W. J. Galloway	G. C. Maling, Jr.	G. S. K. Wong
E. E. Gross, Jr.	A. H. Marsh	R. W. Young
R. M. Guernsey	A. P. G. Peterson	

Working Group S1/WG7, Personal Dosimeters, which assisted the Accredited Standards Committee S1, Acoustics, in the development of this Standard, had the following membership:

J. J. Earshen, *Chairman*

J. P. Barry	R. W. Krug	A. H. Suter
C. D. Bohl	R. G. Kunicki	W. R. Thornton
J. Erdreich	G. A. Luz	E. H. Toothman
T. M. Fairman	G. C. Michel	W. D. Ward
D. L. Johnson	J. P. Seiler	G. S. K. Wong

Suggestions for improvements in this standard will be welcomed. They should be sent to **Accredited Standards Committee S1, Acoustics, at the Standards Secretariat, in care of the Acoustical Society of America, 335 East 45th Street, New York, NY 10017-3483. Telephone: (212) 661-9404.**

CONTENTS

AMERICAN NATIONAL STANDARD SPECIFICATION FOR PERSONAL NOISE DOSIMETERS

1. INTRODUCTION

Personal noise dosimeters are widely used for monitoring noise environments that may be hazardous to hearing. It is important, therefore, that a standard be available to help minimize variations between results obtained with devices of various makes and models that satisfy the standard.

A noise dosimeter is a device that integrates a function of sound pressure over a period of time and thus determines sound exposure as a percentage of a stated criterion sound exposure.

To satisfy various noise hazard criteria, A-weighted sound pressure raised to one of three different exponents is integrated over time. The exponent used is characterized in terms of a level-time exchange rate. Exchange rates of 3, 4, or 5 dB for a two-to-one change in exposure time are specified in this standard. Thus, for example, in a dosimeter having an exchange rate of 3 dB, an identical indicated result will be produced when exposure duration is halved and sound level is increased by 3 dB.

This standard follows the principles adopted for calibration of sound level meters (American National Standard Specification for Sound Level Meters, ANSI S1.4-1983). Thus the instrument is calibrated to read correctly in a random-incidence field without the presence of reflecting objects such as the wearer.

A personal noise dosimeter is frequently carried on the person with the microphone mounted on the shoulder, at the chest, or at an ear. It may also be used as an area monitor, not attached to the person. If a comparison is made between the results of a specific dosimeter when used as an area monitor and the results of the same dosimeter worn by a person who is immersed in the sound field that was monitored by the area monitor, differences are likely to be observed (Ref. 1).

2. SCOPE

This standard specifies certain characteristics of a personal noise dosimeter. It also specifies allowable tolerances of those characteristics, and it describes how those characteristics are to be verified. It provides for three different exchange rates, two frequency weightings, and two exponential averaging time constants.

NOTE: At present, the regulatory practices of the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) specify use of dosimeters having A-weighting, 5 dB exchange rate and SLOW exponential time averaging. The U.S. Department of Defense practices specify A-weighting, 4 dB exchange rate and SLOW exponential time averaging.

Other options including C-weighting, 3 dB exchange rate and FAST exponential time averaging are included to provide instrument standards to serve the needs of research and developing regulatory practices. International Organization for Standardization Standard 1999:1990 for occupational noise specifies only A-weighted sound exposure with 3 dB exchange rate and with no exponential time averaging.

This standard is intended to specify a dosimeter suitable for measurement of impulsive, intermittent, and continuous noise.

3. DEFINITIONS

3.1 Sound-Pressure Level

Twenty times the logarithm to the base ten of the ratio of the root-mean-square (rms) sound pressure to the reference sound pressure. For the purpose of this standard, the reference pressure is 20 micropascal (20 μPa = 20 μN/m^2 = 0.0002 μbar).

3.2 Sound Level

Sound-pressure level in decibels, re 20μPa, obtained by use of standardized frequency weighting and exponential time averaging.

3.3 Peak Sound Pressure

Greatest absolute instantaneous sound pressure during a given time interval.

3.4 Tone Bursts

One or more complete cycles of a sinusoidal signal. For the purpose of this standard, the tone burst signals must start and end at a zero crossing of the waveform.

3.5 Pulse Range

Difference in decibels between the peak signal level of a tone burst and the level of a continuous low level signal specified by the manufacturer for which the specifications of Sec. 5.4 are met.

3.6 Criterion Sound Level (criterion level)

Level of a sound which, continuously applied for eight hours, results in a 100% criterion exposure.

3.7 Criterion Duration

A duration of 8 hours (h), which is used as a basis for measurement.

3.8 Exchange Rate

The change in sound level corresponding to a doubling or halving of the duration of sound level while a constant percentage of criterion exposure is maintained.

3.9 Time Constant

Time required for the amplitude of that component of a field quantity which varies exponentially with time, to be multiplied by the factor $1/e = 0.3679$. Where e is the base of the natural logarithm. A SLOW time constant is 1.0 second. A FAST time constant is 0.125 second.

3.10 Operating Range

The range between the threshold level and an upper sound level within which the dosimeter operates within stated tolerances.

3.11 Threshold Level

A sound level or levels specified by the manufacturer below which the dosimeter produces little or no dose accumulation as specified in this standard (*See* Sec. 7.7).

3.12 Sound Exposure

The time integral over a stated time or event of the SLOW or FAST exponential-time-averaged, squared, A or C-weighted, sound pressure signal when the 3 dB exchange rate is used. For the 5 dB and 4 dB exchange rates respectively, it is the time integral, over a stated time or event of the 0.6 and 0.75 power of the SLOW or FAST exponential-time-averaged, squared, A- or C-weighted, sound pressure signal. Sound exposure is accumulated only when the sound level exceeds the threshold level.

For the personal noise dosimeter, the A or C frequency weighting and SLOW or FAST exponential-time-averaging are to be specified. Otherwise SLOW (1 second) exponential-time-averaging and A-weighting are understood.

NOTE: In general, for the 3 dB exchange rate, which is sometimes called the "true energy" system, sound exposure may be defined as the time integral of squared instantaneous A-weighted sound pressure. Time averaging is optional, or may not be required.

3.13 Criterion Sound Exposure

The product of the criterion duration and the mean-square sound pressure corresponding to the criterion sound level when the 3 dB exchange rate is used. The product of the criterion duration and the 0.6 or 0.75 power of the mean-square sound pressure corresponding to the criterion sound level when the 5 dB or 4 dB exchange rate respectively is used.

3.14 Percentage Criterion Exposure

The ratio of sound exposure and criterion sound exposure, multiplied by 100. The ratio is always expressed as a percentage.

3.15 Class Designation

An alphanumeric sequence that consists of the tolerance descriptor the frequency weighting, the exponential averaging time constant, the criterion sound level, the threshold level and the exchange rate. For example, Class 2AF- 90/80-5 means that the dosimeter has tolerances that correspond to those for a Type 2 sound-level meter (ANSI S1.4-1983), with an A-frequency-weighting network and an exponential averager having FAST response; the criterion level is 90 dB, the threshold level is 80 dB and the exchange rate is 5 dB.

The options for class designation are:

Frequency Weighting	A or C
Time Constant	F (FAST); S (SLOW)
Criterion Level	90, 85, 84, 80, V (Variable)
Threshold Level	90, 80, V (Variable)
Exchange Rate	5, 4, 3

NOTE: For dosimeters with variable criterion and threshold levels, the selected levels shall be specified in order to obtain a valid reading.

4. GENERAL CHARACTERISTICS

4.1 General

A noise dosimeter is generally a combination of a microphone, an amplifier with specified frequency weighting, a squaring device, an exponential averaging device with a specified time constant, a holding upper limit indicator, an exponent circuit with a specified ex-

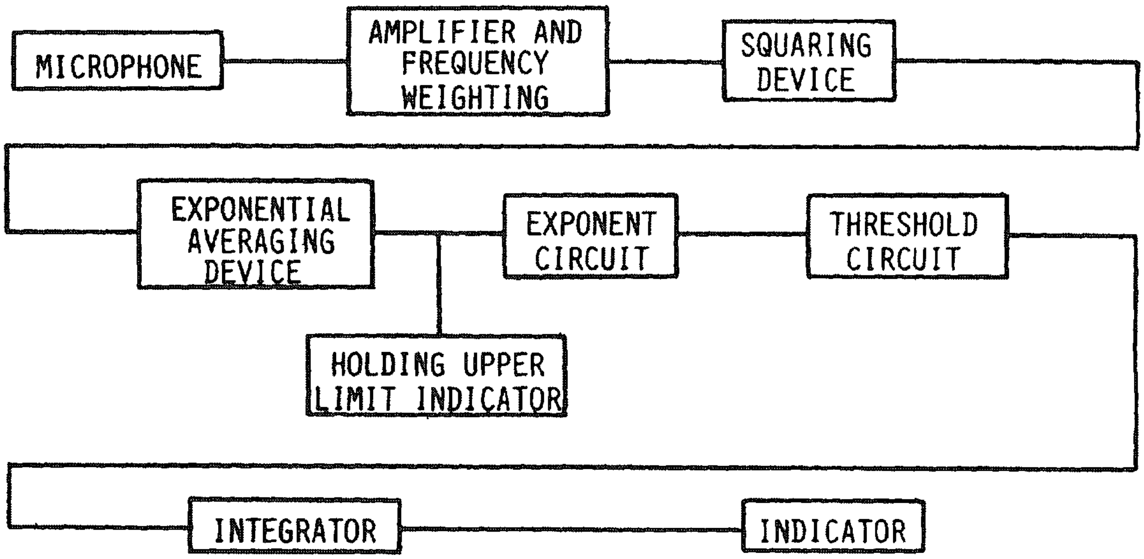

FIG. 1. Block diagram of functional elements of a noise dosimeter.

ponent, a threshold circuit, a device that integrates with respect to time, and an indicator. The actual instrument need not be separable into such individual functional elements since the primary basis of acceptability of the instrument is the overall performance. For convenience of description of the required characteristics of the device, however, the instrument is treated as if it were a cascade of separable individual elements. (*See* Fig. 1.)

4.2 Relative Frequency Response

The frequency characteristics of the overall instrument are specified in Table 1. The relative response level is given at discrete preferred frequencies, but the response must be that corresponding to a smooth curve at the specified frequencies. The tolerances are identical to those for a Type 2 sound-level meter (ANSI S1.4-1983). The specified tolerances are absolute tolerances at the criterion level and at the reference ambient conditions specified in Sec. 7.1. Above 10 kHz, the roll-off rate must not be less than 6 dB/octave.

4.3 Exponential Averaging

The time constant of the exponential averaging device connected to the output of the squaring device is nominally 1 s, corresponding to the SLOW response of a standard sound level meter, or 0.125 s, corresponding to the FAST response.

NOTE: For dosimeters based on the 3 dB exchange rate, the exponential averaging device is optional.

4.4 Threshold

The threshold circuit shall be placed after the exponential averaging device in order that the integrator will properly integrate over sensed sound levels that exceed the threshold.

4.5 Integration

The integrator integrates a power function of the mean square signal over time. This function is determined by the exponent circuit (see the block diagram). The exponent depends on the exchange rate, being 0.6 for the 5 dB rate, 0.75 for the 4 dB rate, and 1.0 for the 3 dB rate. The integrated output over time of the exponential circuit as modified by the threshold circuit is proportional to the percentage criterion exposure.

4.6 Indicator

The indicator may be built into or separate from the dosimeter. The number displayed shall be a percentage. The resolution of the display shall be sufficient to express this percentage rounded to the nearest integer.

TABLE 1. Random incidence relative response level as a function of frequency for A- and C-weighting. (Type 2 Tolerances. ANSI S1.4-1983).

Nominal[a] Frequency Hz	Exact Frequency in Hz	A-Weighting dB	C-Weighting dB	Tolerance
20	19.95	−50.5	−6.2	± 3
25	25.12	−44.7	−4.4	± 3
31.5	31.62	−39.4	−3.0	± 3
40	39.81	−34.6	−2.0	± 2
50	50.12	−30.2	−1.3	± 2
63	63.10	−26.2	−0.8	± 2
80	79.43	−22.5	−0.5	± 2
100	100.0	−19.1	−0.3	± 1.5
125	125.9	−16.1	−0.2	± 1.5
160	158.5	−13.4	−0.1	± 1.5
200	199.5	−10.9	0	± 1.5
250	251.2	−8.6	0	± 1.5
315	316.2	−6.6	0	± 1.5
400	398.1	−4.8	0	± 1.5
500	501.2	−3.2	0	± 1.5
630	631.0	−1.9	0	± 1.5
800	794.3	−0.8	0	± 1.5
1000	1000	0	0	± 1.5
1250	1259	+0.6	0	± 1.5
1600	1585	+1.0	−0.1	± 2
2000	1995	+1.2	−0.2	± 2
2500	2512	+1.3	−0.3	± 2.5
3150	3162	+1.2	−0.5	± 2.5
4000	3981	+1.0	−0.8	± 3
5000	5012	+0.5	−1.3	± 3.5
6300	6310	−0.1	−2.0	± 4.5
8000	7943	−1.1	−3.0	± 5
10000	10000	−2.5	−4.4	+5 −∞

[a] Nominal frequencies are as specified in ANSI S1.6-1984 (R1990), American National Standard Preferred Frequencies and Band Numbers for Acoustical Measurements. Exact frequencies are given above to four significant figures and are calculated from frequency equals $10^{0.1N}$, where N is an integer band number from 10 to 43 (1 Hertz corresponds to N = 0). Above 10 kHz, the roll-off rate must not be less than 6 dB/octave.

4.7 Principle of Operation

The principle of operation of the dosimeter is described in mathematical terms below.

$$D(Q) = (100/T_c)\int_0^T 10^{[(L-L_c)/q]}dt \qquad (1)$$

where:

$D(Q)$ = percentage criterion exposure for exchange rate Q;

T_c = criterion sound duration = 8 hours

T = measurement duration in hours;

t = time in hours;

L = SLOW (or FAST) A-weighted sound level, a function of time, when the sound level is greater than or equal to L, or equals −∞ when the A-weighted sound level is less than Lt;

L_t = threshold sound level specified by the manufacturer;

L_c = criterion sound level specified by the manufacturer;

Q = exchange rate in decibels; and

q = parameter that determines the exchange rate, where

$q = 10$ for a 3 dB exchange rate

$q = 5/\log 2$ for a 5 dB exchange rate

$q = 4/\log 2$ for a 4 dB exchange rate

NOTE: The factor of 100 in the equation produces a result that is a percentage.

If the sound level is greater than the threshold level and it is held constant, as during testing,

$$D(Q) = 100(T/T_c)10^{[(L-L_c)/q]} \qquad (2)$$

The average sound level during the sample time, T, over which a percentage criterion exposure is measured, is

$$L_{av} = L_c + q\log[D(Q)\times T_c/100T] \qquad (3)$$

If the sound level is held constant during a test, the average sound level is that constant level.

4.8 Electrical Test Signal

The manufacturer shall provide the means to substitute an electrical signal for the microphone for the purpose of performing tests on the complete instrument without the microphone. The manufacturer shall also provide suitable test points when required by the test procedures recommended in this standard.

5 INSTRUMENT CHARACTERISTICS AND TOLERANCES

5.1 Frequency Characteristics

The complete instrument, with the microphone mounted in a manner specified by the manufacturer, shall have the frequency response at the criterion level as specified in Table 1, within the absolute tolerance limits there listed, in a random incidence sound field (*See* Sec. 7.2.2). The manufacturer shall state the upper and lower values of sound level L and duration T over which the instrument satisfies the requirements of this standard. A controlled, abrupt cutoff in response shall be provided for sounds having a level less than the threshold level as defined in Sec. 3.10. It is strongly recommended that the threshold level shall be at least 5 dB below the criterion sound level. The actual threshold level must be specified by the manufacturer.

5.2 Directional Characteristics

The maximum deviation of the free-field relative response level with respect to the random-incidence relative response level as a function of angle of incidence shall not exceed the values given in Tables 2 and 3. The specification applies for sound incident on the microphone and whatever part of the instrument case is to be exposed to the sound field when the microphone is mounted relative to the dosimeter in a manner specified by the manufacturer, but without an observer present.

TABLE 2. Maximum allowable deviation of free-field relative response level with respect to random-incidence relative response level when the angle of incidence is varied by $\pm 22.5°$ from the calibration angle of incidence (Type 2, ANSI S1.4-1983). These allowances are added arithmetically to the tolerance limits in Table 1.

Frequency (hz)	Allowance (dB)
31.5 to 2000	$\pm$ 2
2000 to 4000	$\pm$ 2.5
4000 to 5000	$\pm$ 3
5000 to 6300	$\pm$ 3.5
6300 to 8000	$\pm$ 4.5

5.3 Operating Range Characteristics

The instrument shall have an operating range of at least 50 dB.

5.4 Pulse Range

The instrument shall have a pulse range of at least 53 dB. The manufacturer shall state the actual pulse range for tone bursts of 1.0 ms as well as that for the shortest tone burst that meets the accuracy requirement of ± 2.5 dB. (*See* Sec. 7.5).

5.5 Amplifier Characteristics

When a sensitivity range control is included in a noise dosimeter, it shall introduce an error less than ± 0.5 dB over the frequency range from 63 to 2000 Hz and less than ± 1 dB in the frequency ranges from 22.4 to 63 Hz and from 2000 to 11200 Hz for all settings, relative to a range setting specified by the manufacturer as the reference range.

The amplifier shall have a pulse range sufficiently large to allow it to drive the detector system to meet the tests given in Sec. 7.5.

5.6 Linearity

The linearity of the system shall be within ± 0.5 dB over a 30 dB range above the criterion level specified by the manufacturer, with a steady sine-wave test signal. Over the full operating range, specified by the manufacturer, the linearity shall be within ± 1.0 dB. Linearity tests are described in Sec. 7.7.

5.7 Square Law and Averaging Characteristics

The dosimeter shall be calibrated using sine-wave signals. Tests of the accuracy of the detector system (squaring device and exponential averaging device) employing steady state and transient signals are prescribed in Sec. 7.5.

5.8 Power Supply

If the instrument is battery operated, the manufacturer shall prescribe a battery test method that ensures the battery voltage is adequate to operate the instrument within specifications. It is highly desirable that the test method be such as to ensure operation for a time period of eight hours.

TABLE 3. Maximum allowable deviation of free-field relative response level for sounds arriving at any angle of incidence with respect to random-incidence relative response level (Type 2, ANSI S1.4-1983). These allowances are added arithmetically to the tolerance limits in Table 1.

Frequency (Hz)	Allowance (dB)
31.5 to 2000	$\pm$ 3
2000 to 4000	+3, −4
4000 to 5000	+4, −6
5000 to 6300	+5, −8
6300 to 8000	+8, −9

5.9 Field Calibration

A method to confirm that the dosimeter is operational shall be prescribed by the manufacturer. This method shall constitute an acoustical calibration so that the microphone is included in the test. This test shall have the capability of verifying all circuits including the integrator and display. A single sound level at 1 kHz at least 3 dB above the criterion sound level and threshold level (if used) is acceptable for the test.

5.10 Holding Upper Limit Trigger Level

If a holding upper limit indicator is provided, its root-mean-square (rms) trigger level shall be stated by the manufacturer and it shall be tested by the methods given in Sec. 7.6.

6. SENSITIVITY TO VARIOUS ENVIRONMENTS

6.1 Static Pressure

The sensitivity of the instrument shall not change by more than ± 0.5 dB for a variation of $\pm 10\%$ in static pressure, stated in 7.1.

6.2 Noise

When the microphone is replaced by an equivalent electrical impedance and the dosimeter is placed in a sound field equal to the upper limit of the operating range for the period of time corresponding to a criterion exposure of 100%, the indication shall be 1% or less. For very high operating ranges, the time period shall not be shorter than 5 seconds. In a quiet environment (lower than the threshold level) when the microphone is replaced by an equivalent electrical impedance, the dosimeter indication shall not exceed 1% after eight hours.

6.3 Vibration

The effect of vibration shall be indicated by the manufacturer for the complete apparatus, including the microphone, within the frequency range 10 and 500 Hz. The instrument and microphone shall be vibrated sinusoidally along each of three mutually perpendicular axes at an acceleration of 0.1 *g*. One axis shall be perpendicular to the plane of the diaphragm of the microphone. The indications of the instrument under test shall be reported.

6.4 Magnetic and Electrostatic Fields

The effect of magnetic and electrostatic fields should be reduced to a minimum. The complete noise dosimeter, including microphone, shall be tested in a magnetic field at 50 or 60 Hz. The dosimeter shall be oriented in a direction that gives a maximum indication. The manufacturer shall state the magnetic field strength in amperes/meter that produces an indication equivalent to the threshold level. It may be stated as a minimum specification, for example "greater than 300-A/m."

6.5 Temperature

The manufacturer shall state the temperature range over which the dosimeter, including the microphone, will meet the tolerances specified in this standard when the dosimeter is used in the recommended manner. Further, the manufacturer shall state the extremes in temperature at which the instrument including its batteries may be stored without damage.

7. CALIBRATION AND VERIFICATION OF THE BASIC CHARACTERISTICS OF THE DOSIMETER

7.0 Scope

The tests described below are for type qualification testing only. The extent to which they must be repeated in periodic calibrations must be specified by the manufacturer.

7.1 Reference Ambient Conditions

The tests described in the following paragraphs should be used to check that the requirements of Sec. 5 are met. All tests should be made at or corrected to the standard reference conditions of 20 °C; 65% relative humdity and the standard atmospheric pressure of 101.3 kPa.

7.2 General

Calibration procedure and tests related to the noise dosimeter are described in Secs. 7.2.1 and 7.2.2.

7.2.1 Absolute sensitivity

The complete instrument shall be calibrated at 1000 Hz. The accuracy of the instrument at 1000 Hz shall be within ± 1.5 dB at the criterion sound level.

7.2.2 Frequency response

The frequency weighting of the noise dosimeter shall be tested at frequencies between 20 Hz and 10 kHz. This test may be performed as a combination of electrical and acoustical tests. For the basic electrical test a sine-wave signal shall be applied at a convenient level to the electrical input of the dosimeter in series with the microphone or its electrical equivalent. The frequency of this signal is varied over the 20 Hz–10 kHz range, either continuously or in one-third-octave steps, and the level may also be adjusted in known steps to keep the output level within the nominal operating range. If the behavior of the integrator circuit is not a function of the input signal frequency, the relative response level that occurs at a circuit point just preceding the integrator circuit may be noted as the frequency is varied. Otherwise, the relative response at the output indicator is to be noted.

The relative response of the microphone for random incidence shall be added to this electrical response to obtain the overall response. If the microphone is attached to a case or mounting bracket when in normal use, the response shall be measured with the microphone mounted in that way. This microphone response may be measured in a diffuse sound field or calculated from free-field responses to sound arriving from different directions. One of the various methods of measurement and calculation is given in Appendix B of American National Standard Specification for Sound Level Meters, S1.4-1983. At frequencies where the wavelength of the sound is at least ten times the maximum linear dimension of the microphone, a pressure calibration may be used. The results of this relative response test shall satisfy Table 1.

If the instrument can be read out in terms of sound pressure level, such readings may be used in obtaining results of frequency response tests.

The performance of the dosimeter at low frequencies is to be tested at high levels also. The following test is a minimum test. With the dosimeter set on A weighting, apply a 1000 Hz sine-wave signal equal to the specified maximum limit of the operating range to the electrical input of the dosimeter in series with the microphone or its electrical equivalent. Apply this signal for a time (T_1) long enough to get a convenient reference indication. Change the frequency of the test signal to 50 Hz with the level increased by 10 dB. Apply this signal for a time adjusted for the expected change in response as shown in Table 1, ($10 - 30.2 = -20.2$ dB) so that the same reference indication should be obtained. (For the 3 dB exchange rate, the time corresponding to the change of 20.2 dB should be $104.7 \times T_1$; for the 4 dB exchange rate the time should be $33.1 \times T_1$; and for the 5 dB exchange rate the time should be $16.45 \times T_1$.) The actual relative indication should be such that it falls within the ± 2 dB tolerancce allowed at 50 Hz, taking into account the actual change in acoustical response of the microphone between 1000 and 50 Hz. [The observed indications can be converted to average levels by Eq. (3) of Sec. 4.7. Then the ± 2 dB tolerances can be applied to these converted levels.]

7.3 Directional Characteristics

The variation in sensitivity as a function of angle of incidence shall be measured at the one-third-octave frequencies between 31.5 and 8000 Hz, to ensure that the requirements of Sec. 5.2 are met.

7.4 Amplifier Circuits

The pulse range capacity of the amplifier is tested simultaneously with that of the squaring, averaging and exponential circuits in Sec. 7.5.

Amplifier noise shall be tested by replacing the microphone with an equivalent electrical impedance or by operating the dosimeter in a place where the sound level is at least 30 dB below the criterion level. The dosimeter is then operated for 8 hours. The output indication must be less than 1%.

7.5 Squaring, Averaging, and Exponential Circuits

Testing is achieved by applying a single short duration tone burst at a frequency of 4 kHz superimposed with matched zero crossings upon a low level 4 kHz continuous sinusoidal signal. The level of the continuous signal shall be above the noise floor of the dosimeter and shall be specified by the manufacturer. An integration period, timed with 2%, consisting of integral multiples of 10 s shall be used. The test shall be conducted using tone burst durations ranging from 1 ms to 1 s. It is recommended that tests be conducted with burst durations of 1 ms, 10 ms, 100 ms, and 1 s. The peak level of the tone burst when superimposed on the continuous signal shall exceed the level of the continuous signal by 53 decibels. The average sound level computed from the dose by Eq. 3 shall exceed the level of the continuous signal by an amount shown and within the tolerance given in Table 4A for SLOW response and 4B for FAST response.

For instruments whose linearity range is greater than their pulse range, the test shall be repeated at a level for the continuous signal equal to the upper limit of the linearity range minus the pulse range given.

7.6 Holding Upper Limit Indicator

When the microphone is replaced by an equivalent electrical impedance and a 1 kHz sinusoid is applied at a level 2 dB greater than the specified trigger level for the holding upper limit indicator, the indicator shall trigger within 2 s after signal application. The test shall be repeated at the specified trigger level, and the holding upper limit indicator shall not trigger. Other delay times after signal application may be provided.

TABLE 4-A. 53 dB Pulse range response (SLOW time constant) averaging.

Burst duration	Exchange rate 3	4	5	Tolerance
1 ms	10.4 dB	9.2 dB	8.4 dB	±2.5 dB
10 ms	20.0 dB	18.5 dB	17.3 dB	±2.5 dB
100 ms	30.0 dB	28.4 dB	27.1 dB	±2.5 dB
1 s	40.0 dB	38.6 dB	37.5 dB	±2.5 dB

TABLE 4B. 53 dB Pulse range response (FAST time constant)

Tone burst duration	Exchange rate 3	4	5	Tolerance
1 ms	10.4 dB	7.2 dB	5.3 dB	±2.5 dB
10 ms	20.0 dB	15.8 dB	12.4 dB	±2.5 dB
100 ms	30.0 dB	25.7 dB	21.8 dB	±2.5 dB
1 s	40.0 dB	37.1 dB	34.3 dB	±2.5 dB

Alternatively, the time duration for which the exponentially averaged sound level exceeded the trigger level can be recorded. Time duration must be determined with an accuracy of ±1 s.

7.7 Exponent Circuit and Integrator

The linearity of the integrator including the exponent circuit (if provided) and the indicator shall be tested at a frequency of 1000 Hz to satisfy the tolerance given in Sec. 5.5. The test signal level corresponding to the criterion level L_c is taken as the reference in determining linearity. The instrument is first tested at various levels while the duration of the test signal is held constant for a time corresponding to a dose of 100% of the maximum input level. The test shall be made at the maximum and minimum limits of the operating range and at levels between the extremes at intervals no greater than 10 dB. The tolerances on the indication are calculated using Eq. 2 of Sec. 4.7 and inserting the appropriate ±0.5 or ±1 dB limits for L, as given in Sec. 5.6.

The instrument is then tested at various durations (T) with the test signal applied at the criterion level L_c. The test shall be made at the maximum duration allowed (i.e. the duration which should produce an indication of 100% at the test level), at a duration that produces an indication of 10%, and at intermediate steps not to exceed 20%. Tolerance on the indication is 0.05 times the indicated value or 1%, whichever is larger.

Another test shall be made to demonstrate that the exponent circuit and the integrator are arranged properly in the circuit. A steady test with sine waves cannot assure this. This test shall be made at a frequency of 1 kHz. Equipment shall be arranged to apply a voltage equivalent to the maximum input within the operating range for a time one-tenth the maximum measurement duration (T) allowed by the instrument at this input. (Duration of T does not have to be less than 1 minute.) This is followed by a voltage 20 dB less than the initial voltage for a time nine-tenths T. The sequence is repeated as indicated in Fig. 2.

The indication corresponding to the maximum limit of the operating range at the maximum duration allowed (T) at that level shall be taken as a reference indication for this test (note that this is one-half the duration ($2T$) of the test sequence).

The indication produced by this signal shall fall within the range 0.19–0.25 times the reference indication when the exchange rate is 3 dB. For an exchange rate of 4 dB, the indication shall fall within the range 0.23 to 0.28 times the reference indication. When the exchange rate is 5 dB, the indication shall fall within the range of 0.29–0.34 times the reference indication. The tolerance in each case corresponds to a tolerance of ±0.5 dB in average level.

The threshold circuit shall be tested at levels specified by the manufacturer at a frequency of 1000 Hz with a cyclic signal having a period of 10 s. Half the

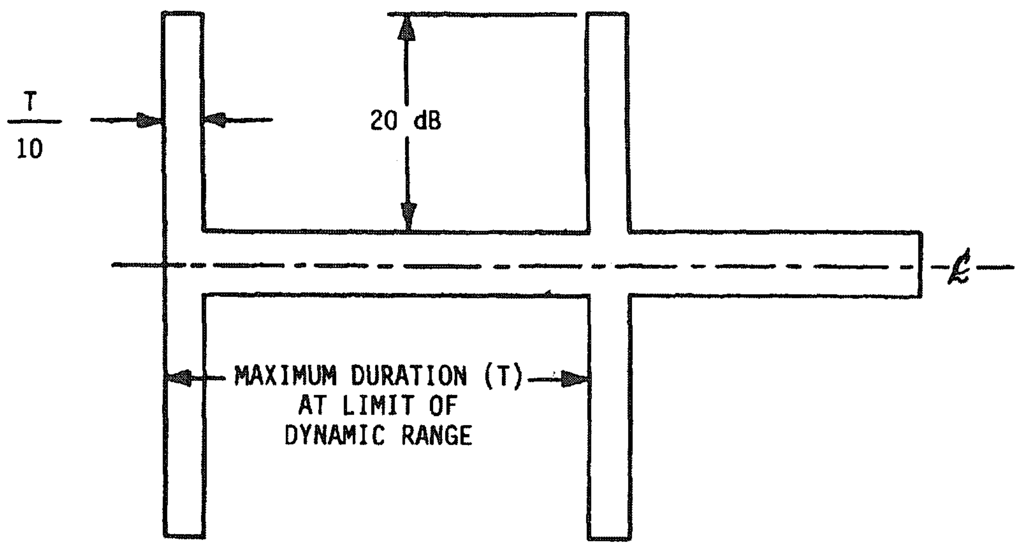

FIG. 2. Envelope of modulated test signal.

period will be at a level 3 dB above the threshold if the instrument's exchange rate is 3 dB, and 4 dB or 5 dB above the threshold when using the 4 dB or 5 dB exchange rate respectively, and the other half of the period will be at a level 2 dB below the threshold level for all exchange rates. This amplitude varying signal is applied for a time duration that will produce an indication of 100% at the threshold level based on the unit's exchange rate and criterion level. The resulting indication over this time period will be within the limits shown in Tables 5A and 5B and correspond to a tolerance of $\pm$ 0.5 dB in average level.

TABLE 5A. Threshold tolerances (SLOW time constant)

Exchange rate	Tolerance limits (percent criterion exposure)
5	54–62
4	49–59
3	45–57

TABLE 5B. Threshold tolerances (FAST time constant)

Exchange rate	Tolerance limits (percent criterion exposure)
5	47–55
4	46–55
3	44–56

7.8 Rise and Decay Times

The rise and decay time constant of the exponential averaging device shall be 1 s for SLOW, and 0.125 s for FAST, and will be tested for compliance by the 1 s tone burst used in the pulse range tests of Sec. 7.5. (*See* Table 4A and 4B.)

NOTE: When applied to an instrument having a 3 dB exchange rate, this test verifies only the symmetry of the rise and decay time constants.

7.9 Fold-Over Distortion

The behavior at levels above the normal operating range shall be tested to ensure that the response is monotonic over an extended range. If any sinusoidal signal having a frequency in the range 20 Hz–10 kHz is applied at any level above the maximum limit of the specified operating range, up to a level which is 40 dB higher than the maximum limit of the specified operating range, the resultant indication shall not be less than that produced by a signal at the maximum limit and having the same frequency. This test may be an electrical test at the input of the dosimeter with the signal fed in series with the microphone or its equivalent impedance, provided the response of the microphone itself is monotonic over the range to be tested. The input must be limited, however, so that neither the acoustic or electrical test signals exceed the maximum safe operating level of the microphone or electrical circuits.

8. RATING INFORMATION AND INSTRUCTION MANUAL

8.1 Label

A dosimeter that complied with this standard shall be marked with "complies with ANSI S1.25-1992," and shows the name of the manufacturer, a model number, a serial number or equivalent, and either the class designation (Sec. 3.15) or a means to obtain the information required in the class designation, (e.g., class: *See* manual).

8.2 Instruction Manual

An instruction manual shall be supplied with the dosimeter that includes at least the information listed below in addition to that marked on the instrument.

(1) Class designation
(2) *Exchange rate
(3) *Threshold level (L_t)
(4) *Criterion level (L_c)
(5) *Criterion duration (T_c)
(6) Trigger level and delay time for holding upper limit indicator
(7) Operating range over which the characteristics of the dosimeter are within all specified tolerances
(8) Pulse range
(9) Microphone:
  (a) Typical type tested frequency response characteristic for free field (at least at 0 and 90) and pressure or random incidence
  (b) Maximum safe SPL.
(10) Effect of vibration on dosimeter accuracy
(11) Sensitivity to magnetic fields
(12) Operational temperature range
(13) Operational humidity range
(14) Limits of temperature and humidity for storage of the instrument including its batteries
(15) Calibration procedure, including the effects of altitude on the calibration
(16) Battery check procedure
(17) Recommendations for position of instrument case and wearer relative to the microphone for normal use
(18) Test points as required in Sec. 4.8 in the instrument if any are available. The electrical impedance that may be connected between each test point and reference ground shall be stated
(19) The sound level corresponding to the peak sound pressure level to which the dosimeter may be exposed without significant nonlinear effects
(20) Recommended time interval between laboratory recalibrations
(21) Operational instructions and tests to ensure that the dosimeter satisfies the requirements of this standard

*If these are selectable, the values available and means for setting and identifying them must be given.

REFERENCES

(1) G. F. Kuhn, R. M. Guernsey, "Sound Pressure Distribution About the Human Head and Torso," *J. Acoust. Soc. Am.* 73, 1983, pp. 95–105.

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 S1.4-1983 (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 (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 (ASA 75)** American National Standard Procedures for Calibration of Underwater Electroacoustic Transducers
- **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 (ASA 64)** American National Standard Design Response of Weighting Networks for Acoustical Measurements

S2 STANDARDS ON MECHANICAL SHOCK AND VIBRATION

- **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
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- **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*
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- **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

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- **ANSI S3.3-1960 (R 1990)** American National Standard Methods for Measurement of Electroacoustical Characteristics of Hearing Aids
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- **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 (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 1986) (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 1986) (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

• **ANSI S3.26-1981 (R 1990) (ASA 41)** American National Standard Reference Equivalent Threshold Force Levels for Audiometric Bone Vibrators

• **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 (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 (ASA 69)** American National Standard Preferred Earhook Nozzle Thread for Postauricular Hearing Aids

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• **ANSI S12.4-1986 (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

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

• **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 (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)

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