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AMERICAN NATIONAL STANDARD

SPECIFICATIONS FOR INTEGRATING-AVERAGING SOUND LEVEL METERS

ANSI S1.43-1997

Accredited Standards Committee S1, Acoustics

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

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ANSI S1.43-1997

American National Standard

Specifications for Integrating-Averaging Sound Level Meters

Secretariat

Acoustical Society of America

Approved 12 June 1997

American National Standards Institute, Inc.

Abstract

This Standard describes instruments for the measurement of frequency-weighted and time-average sound pressure levels. Optionally, sound exposure levels may be measured. This Standard is consistent with the relevant requirements of ANSI S1.4-1983 (R 1997) *American National Standard Specification for Sound Level Meters,* but specifies additional characteristics that are necessary to measure the time-average sound pressure level of steady, intermittent, fluctuating, and impulsive sounds.

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Foreword

[This Foreword is not an integral part of ANSI S1.43-1997 *American National Standard Specifications for Integrating-Averaging Sound Level Meters.*]

This Standard is intended to be consistent with IEC 804:1985, *Integrating averaging sound level meters*, including Amendment No. 1 and Amendment No. 2. The Standard differs from IEC 804:1985 in the following ways:

a) References to corresponding ANSI Standards are given instead of exclusive references to International Standards;

b) No specifications for Type 3 accuracy class are included, to be consistent with ANSI S1.4-1983 (R 1997) *American National Standard Specification for Sound Level Meters*;

c) Requirements for the response of the instrument to sounds incident from random directions or in a diffuse sound field are consistent with similar requirements in ANSI S1.4-1983 (R 1997);

d) Texts of Amendment No. 1 and Amendment No. 2 to IEC 804:1985 are incorporated into the main text of the Standard rather than as separate amendments;

e) Specifications for time-average AI-weighted sound pressure level are retained for compatibility with IEC 804:1985. It is recommended that time-average AI-weighted sound pressure level not be used in any future standards or regulations.

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

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

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

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Working Group S1/WG17, Sound Level Meters, which assisted Accredited Standards Committee S1, Acoustics, in the development of this Standard, had the following membership:

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Suggestions for improvement will be welcomed. Send suggestions for improvement to Accredited Standards Committee S1, Acoustics, in care of the ASA Standards Secretariat, 120 Wall Street, 32nd Floor, New York, New York 10005-3993, USA. E-mail: asastds@aip.org; Telephone: +1 212 248 0373; Fax +1 212 248 0146.

*Mr. Krug died during 1996 whereupon Mr. Kuemmel assumed the position of Chair of the Working Group.

American National Standard

Specifications for Integrating-Averaging Sound Level Meters

1 Scope

1.1 Scope

1.1.1 General

This Standard describes instruments for the measurement of frequency-weighted, time-average sound pressure levels. Optionally, sound exposure levels may be measured. This Standard is consistent with the relevant requirements of ANSI S1.4-1983 (R 1997) *American National Standard Specification for Sound Level Meters*, but specifies additional characteristics that are necessary to measure the time-average sound pressure level of steady, intermittent, fluctuating, and impulsive sounds.

NOTE – Throughout this document, reference to ANSI S1.4-1983 (R 1997) includes the ANSI S1.4A-1985 amendment.

Though a complete integrating-averaging sound level meter is specified, the combination of a conventional sound level meter that satisfies ANSI S1.4-1983 (R 1997) and an accessory or "plug-in" that provides the time averaging capability is admissible if the complete system conforms to the specifications of this Standard.

The instrument is called "integrating-averaging sound level meter," but the short form "integrating sound level meter" or "averaging sound level meter" may also be used. In this Standard, "integrating sound level meter" is used.

There are some important differences between the time averaging characteristics of an integrating sound level meter and those of a conventional sound level meter with exponential time weighting. Integrating-averaging sound level meters are inherently different from conventional sound level meters with exponential time weighting. As such, they may produce different results. These differences are discussed in annex A.

1.1.2 Types

This Standard specifies integrating sound level meters of three grades of accuracy, designated Types 0, 1, and 2. For each Type, the specification for directional characteristics and frequency weighting and amplifier characteristics are identical with those of ANSI S1.4-1983 (R 1997). Time averaging and indicator specifications differ from those specified in ANSI S1.4-1983 (R 1997).

1.1.3 Characteristics specified

1.1.3.1 This Standard specifies the following characteristics for integrating sound level meters:

(a) integrating and time averaging;

(b) indicator; and

(c) overload indications.

1.1.3.2 Integrating sound level meters also shall comply with the requirements in ANSI S1.4-1983 (R 1997) as follows:

(a) directional characteristics [from 4.1 and 4.2 of ANSI S1.4-1983 (R 1997)];

(b) frequency weighting characteristics [from 5.1 and 5.2 of ANSI S1.4-1983 (R 1997)];

(c) sensitivity to various environments [from 7 of ANSI S1.4-1983 (R 1997)].

1.1.4 Tolerances

Specifications for Types 0, 1, and 2 integrating sound level meters have the same design goals and differ only in the tolerance limits allowed. Tolerance limits broaden as the Type number increases.

1.1.5 Tests specified

This Standard specifies acoustical and electrical tests to verify conformance to the characteristics specified.

1.2 Purpose

The purpose of this Standard is to ensure specified accuracy and stability of an integrating sound level meter and to reduce to the practical minimum any differences between equivalent measurements taken with instruments of various makes and models that satisfy the requirements of this Standard.

1.3 Applications

The Type 0 integrating sound level meter is intended for use as a laboratory reference standard. Type 1 is intended for laboratory use and for field use where the acoustical environment can be closely specified or controlled. The Type 2 integrating sound level meter is suitable for general field applications.

An integrating sound level meter is well suited for measurement of the average sound level (time-average sound pressure level) or sound exposure levels of impulsive sounds. Such impulsive sounds have high peak amplitude and duration as short as 1 ms.

NOTE – Measurement of the time-average sound pressure level or sound exposure level of impulses with durations less than 1 ms should be regarded as an extrapolation because testing is not required for toneburst durations of less than 1 ms.

Integrating sound level meters intended for field use shall conform to the environmental specifications of ANSI S1.4-1983 (R 1997).

Integrating sound level meters are usually designed to be hand-held or bench mounted. Personal noise dosimeters that may be worn on a person with performance characteristics of Type 2 integrating sound level meters are also available [see ANSI S1.25-1991 (R 1997)].

Integrating sound level meters are used to measure many types of sound, under different conditions and for a variety of reasons. For each application, the measurement technique should be chosen and controlled carefully to obtain valid and consistent results. It is important to recognize that the method of use may have as much effect on a measurement as the quality of the instrument itself; errors will often result if the effect of the environment and (especially for hand-held instruments) the presence of the observer are ignored. Annexes A and B provide additional guidance on the use of integrating sound level meters.

Instruments designed to conform to the specifications of this Standard may not be appropriate for measurements that require a function other than the time integral of the square of the instantaneous sound pressure signal to determine the time-mean-square sound pressure. For such measurements, with a constant sound pressure at the microphone, the indicated signal level does not change by 3 dB for a doubling or halving of the duration of the integration period.

2 Normative references

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

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

[2] ANSI S1.4-1983 (R 1997) *American National Standard Specification for Sound Level Meters* and Amendment 1, ANSI S1.4A-1985.

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

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

[5] ANSI S1.15-19997/Part 1 *American National Standard Measurement Microphones—Part 1: Specifications for Laboratory Standard Microphones.*

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

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

[8] IEC 804:1985 *Integrating-averaging sound level meters*, First edition 1985, Amendment 1 (1989 September), and Amendment 2, (1993 September). Geneva, Switzerland.

3 Definitions

Definitions of most of the terms used in this Standard may be found in ANSI S1.1-1994. Certain additional terms are given in ANSI S1.4-1983 (R 1997) or are defined below.

3.1 frequency-weighted sound pressure level. Ten times the logarithm to the base ten of the ratio of the frequency-weighted squared sound pressure to the square of the reference sound pressure of 20 μPa. The frequency weighting shall be indicated, or if no frequency weighting is stated, the A-frequency weighting is understood. Unit, decibel (dB); symbol, L, with subscript indicating frequency weighting, e.g., L_A.

3.2 time-average sound level; equivalent continuous A-frequency weighted sound pressure level. Ten times the logarithm to the base ten of the ratio of time-mean-square instantaneous A-weighted sound pressure, during a stated time interval T, to the square of the standard reference sound pressure of 20 μPa. Unit, decibel (dB); abbreviations, TAV and TEQ; respective symbols L_{AT} and L_{AeqT}.

NOTES

1 In symbols, time-average (time-interval equivalent continuous) A-weighted sound level in decibels is:

$$L_{AT} = 10 \lg\left\{\left[(1/T) \int_0^T p_A^2(t)\mathrm{d}t\right] \Big/ p_0^2\right\} \qquad (1)$$

$$= L_{AeqT} \qquad (2)$$

where $p_A^2(t)$ is the squared instantaneous A-weighted sound pressure, a function of time t; for gases, reference sound pressure $p_0 = 20$ μPa; the integral from 0 to time T is for a stated time interval, $t_2 - t_1$.

2 In principle, the sound pressure signal is not exponentially time-weighted, either before or after squaring.

3 A frequency weighting other than the standard A-weighting may be employed if specified explicitly. The frequency weighting that is essentially constant between limits specified by the manufacturer in the Instruction Manual of the sound level meter is called FLAT.

4 For the definition of time-average AI-weighted sound pressure level, see annex C.

3.3 sound exposure level. Ten times the logarithm to the base ten of the ratio of a given time integral of squared instantaneous A-weighted sound pressure, over a stated time interval or event, to the product of the squared reference sound pressure of 20 μPa and reference sound exposure duration of 1 s. The frequency weighting and reference sound exposure may be otherwise if explicitly stated. Unit, decibel (dB); abbreviation, SEL, ASEL, symbol, L_{AE}.

NOTE – In symbols, (A-weighted) sound exposure level (ASEL) is:

$$L_{AE} = 10 \lg\left\{\left[\int_0^T p_A^2(t)\mathrm{d}t\right] \Big/ p_0^2 t_0\right\} \qquad (3)$$

$$= 10 \lg(E / E_0) \qquad (4)$$

$$= L_{AT} + 10 \lg(T / t_0) \qquad (5)$$

where $p_A^2(t)$ is the squared instantaneous A-weighted sound pressure, a function of time t; for gases, reference sound pressure $p_0 = 20$ μPa; $t_0 = 1$ s; E is sound exposure; $E_0 = p_0^2 t_0 = (20\ \mu\text{Pa})^2\text{s}$ is reference sound exposure; the integral from 0 to time T is for a stated time interval, $t_2 - t_1$.

3.4 linear operating range. Difference between the upper and lower levels of time-average sinusoidal signals applied to the input within which the level-linearity requirements given in 6.2 are met. Unit, decibel (dB).

3.5 pulse range. Greatest level difference between the peak level of a toneburst and the level of the time-averaged low-level continuous signal for which the specifications given in 6.2 are met. For the purposes of this Standard, the peak level of a toneburst is 3 dB greater than the time-average sound level of the continuous sinusoidal signal from which the toneburst was extracted. Unit, decibel (dB).

3.6 reference level range. Of an integrating sound level meter, a level range specified in the Instruction Manual for calibration purposes and including the reference sound pressure level (see 3.14). Unit, decibel (dB).

3.7 indicator range. Range of levels which can be indicated at each setting of the level range control (if any). An indicator range has level linearity tolerances equal to those within the primary indicator range as defined in 2.11 of ANSI S1.4-1983 (R 1997). Unit, decibel (dB).

3.8 tonebursts. One or more complete cycles of a sinusoidal signal. For the purpose of this Standard, toneburst signals start and end at a zero crossing of the waveform.

3.9 burst duty factor. For the test signal of table 7 and 9.3.2, ratio of the duration of the toneburst to the duration of a complete cycle at the repetition frequency.

3.10 reference direction. Direction of sound incidence specified in the Instruction Manual and used for testing the directional characteristics of the integrating sound level meter. For free-field response, the reference direction is also the direction of sound incidence for determining the absolute sensitivity and frequency weighting (see 3.13). For random incidence response (see 3.12), the reference direction shall be such that, for plane progressive waves arriving at the microphone from this direction, the frequency response approximates most closely the response in a random-incidence sound field. Unit: degree.

For the reference direction of random incidence microphones or sound level meters, the Instruction Manual shall specify the free-field frequency response and the accuracy type for which the tolerances are met.

3.11 calibration frequency. Frequency specified in the Instruction Manual in the nominal range from 200 to 1200 Hz to be used for determining the absolute sensitivity of a sound level meter. Unit, hertz (Hz).

3.12 random-incidence response. Determination of absolute sensitivity and frequency weighting for a random incidence sound field (see 9.1 and annex B).

3.13 free-field response. Determination of absolute sensitivity and frequency weighting for plane progressive sound waves in the free-field reference direction (see 9.1 and annex B).

3.14 reference sound pressure level. Sound pressure level specified in the Instruction Manual and used for calibrating the absolute sensitivity of the integrating sound level meter. Unit, decibel (dB).

NOTE – A reference sound pressure level of 94 dB is preferred or, if this level is not within the measuring range of the instrument, 84 dB or 74 dB.

4 General characteristics

4.1 General design

An integrating sound level meter is generally a combination of a microphone, an amplifier with specified frequency weighting, a time averager, and an indicator. An overload indicator is required. Specifications are given for these parts of the integrating sound level meter in clauses 4, 5, 6 and 7, with tolerance limits for three types of meters. Specifications for the sensitivity to various environments are given in clause 8. Any additional items necessary to meet any of the requirements (such as extension rods, cables, or random-incidence correctors) are integral parts of an integrating sound level meter.

Besides indicating the time-average sound pressure level, the integrating sound level meter may indicate sound exposure level and may include other facilities as described in ANSI S1.4-1983 (R 1997).

Annex C provides optional specifications if the integrating sound level meter is designed to indicate the time-average AI-weighted sound pressure level.

4.2 Overall accuracy

The indication of time-average sound pressure level by an integrating sound level meter under the reference environmental conditions of 9.1 and at the reference sound pressure level and calibration frequency shall be accurate to within ±0.4 dB, ±0.7 dB, and ±1.0 dB for Types 0, 1, and 2 instruments respectively, after any warm-up period specified in the Instruction Manual.

NOTE – A calibration frequency of 1 kHz is preferred.

A means shall be available [for example, a sound calibrator conforming with the requirements of S1.40-1984 (R 1997)] to field check the acoustical sensitivity such that the tolerance limits specified above are met for the reading, at least at one frequency and sound pressure level, under the reference environmental conditions of 9.1.

4.3 Directional characteristics

Microphone and instrument case shall satisfy the directional-response requirements of 4.3.1 and 4.3.2 below. These are identical to 4.1 and 4.2 of ANSI S1.4-1983 (R 1997).

4.3.1 Omnidirectional response

The frequency-weighting characteristics and tolerance limits given in 5.2, table 4 and table 5, shall apply for sound at random incidence. The random-incidence response of a sound level meter may be calculated from free-field responses to sound arriving from different directions. Determination of free-field response may be accomplished in comparison, under the general principles set forth in 7.2.1 of ANSI S1.10-1966 (R 1997), except that sound level is to be measured instead of output voltage level. One method of approximating the relative response level for random incidence is given in annex D.

4.3.2 Calibration angle and directional-response tolerances

Directional characteristics of the instrument shall be controlled. To accommodate needs for measuring sounds that arrive at the microphone at a known or principal angle of incidence, i.e., in a quasi-free field, the Instruction Manual shall state a free-field calibration angle of incidence that provides a frequency response closely approximating that for random incidence. It is not necessary that the frequency-weighting tolerance limits given in table 5 be satisfied at that angle of incidence. However, if the instrument does conform with the tolerance limits of table 5, the Instruction Manual shall state that fact and define the calibration angle and microphone required. In any case, the Instruction Manual shall show the difference as a function of frequency between the response at the free-field calibration angle and the random-incidence response.

Directional response error shall be measured relative to the stated free-field calibration angle for random-incidence sound. The errors shall conform to the limits given in table 1 for the complete instrument with the microphone mounted as it normally is for hand-held operation, if the sound level meter is so designed. Directional response error shall also conform with the limits in table 2. The microphone may be mounted at the end of an extension rod or cable in order to satisfy the specifications in table 2. When an extension rod or cable is required, it shall be provided by the manufacturer as an integral part of the instrument and the Instruction Manual shall state that the extension rod or cable is required to conform to the specifications of this Standard.

4.4 Frequency weighting

The output signal of the microphone is amplified and frequency weighted to produce the A-frequency weighting. Other frequency weightings are optional. Frequency weightings shall conform to the specifications of 5.1 and 5.2 of ANSI S1.4-1983 (R 1997), which are reproduced in clause 5 of this Standard.

4.5 Time averaging and indicator

Time averaging and indicator characteristics shall be in accordance with the specifications given in clause 6.

4.6 Overload indicator

An integrating sound level meter shall include an overload indicator with characteristics as specified in clause 7.

4.7 Performance testing

Methods to test the performance of an integrating sound level meter for conformance to the specifications of this Standard are given in clause 9.

Table 1 — Maximum allowable deviation of free-field relative response level with respect to the random-incidence relative response level when the angle of incidence is varied by ±22.5 deg from the free-field calibration angle of incidence.

Frequency range Hz	Type 0 dB	Type 1 dB	Type 2 dB
31.5 to 2000	±0.5	±1	±2
2000 to 4000	±1	+1.5, −1	±2.5
4000 to 5000	±1	+2, −1.5	±3
5000 to 6300	±1.5	+2.5, −2	±3.5
6300 to 8000	±2	+3, −2.5	±4.5
8000 to 10 000	±2	+3.5, −3.5	*
10 000 to 12 500	±3	+4, −6.5	*

*None specified.

Table 2 — Maximum allowable deviation of free-field relative frequency response level for sounds arriving at any angle of incidence with respect to the random-incidence relative response level.

Frequency range Hz	Type 0 dB	Type 1 dB	Type 2 dB
31.5 to 2000	±1	+1.5, −1	±3
2000 to 4000	±1.5	+2.5, −2	+3, −4
4000 to 5000	±1.5	+3.5, −3	+4, −6
5000 to 6300	±2	+4, −4	+5, −8
6300 to 8000	±3	+5.5, −5.5	+8, −9
8000 to 10 000	±3.5	+7, −8	*
10 000 to 12 500	±4.5	+8, −11	*

*None specified.

4.8 Electrical input

A means shall be provided to substitute an electrical signal for the output of the microphone to perform tests on a complete instrument without the microphone.

4.9 Battery Operation

If the instrument is battery operated, suitable means shall be provided to check that a battery voltage adequate to operate the instrument according to the specifications is maintained.

NOTE – A check of battery voltage should not disturb a measurement of any acoustical quantity that the instrument is designed to measure.

4.10 Stability

After a warm-up period to be specified in the Instruction Manual, but less than 10 minutes, the reading of a signal within the linear operating range shall not change during 1 hour of continuous operation under constant test conditions by more than the values shown in table 3.

4.11 Elapsed time

An integrating sound level meter may be equipped to measure and display the time elapsed since the beginning of an integration or to permit presetting of a desired integration period. If timing facilities are included, they shall measure elapsed time to an accuracy of ± 1%. If preset averaging times are included, it is recommended that they be chosen from among the following: 10 s, 1 min, 5 min, 10 min, 15 min, 1 h, 3 h, 8 h, and 24 h.

5 Frequency weighting and amplifier characteristics

5.1 Frequency weighting

The complete instrument composed of the microphone, amplifier, frequency-weighting, time averager and indicator shall have the A-frequency weighting characteristic with the response and tolerance limits specified in clauses 5.2 and 5.3 and tables 4 and 5. When other frequency weightings are provided, they shall also meet the requirements of these clauses. These requirements of this Standard are identical to those of ANSI S1.4-1983 (R 1997).

Table 3 — Maximum change of reading, in decibels, during 1 h of operation.

Type 0	Type 1	Type 2
0.2	0.3	0.5

Table 4 — Random-incidence relative response level as a function of frequency for various frequency weightings.

Frequency, Hz		Weighting, dB		
Nominal*	Exact*	A	B	C
10	10.00	−70.4	−38.2	−14.3
12.5	12.59	−63.4	−33.2	−11.2
16	15.85	−56.7	−28.5	−8.5
20	19.95	−50.5	−24.2	−6.2
25	25.12	−44.7	−20.4	−4.4
31.5	31.62	−39.4	−17.1	−3.0
40	39.81	−34.6	−14.2	−2.0
50	50.12	−30.2	−11.6	−1.3
63	63.10	−26.2	−9.3	−0.8
80	79.43	−22.5	−7.4	−0.5
100	100.0	−19.1	−5.6	−0.3
125	125.9	−16.1	−4.2	−0.2
160	158.5	−13.4	−3.0	−0.1
200	199.5	−10.9	−2.0	0
250	251.2	−8.6	−1.3	0
315	316.2	−6.6	−0.8	0
400	398.1	−4.8	−0.5	0
500	501.2	−3.2	−0.3	0
630	631.0	−1.9	−0.1	0
800	794.3	−0.8	0	0
1000	1000	0	0	0
1250	1259	+0.6	0	0
1600	1585	+1.0	0	−0.1
2000	1995	+1.2	−0.1	−0.2
2500	2512	+1.3	−0.2	−0.3
3150	3162	+1.2	−0.4	−0.5
4000	3981	+1.0	−0.7	−0.8
5000	5012	+0.5	−1.2	−1.3
6300	6310	−0.1	−1.9	−2.0
8000	7943	−1.1	−2.9	−3.0
10 000	10000	−2.5	−4.3	−4.4
12 500	12590	−4.3	−6.1	−6.2
16 000	15850	−6.6	−8.4	−8.5
20 000	19950	−9.3	−11.1	−11.2

*Nominal frequencies are as specified in ANSI S1.6-1984 (R 1997). Exact frequencies f are given above to four significant figures and are calculated from $f = (f_0)(10^{0.1N})$ where N is an integer from 10 to 43 and $f_0 = 1$ Hz.

Table 5 — Tolerance limits, in decibels, on design-goal frequency weightings for sound at random incidence measured on an instrument's reference level range.

Nominal frequency Hz	Tolerance limits, dB Instrument type 0	1	2
10	+2, −5	±4	+5, −∞
12.5	+2, −4	±3.5	+5, −∞
16	+2, −3	±3	+5, −∞
20	±2	±2.5	±3
25	±1.5	±2	±3
31.5	±1	±1.5	±3
40	±1	±1.5	±2
50	±1	±1	±2
63	±1	±1	±2
80	±1	±1	±1.5
100	±0.7	±1	±1.5
125	±0.7	±1	±1.5
160	±0.7	±1	±1.5
200	±0.7	±1	±1.5
250	±0.7	±1	±1.5
315	±0.7	±1	±1.5
400	±0.7	±1	±1.5
500	±0.7	±1	±1.5
630	±0.7	±1	±1.5
800	±0.7	±1	±1.5
1000	±0.7	±1	±1.5
1250	±0.7	±1	±1.5
1600	±0.7	±1	±2
2000	±0.7	±1	±2
2500	±0.7	±1	±2.5
3150	±0.7	±1	±2.5
4000	±0.7	±1	±3
5000	±1	±1.5	±3.5
6300	+1, −1.5	+1.5, −2	±4.5
8000	+1, −2	+1.5, −3	±5
10 000	+2, −3	+2, −4	+5, −∞
12 500	+2, −3	+3, −6	+5, −∞
16 000	+2, −3	+3, −∞	+5, −∞
20 000	+2, −3	+3, −∞	+5, −∞

5.2 Frequency-weighting characteristics and tolerance limits

Frequency-weighting design-goal characteristics for the complete instrument are given in table 4. Overall tolerance limits on relative response levels are given in table 5 for random-incidence sound. Tolerance limits in table 5 are identical for all frequency-weighting characteristics included in the instrument. The tolerance limits on relative response level shall be zero at the calibration frequency.

Table 6 — Tolerance limits on level range control accuracy in two frequency ranges, in decibels.

Frequency range Hz	Instrument type 0	1	2
31.5–2000	±0.3	±0.5	±0.7
20–12 500	±0.5	±1	...

5.3 Frequency-weighting design goals

Frequency-weighting design goals in table 4 correspond to the pole-zero specifications in annex E.

NOTE – Frequency-weighting B is included for consistency with ANSI S1.4-1983 (R 1997).

At frequencies greater than 20 kHz, the relative response level shall decrease by at least 12 dB per octave for any frequency-weighting characteristic.

5.4 Level range control

When a level range control is included, it shall not introduce errors in excess of those given in table 6. This requirement is identical to 5.3 and table VI of ANSI S1.4-1983 (R 1997).

6 Time averaging and indicator characteristics

6.1 Indicator

The indicator shall display the time-average frequency-weighted sound pressure level in decibels and shall meet the requirements of table 7. In addition, it also may display the frequency-weighted sound exposure level in decibels. Time-average AI-weighted sound pressure level in decibels is another option. (See annex C).

6.2 Linear operating range and pulse range

The linear operating range (for both time-average frequency-weighted sound pressure level and the optional frequency-weighted sound exposure

Table 7 — Tolerance limits for time averaging.

Burst duty factor of test signal	Level of tone-burst relative to continuous signal, dB	Tolerance limits, dB Instrument type 0	1	2
Continuous	0	—	—	—
1/10	10	±0.5	±0.5	±1
1/100	20	±0.5	±0.5	±1
1/1000	30	±0.5	±1	±1.5
1/10 000	40	±1	±1	—
1/100 000	50	±1	—	—

NOTE – The continuous signal and all toneburst sequences have identical time-average levels.

level) shall be stated in the Instruction Manual. The linear operating range shall conform to, or exceed, the requirements of table 8 on the reference level range for sinusoidal signals at a frequency of 4 kHz.

The pulse range shall be stated in the Instruction Manual and shall at least conform to the requirements of table 8.

Table 8 — Minimum values for linear operating range and pulse range with tolerance limits, in decibels.

	Instrument type 0	1	2
Minimum value of linear operating range	70	60	50*
Tolerance limits (for testing according to 9.3.3)	±0.4	±0.7	±1
Minimum value for pulse range	73	63	53*
Tolerance limit, burst duration < 10 ms but ⩾ 1 ms (for testing according to 9.3.4)	±1.9	±2.2	±2.5
Tolerance limit, burst duration ⩾ 10 ms (for testing according to 9.3.4)	±1.4	±1.7	±2

*A minimum linear operating range of 60 dB and a pulse range of 63 dB are recommended for Type 2 instruments designed after the publication date of this Standard.

The numerical value of the linear operating range shall be no more than 3 dB less than the numerical value of the pulse range. It may however be equal to or exceed the pulse range.

NOTE – A linear operating range exceeding the minimum values in table 8 or an automatic level range control may be advantageous for unattended measurements.

If the instrument includes a manual level range control, it is permissible to allow a reduced linear operating range and pulse range on the lowest and highest level ranges. Any reduction shall be stated in the Instruction Manual and shall not exceed 10 dB. The reduction shall include the effects of the microphone and preamplifier.

6.3 Indicator range

The extent of the indicator range, whether analog or digital, shall be at least 30 dB. The indicator range shall extend neither above nor below the linear operating range, except for the lowest and highest level ranges if the instrument includes a manual level range control.

6.4 Multiple ranges

When the integrating sound level meter has more than one level range, there shall be an overlap of indicator range of at least 20 dB for Types 0 and 1, and 10 dB for Type 2 between adjacent level ranges.

6.5 Start-up time

The Instruction Manual shall state the settling times for integration. After start of an integration, settling times are the maximum times needed for the indication of the instrument to settle within 0.5 dB and within 0.1 dB of the final indication. Settling times shall be determined for constant-level sinusoidal signals within the linear operating range of the instrument.

NOTE – It is recommended that the settling time corresponding to 0.5 dB should be less than 10 s for time-average frequency-weighted sound pressure level indications of more than 30 dB re 20 μPa.

In all cases, the settling time shall be less than one minute.

Where optional timing facilities (see 4.11) are operative and no indication is available until the end of the preset averaging time, the above requirement for 0.1 dB shall apply when the indication first occurs.

The Instruction Manual shall state the minimum hold time if the result of a measurement is not held continuously.

6.6 Indicator resolution

The scale of an analog indicator (meter or recorder) shall be graduated in steps not greater than 1 dB. Each decibel step shall be at least 1 mm wide.

A digital indicator shall have a resolution of not greater than 0.1 dB. When a discontinuous analog indicator is used, reduced resolution is permitted. Resolution shall be not greater than 0.2 dB for Types 0 and 1 instruments, and 1 dB for Type 2 instruments. Because of the low resolution for Type 2 instruments, special test methods will be required to demonstrate that all requirements of this Standard are met.

6.7 Reset

A reset facility that re-initiates the computation of time-average frequency-weighted sound pressure level or frequency-weighted sound exposure level shall be included. It also shall reset any overload indication.

6.8 Pause

A "pause" or "cancel" facility may be provided either to interrupt the integration for a certain time or to cancel an increase in time-average sound pressure level or sound exposure level caused by integration during a specified elapsed time. The use of these facilities shall not cause spurious indications.

NOTE – The cancel facility may be such as to delete the signal and measured elapsed time for as much as 10 s before the moment of activation.

7 Overload indication

7.1 Latched overload

An integrating sound level meter shall have an indicator to provide a latched indication if an overload has existed during any part of the integration period. The overload indication shall be reset only by re-initiating the computation of time-average sound pressure level or sound exposure level.

7.2 Optional overload indicators

Additional overload indicators with or without automatic reset are optional.

7.3 Overload requirements

The overload indication shall conform to the requirements given with the test procedures described in 9.3.5.

8 Sensitivity to various environments

Integrating sound level meters shall conform to the following specifications, which are identical to the requirements of 7.1 to 7.6 of ANSI S1.4-1983 (R 1997).

8.1 Atmospheric pressure

For a variation of $\pm 10\%$ in static pressure around the reference static pressure of 101.325 kPa, the sensitivity level of the complete instrument shall change by not more than ± 0.3 dB for Types 0 and 1 instruments, and by not more than ± 0.5 dB for Type 2 instruments when tested with sound at a frequency between 200 and 1000 Hz.

8.2 Intense sound fields

When the microphone is replaced by an equivalent electrical impedance and the sound level meter is placed in a sound field, the response of the sound level meter shall be at least 20 dB less than that obtained with the microphone installed. The requirement shall be fulfilled using a sinusoidal sound at a test sound pressure level of 100 dB or at the upper limit of sound pressure level which the instrument is designed to measure, whichever is lower, and for frequencies at nominal one-third-octave intervals in the range between 31.5 Hz and 8 kHz. The sine-wave sweep rate, where used, shall not exceed 0.1 octave per second.

8.3 Vibration

The influence of mechanical vibrations on the operation of the sound level meter shall be reduced as far as practical. The effect of vibration between 20 Hz and 1000 Hz shall be indicated in the Instruction Manual for the complete apparatus if the microphone is not intended to be mounted on an extension cable for normal use, otherwise at least for the microphone assembly.

The instrument shall be vibrated sinusoidally at a root-mean-square acceleration of 1 m/s^2. A reference sound level meter that is not being vibrated shall be used to measure the sound produced by the vibration exciter. The readings of both the sound level meter under test and the reference sound level meter shall be reported and shall differ by at least 10 dB for the test results to be considered valid. The test shall be performed for the broadest-band frequency weighting characteristic provided or FLAT response if available.

During the test the instrument shall be mounted by the tripod mount if one is available and the vibration shall be applied in the direction of the axis of the tripod mount. If there are two possible mounting methods, the test shall be performed with both. If there is no tripod mount, the Instruction Manual shall specify the mounting of the sound level meter to be tested. In this case and for adjustable mountings, the vibration shall be applied in a direction perpendicular to the plane of the diaphragm of the microphone's sensing element.

8.4 Alternating magnetic fields

The effects of alternating magnetic fields shall be reduced as far as practical. Sound level meters with attached microphones shall be tested in a magnetic field of strength 80 A/m at 50 or 60 Hz, preferably at 60 Hz. The sound level meter shall be oriented in a direction which gives maximum indication, and this indication shall be stated for each frequency weighting characteristic provided. For instruments using an extension cable between the microphone and sound level meter, the test shall also be performed on the microphone. The test frequency shall be stated.

8.5 Air temperature

The Instruction Manual shall state the air temperature range over which the indicated sensitivity level, at the calibration frequency, of the complete instrument, including microphone, is not affected by more than 0.5 dB, referred to the indication at the reference temperature. If the change in sensitivity level at the calibration frequency exceeds ±0.5 dB in the temperature range between 10°C and 50°C, correction information shall be provided in the Instruction Manual.

8.6 Humidity

The Instruction Manual shall state the range of relative humidity over which the instrument, including the microphone, is intended to operate continuously at air temperatures in the range from 10 °C to 50°C. The indicated sensitivity level at the calibration frequency shall not change by more than ±0.5 dB, referred to the indicated sensitivity level at the reference relative humidity, in the range of relative humidity from 30 % to 90 %. The test shall be conducted at an air temperature of 40°C.

9 Calibration and verification of the basic characteristics

9.1 Introduction and reference environmental conditions

The following tests shall be performed to determine that an integrating sound level meter conforms to the specifications of this Standard. All tests shall be made at or referred to the reference environmental conditions given in ANSI S1.15-1997/Part 1. Unless otherwise stated, the tests shall be performed using low distortion sinusoidal signals.

NOTE – The Instruction Manual should provide detailed information on how tests are to be performed.

Testing under free-field conditions refers to a sound field consisting of plane progressive waves arriving from the reference direction of incidence.

If the same integrating sound level meter is equipped to measure both random-incidence and free-field sound levels, the Instruction Manual shall state clearly which kind of microphone or which switch position belongs to free-field and which to random-incidence response. Such change shall not alter the accuracy grade of the instrument.

NOTE – If, for a given model of microphone or sound level meter, the difference between random-incidence and reference-direction free-field sensitivity level is known from measurements, the random-incidence sensitivity level may be determined alternatively from the free-field sensitivity level by adding this difference as an adjustment at each frequency of interest.

9.2 Overall instrument characteristics

Calibration procedures and tests related to a complete integrating sound level meter are described in 9.2.1 and 9.2.2. The tests may be carried out partly as acoustical and partly as electrical tests if no loss in accuracy results.

9.2.1 Testing for random-incidence response is performed with plane progressive waves arriving at the microphone at various angles of incidence as described in annex D. For instruments that do not have rotational symmetry, this test shall be performed in two planes perpendicular to each other. From the results of the random incidence sensitivities S_1 and S_2 in the two planes, the geometric average S is calculated from:

$$S = (S_1 \times S_2)^{1/2} \quad (6)$$

During acoustical tests, the sound field shall not be significantly disturbed by the presence of the observer. The observer preferably should not be present in the sound field, but should, for example, read the indicated signal level remotely.

The random-incidence relative response level shall be determined from the measured free-field response at a sufficient number of frequencies and directions (see annex D). The random-incidence response level of the sound level meter shall conform to the frequency response characteristics and within the tolerance limits given in tables 4 and 5. At the calibration frequency, the level of the non-frequency-weighted sound pressure of the sound waves shall be at the calibration sound pressure level or in a range not more than 20 dB below that level.

The overall accuracy shall be within the tolerance limits given in 4.2 for the reference environmental conditions given in 9.1.

9.2.2 When testing with acoustical signals, at the reference frequency, the sound pressure level should be the reference sound pressure level, but if it is not, shall be not more than 20 dB less than this level during testing.

The testing of the frequency weighting may be divided into:

(a) testing of the microphone and those parts of an integrating sound level meter that affect the sound field around the microphone in a suitable sound field; and

(b) testing of all other parts of an integrating sound level meter with electrical signals and an equivalent electrical impedance substituted for the microphone.

When testing of frequency weighting is divided into acoustical and electrical tests, the diffraction effects of the microphone and instrument case shall be applied as an adjustment to the electrical frequency response in determining conformance to the specifications of tables 4 and 5. The effects of any compensation for the frequency response of the microphone shall be taken into account.

9.3 Amplifier and indicator characteristics

The following tests shall be carried out using electrical signals and an equivalent electrical impedance substituted for the microphone.

9.3.1 Level range control

When a level range control is included, it shall be tested to verify conformance to the requirements of 5.4.

9.3.2 Time averaging

The time averaging test compares the reading indicated on the reference level range for continuous sinusoidal signals with that obtained from a sequence of sinusoidal tonebursts having the same time-average sound level.

A continuous signal at 4 kHz is applied to the instrument to give an indication 20 dB above the lower boundary of the 4 kHz linear operating range on the reference level range. A sequence of tonebursts at a frequency of 4 kHz for which the calculated time-average level is identical with the level of the continuous signal is substituted. The indication shall be identical with that for the continuous signal within the tolerance limits given in table 7. For burst duty factors between consecutive values of table 7, the wider of the two corresponding tolerance limits shall apply.

The duration of the sequence of tonebursts shall be at least 10 s. At least for the smallest relevant burst duty factor, the test also shall be performed with the test signal applied for a duration equal to the maximum integration time of the instrument or 1 h, whichever is less. The duration of individual tonebursts shall be not less than 1 ms.

For instruments capable of measuring A-frequency-weighted sound exposure level, the time averaging tests shall be repeated in the A-frequency-weighted sound exposure level mode.

All time averaging tests shall be carried out using A-frequency weighting.

NOTE – The systematic effect of the A-frequency weighting on the level of the 4 kHz time-average signal is less than 0.1 dB for all burst duty factors of table 7 and is ignored.

For instruments for which the linear operating range is greater than their pulse range, the time averaging tests shall be repeated at higher levels for the continuous signal until an overload indication occurs.

9.3.3 Linear operating range

Error in level linearity is referred to the reference sound pressure level on the reference level range. The test shall be performed with sinusoidal signals at a frequency of 4 kHz.

For testing of level linearity outside the indicator range at signal levels that, if continuous, would exceed the limits of the indicator range, a sequence of tonebursts may be used. The duration of the toneburst shall be at least 1 ms and the burst duty factor shall not lie outside the range of values of table 7.

9.3.4 Pulse range

An ideal integrating sound level meter is limited in pulse handling capability only by the limit imposed at the upper boundary of the linear operating range. It will measure short duration, impulsive or discontinuous signals as accurately as signals that are continuous or only slowly varying. The following tests ensure that this ideal characteristic is met within certain tolerance limits.

Apply a single short duration toneburst at a frequency of 4 kHz during a predetermined integration period, for example 10 s, superimposed upon a low-level continuous sinusoidal signal at a level corresponding to the lower boundary of the linear operating range. Timing of the integration period shall be within ±2 %. The low-level continuous signal and the toneburst shall be in phase with one another. The test shall be conducted on the reference level range using toneburst durations ranging from 1 ms to 1 s.

The level of a 4 kHz toneburst when superimposed on the continuous signal shall be increased gradually until it exceeds the level of the time-averaged low-level continuous signal by the minimum pulse range specified in table 8.

At no peak level of the tonebursts during this test shall the indicated level deviate from the theoretical time-average level of the test signal by more than the tolerance limits for the pulse range specified in table 8.

NOTE – Integrating sound level meters specified in this Standard are not required to measure any peak levels. See 3.5.

Table 9 — Examples of theoretical time-average levels, in decibels, of toneburst test signals relative to level of the time-average continuous low level signal alone.

Toneburst duration ms	Peak level* of toneburst relative to level of low-level continuous signal, dB 73	63	53
1	30	20	10.4**
10	40	30	20
100	50	40	30
1000	60	50	40

*These relative peak levels correspond to the minimum values of the pulse range, as specified in table 8 for Types 0, 1, and 2 instruments respectively.

**The increase from 10 dB to 10.4 dB is due to the low-level continuous signal.

The time-average sound pressure level of the test signal shall be calculated from the amplitude and duration of the toneburst, the amplitude of the continuous signal, and the integration interval. Tests should be conducted with toneburst durations of 1 ms, 10 ms, 100 ms, and 1 s for which the theoretical time-average levels are given in table 9 for the pulse ranges specified in table 8 and an integration duration of 10 s.

For instruments for which the linear operating range is greater than the pulse range, the test shall be repeated at a level for the continuous signal equal to the upper boundary of the linear operating range minus the minimum pulse range from table 8.

For instruments capable of measuring A-frequency-weighted sound exposure level, the pulse range tests shall be repeated with the instrument set to the A-frequency-weighted sound exposure level mode.

9.3.5 Overload indicator

The overload indicator shall be checked at the same time as the pulse range is tested as described in 9.3.4. The overload indicator shall be checked by a 1 ms burst of a 4 kHz signal. The amplitude of the toneburst is increased until overload indication occurs.

An overload indication for instruments operating with A-weighting shall occur according to the following test when the indication of the instrument exceeds the tolerance limits in table 5 relative to its indication at 1000 Hz. The instrument is set to A-weighting and the microphone is replaced by an equivalent electrical impedance. Through this impedance, a 1000 Hz sinusoidal signal is fed to the instrument with an amplitude giving a reading that is 5 dB less than the greatest A-weighted sound level that the instrument is designed to measure. The frequency of the input signal shall be decreased in steps in accordance with the nominal frequencies in table 4 to 20 Hz while simultaneously the amplitude is raised by an amount, in decibels, equal to the inverse of the A-weighting characteristic given in table 4. Dual independently adjustable range controls shall be set according to the manufacturer's instructions.

10 Provision for use with auxiliary equipment

10.1 Cables

If an integrating sound level meter can be used with a cable, specified or supplied by the manufacturer, between the microphone and the amplifier, the corrections corresponding to this method of use shall be stated in the Instruction Manual.

NOTE – Corrections due to the use of other available accessories should be stated. These accessories include windscreens and rain protectors.

10.2 Output requirements

If an integrating sound level meter is provided with one or more electrical outputs for use in driving spectrum analyzers, recorders and other equipment, the following requirements shall apply:

(a) if connection of external equipment having an impedance within the range specified in the Instruction Manual would affect the indicator by more than 0.1 dB for Type 0, 0.2 dB for Type 1, and 0.5 dB for Type 2 instruments, the indicator shall be automatically muted or disconnected when such external equipment is connected;

(b) full details relating to the output characteristics of the signal shall be given in the Instruction Manual.

NOTE – When an output signal is provided, it should be possible to terminate the output in any impedance without affecting either the indicator or the linear operation of the instrument.

10.3 Filters

If connections are provided to permit insertion of an external filter, the Instruction Manual shall state clearly how these connections are to be used.

10.4 Digital output

If a digital output is provided, the data format shall be specified in the Instruction Manual.

11 Rating information and Instruction Manual

11.1 Instrument markings

An integrating sound level meter that conforms to the specifications of this Standard shall be marked to show the number of this Standard, its year of issue, and the instrument type number designation. If the instrument is intended for laboratory use only, it shall be marked additionally with the letter "L." It also shall be marked with the name of the manufacturer, the model number, and the serial number.

11.2 Instruction Manual

An Instruction Manual shall be supplied with the instrument and shall include at least the information listed below:

(1) kind of microphone (piezoelectric, capacitor, etc.) and method of mounting necessary to conform to the tolerance limits specified for that particular accuracy grade of integrating sound level meter;

(2) reference direction of incidence as defined in 3.10 for random-incidence response and, optionally, for free-field response;

(3) linear operating range and pulse range, for each indicator range, as defined in 3.4 and 3.5;

(4) fixed integration periods provided, if any;

(5) calibration frequency, as defined in 3.11;

(6) reference sound pressure level, as defined in 3.14;

(7) reference level range, as defined in 3.6;

(8) effect of vibrations on the operation of the integrating sound level meter when tested in accordance with 8.3;

(9) effect of alternating magnetic fields when tested in accordance with 8.4;

(10) effects of temperature when tested in accordance with 8.5;

(11) effects of humidity when tested in accordance with 8.6;

(12) any correction to the response required when a microphone extension cable specified or supplied by the manufacturer is used;

(13) effect on the performance of the instrument caused by using manufacturer-recommended microphone accessories such as windscreens;

(14) procedure necessary to maintain the accuracy as specified in 4.2 for random-incidence or, optionally, free-field response;

(15) position of the instrument case and observer relative to the microphone to minimize their influence on the sound field;

(16) procedure to ensure optimum operating conditions when the integrating sound level meter is used with external filters or analyzers, if applicable;

(17) limitations on the electrical impedance that may be connected to the output connectors, if provided;

(18) warm-up time before valid readings can be made, as defined in 4.10;

(19) start-up time before valid readings are obtained, as defined in 6.5;

(20) expected battery life for continuous operation under reference environmental conditions of 9.1;

(21) information regarding the sensitivity level for random-incidence and in a free-field at the reference direction, as a function of frequency. These data shall be given for frequencies at least at nominal one-third octave intervals from 31.5 Hz up to 10 kHz for Types 0 and 1, and to 8 kHz for Type 2;

(22) directional response of the integrating sound level meter at various frequencies including at least 1 kHz, 2 kHz, 4 kHz, and 8 kHz for Types 0, 1, and 2, and additionally 12.5 kHz for Types 0 and 1 instruments;

(23) electrical impedance that shall be substituted for the microphone for electrical testing purposes;

(24) instructions on how to change from random-incidence to free-field response, or vice versa, if applicable;

(25) indicator range, as defined in 3.7.

Annex A
(informative)
Difference between time averaging capability of integrating and conventional sound level meters

Both integrating sound level meters and conventional sound level meters form the time average of frequency-weighted sound pressures. The time averaging processes are different, however, in two respects.

First, the conventional sound level meter has a limited number of fixed and relatively short-duration time-weighting characteristics, the most common ones being designated F and S for fast and slow, with nominal exponential time constants of 125 ms and 1000 ms respectively. In contrast, time averaging durations for an integrating sound level meter may extend from milliseconds to many minutes or hours.

Secondly, an integrating sound level meter gives equal emphasis to all sounds that occur during the selected time averaging period, whereas a conventional sound level meter gives greater emphasis to recently occurring sounds than to sounds that occurred less recently. The time weightings of conventional sound level meters decay exponentially so that, for example, using the S time-weighting, principal weight is given to sounds that occurred less than 1 s previously, and very little weight is given to sounds that occurred even 10 s previously.

Annex B
(informative)
Use of free-field and random-incidence responses

The method of use of the instrument may have as much effect on a measurement as the quality of the instrument itself. Errors often will result if the effects of the environment are ignored. Among the environments to be considered are random-incidence and free-field acoustical conditions.

An instrument designed for random-incidence response may not conform to the specifications of IEC 804 for free-field response within the tolerance limits for the same accuracy grade. An instrument designed to conform to the specifications of this Standard should conform to the free-field response specifications of IEC 804.

Annex C
(informative)
Time-average AI-weighted sound pressure level

It is recommended that time-average AI-weighted sound pressure level not be used in future standards or regulations.

C.1 Definition

time-average AI-weighted sound pressure level. Ten times the logarithm to the base ten of the ratio of time-mean-square, A-frequency-weighted, I-time-weighted sound pressure, during a stated time interval T, to the square of the reference sound pressure of 20 μPa. Unit, decibel (dB); symbol $L_{\mathrm{Aleq}T}$.

NOTE – In symbols, time-average AI-weighted sound pressure level in decibels is:

$$L_{\mathrm{Aleq}T} = 10 \lg\left\{\left[(1/T)\int_0^T p_{\mathrm{AI}}^2(t)\mathrm{d}t\right] \Big/ p_0^2\right\} \quad \text{(C1)}$$

where p_{AI}^2 is the squared A-frequency-weighted, I-time-weighted, sound pressure signal, a function of elapsed time t; for gases, reference sound pressure $p_0 = 20$ μPa; the integral from 0 to time T is for a stated time interval, $t_2 - t_1$.

C.2 Characteristics

An integrating sound level meter set to the I-time weighting performs the I-time weighting on the squared signal as specified in 6.3 of ANSI S1.4-1983 (R 1997) before the final averaging operation. These specifications are given here in C.2.1.

C.2.1 I-time-weighting

In principle, the characteristics of I-time-weighting are similar to those for F-time-weighting and S-time-weighting. For sound pressure that increases with increasing time, the time constant is 35 ms. For sound pressure that decreases with increasing time, the time constant is 1500 ms.

The rise time constant of the peak detector should be small (e.g., 1 ms or less) compared with the 35 ms time constant. The decay rate should be 2.9 dB/s ± 0.5 dB/s for Types 0 and 1 instruments and 2.9 dB/s ± 1.0 dB/s for a Type 2 instrument. The nominal decay rate and tolerance limits correspond approximately to a time constant of 1500 ms ± 250 ms for Types 0 and 1 instruments and 1500 ms ± 500 ms for Type 2 instruments.

Testing with a sequence of tonebursts is described in C.3. The indication of the integrating sound level meter with tolerance limits is given in table C.1.

Table C.1 — Response to a continuous sequence of tonebursts of repetition frequency 0.2 Hz with tolerance limits.

Toneburst duration ms	Level of toneburst relative to level of continuous reference signal dB	Tolerance limits dB Types 0 and 1	Tolerance limits dB Type 2
1000	-3.3	±0.5	±1.0
20	-9.0	±1.0	±2.0
5	-14.1	±2.0	±3.0
1	-20.9	±2.0	±3.0

C.3 Test

(a) A sequence of tonebursts at a frequency of 4 kHz is applied (see 9.3.2). The repetition frequency of the sequence is 0.2 Hz.

(b) The continuous reference signal has the same root-mean-square amplitude as the tonebursts and produces an indication at the upper end of the indicator range.

(c) The averaging duration is at least 10 s.

(d) The test is performed with A-frequency weighting.

NOTE – The systematic effects of A-weighting on the time-average level are less than 0.1 dB for the test signal and are ignored.

(e) When the range of the indicator is more than 30 dB, the test is repeated at intervals of 10 dB below full scale down to the lowest level that produces an indication inside the indicator range specified in the Instruction Manual.

(f) If the amplitude of the toneburst is increased by 10 dB for the burst duration of 5 ms and by 20 dB for the burst duration of 1 ms, the indication should increase by 10 dB ± 1 dB and 20 dB ± 1 dB respectively.

The above requirements should be met on all level ranges of the instrument.

Annex D
(informative)
Approximation of the random-incidence relative response level

[This annex is equivalent to Appendix B of S1.4-1983 (R 1997)].

This annex reviews the concept of the random incidence response required for instruments that conform to the specifications of this Standard and suggests a method for determination of the random-incidence relative response level. [See clause 8 of ANSI S1.10-1966 (R 1997).]

The square of the random incidence sensitivity, $S_d(f)$, is the space average mean of the squares of the sensitivities for all directions, given by

$$S_d^2(f)=(1/4\pi)\int_0^{2\pi}\int_0^{\pi} S_0^2(\theta,\phi,f)\sin\theta\,d\theta\,d\phi. \tag{D1}$$

where $S_0(\theta,\phi,f)$ is the free-field sensitivity to sound incident at the angles θ and ϕ (where θ is measured from the principal axis of the microphone and ϕ is from an arbitrary reference in the plane perpendicular to the axis), and at frequency f. Both S_d and S_0 are expressed in the same unit, for example, volts per pascal.

For the purpose of basic calibration of a sound level meter as a function of both angle of incidence and frequency, it is necessary to determine the relative response level for random incidence sound as a function of frequency. The relative response for random incidence may be calculated as indicated by equation (D2):

$$R_r(f)=10\,\lg\left[(1/4\pi)\int_0^{2\pi}\int_0^{\pi}10^{[0.1R(\theta,\phi,f)]}\times\sin\theta\,d\theta\,d\phi\right] \tag{D2}$$

where $R_r(f)$ is the relative response level, in decibels, for random incidence sound at frequency f and $R(\theta,\phi,f)$ is the relative response level, in decibels, for plane-wave sound at angles θ and ϕ, and at frequency f.

The relative response level for random incidence may be computed from relative response levels obtained at a finite number of angular orientations for several discrete-frequency sounds. The contribution (ΔK) to the random-incidence relative response from each orientation (θ,ϕ) is given by:

$$\begin{aligned}\Delta K(\theta_r,\phi_s,f) &= (1/4\pi)\int_{\phi_s-\Delta\phi/2}^{\phi_s+\Delta\phi/2}\int_{\theta_r-\Delta\theta/2}^{\theta_r+\Delta\theta/2} \times 10^{[0.1R(\theta,\phi,f)]}\times\sin\theta\,d\theta\,d\phi\\ &\approx(1/4\pi)10^{[0.1R(\theta,\phi,f)]}\times[\cos(\theta_r-\Delta\theta/2)-\cos(\theta_r+\Delta\theta/2)]\Delta\phi\end{aligned} \tag{D3}$$

where the orientation angles θ_r and ϕ_s give the position of an elemental area on a unit sphere. The extent of the area is defined by the elements $\Delta\phi$ and $\Delta\theta$ and r and s are integers representing the various elements.

The relative response level for random incidence is calculated from:

$$R_r(f) \approx 10 \lg \sum_n \Delta K(\theta_r, \phi_s, f) \qquad \text{(D4)}$$

where n is the number of elemental areas.

For the purpose of this annex, the enveloping sphere is divided into non-overlapping areas that cover the sphere completely. In no case should n be less than eight. The angular orientations should be chosen such that the elemental areas are equal. In general, for equal areas and cylindrical symmetry, the angles are selected by setting

$$\cos \theta = \pm 2k/n, \quad k = 0,1,2,\ldots(n-1)/2 \quad (n,\ \text{odd})$$

$$\cos \theta = \pm(2k+1)/n, \quad k = 0,1,2,\ldots[(n/2)-1] \quad (n,\ \text{even})$$

For cylindrical symmetry and with n chosen as 8, the values of θ, in degrees, which give equal area contributions are

28.96, 51.32, 67.98, 82.82,
97.18, 112.03, 128.68, 151.04, and

$$\Delta K(\theta, f) = (1/8)10^{0.1R(\theta, f)} \qquad \text{(D5)}$$

Annex E
(informative)
Relative response levels of frequency weighting characteristic

The steady-state relative response level W, in decibels, is given below for each frequency weighting characteristic of table 4.

For C weighting:

$$W_C(f) = 20 \lg\left[\frac{f_4^2 f^2}{(f^2+f_1^2)(f^2+f_4^2)}\right] + C_{1000} \qquad \text{(E1)}$$

For B weighting:

$$W_B(f) = 20 \lg\left[\frac{f_4^2 f^3}{(f^2+f_1^2)(f^2+f_4^2)(f^2+f_5^2)^{1/2}}\right] + B_{1000} \qquad \text{(E2)}$$

For A weighting:

$$W_A(f) = 20 \lg\left[\frac{f_4^2 f^4}{(f^2+f_1^2)(f^2+f_2^2)^{1/2}(f^2+f_3^2)^{1/2}(f^2+f_4^2)}\right] + A_{1000} \qquad \text{(E3)}$$

Frequency f is in hertz and C_{1000}, B_{1000}, and A_{1000}, in decibels, are scale factors such that W_C, W_B, and W_A are zero at 1000 Hz to the nearest tenth of a decibel. The values for f_1 through f_5 in hertz and C_{1000}, B_{1000}, and A_{1000} in decibels are:

f_1 = 20.598997 $\qquad C_{1000}$ = 0.0619

f_2 = 107.65265 $\qquad B_{1000}$ = 0.1696

f_3 = 737.86223 $\qquad A_{1000}$ = 1.9997

f_4 = 12194.22

f_5 = 158.48932.

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

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

S1 STANDARDS ON ACOUSTICS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

S2 STANDARDS ON MECHANICAL VIBRATION AND SHOCK

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

• **ANSI S2.21-1998** American National Standard Method for Preparation of a Standard Material for Dynamic Mechanical Measurements

• **ANSI S2.22-1998** American National Standard Resonance Method for Measuring Dynamic Mechanical Properties of Viscoelastic Materials

• **ANSI S2.23-1998** American National Standard Single Cantilever Beam Method for Measuring the Dynamic Mechanical Properties of Viscoelastic Materials

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

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

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

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

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

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

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

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

• **ANSI S2.45-1983 (R 1997)** American National Standard Electrodynamic Test Equipment for Generating Vibration—Methods of Describing Equipment Characteristics

• **ANSI S2.46-1989 (R 1997)** American National Standard Characteristics to be Specified for Seismic Transducers

• **ANSI S2.47-1990 (R 1997)** American National Standard Vibration of Buildings—Guidelines for the Measurement of Vibrations and Evaluation of Their Effects on Buildings

• **ANSI S2.48-1993 (R 1997)** American National Standard Servo-Hydraulic Test Equipment for Generating Vibration—Methods of Describing Characteristics

• **ANSI S2.58-1983 (R 1997)** American National Standard Auxiliary Tables for Vibration Generators—Methods of Describing Equipment Characteristics

• **ANSI S2.60-1987 (R 1997)** American National Standard Balancing Machines—Enclosures and Other Safety Measures

• **ANSI S2.61-1989 (R 1997)** American National Standard Guide to the Mechanical Mounting of Accelerometers

S3 STANDARDS ON BIOACOUSTICS

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

• **ANSI S3.2-1989 (R 1995)** American National Standard Method for Measuring the Intelligibility of Speech Over Communication Systems

• **ANSI S3.4-1980 (R 1997)** American National Standard Procedure for the Computation of Loudness of Noise

• **ANSI S3.5-1997** American National Standard Methods for Calculation of the Speech Intelligibility Index

• **ANSI S3.6-1996** American National Standard Specification for Audiometers

• **ANSI S3.7-1995** American National Standard Method for Coupler Calibration of Earphones

• **ANSI S3.13-1987 (R 1997)** American National Standard Mechanical Coupler for Measurement of Bone Vibrators

• **ANSI S3.14-1977 (R 1997)** American National Standard for Rating Noise with Respect to Speech Interference

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

• **ANSI S3.20-1995** American National Standard Bioacoustical Terminology

• **ANSI S3.21-1978 (R 1997)** American National Standard Method for Manual Pure-Tone Threshold Audiometry

• **ANSI S3.22-1996** American National Standard Specification of Hearing Aid Characteristics

• **ANSI S3.25-1989 (R 1995)** American National Standard for an Occluded Ear Simulator

• **ANSI S3.29-1983 (R 1996)** American National Standard Guide to the Evaluation of Human Exposure to Vibration in Buildings

• **ANSI S3.32-1982 (R 1995)** American National Standard Mechanical Vibration and Shock Affecting Man—Vocabulary

• **ANSI S3.34-1986 (R 1997)** American National Standard Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand

• **ANSI S3.35-1985 (R 1997)** American National Standard Methods of Measurement of Performance Characteristics of Hearing Aids Under Simulated *in-situ* Working Conditions

• **ANSI S3.36-1985 (R 1996)** American National Standard Specification for a Manikin for Simulated *in situ* Airborne Acoustic Measurements

• **ANSI S3.37-1987 (R 1997)** American National Standard Preferred Earhook Nozzle Thread for Postauricular Hearing Aids

• **ANSI S3.39-1987 (R 1996)** American National Standard Specifications for Instruments to Measure Aural Acoustic Impedance and Admittance (Aural Acoustic Immittance)

• **ANSI S3.40-1989 (R 1995)** American National Standard Guide for the Measurement and Evaluation of Gloves Which are Used to Reduce Exposure to Vibration Transmitted to the Hand

• **ANSI S3.41-1990 (R 1996)** American National Standard Audible Emergency Evacuation Signal

• **ANSI S3.42-1992 (R 1997)** American National Standard Testing Hearing Aids with a Broad-Band Noise Signal

• **ANSI S3.44-1996** American National Standard Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment

• **ANSI S3.46-1997** American National Standard Methods of Measurement of Real-Ear Performance Characteristics of Hearing Aids

S12 STANDARDS ON NOISE

• **ANSI S12.1-1983 (R 1996)** American National Standard Guidelines for the Preparation of Standard Procedures for the Determination of Noise Emission from Sources

• **ANSI S12.2-1995** American National Standard Criteria for Evaluating Room Noise

• **ANSI S12.3-1985 (R 1996)** American National Standard Statistical Methods for Determining and Verifying Stated Noise Emission Values of Machinery and Equipment

• **ANSI S12.5-1990 (R 1997)** American National Standard Requirements for the Performance and Calibration of Reference Sound Sources

• **ANSI S12.6-1997** American National Standard Method for the Measurement of the Real-Ear Attenuation of Hearing Protectors (Revision of ANSI S12.6-1984)

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

• **ANSI S12.8-1998** American National Standard Methods for Determining the Insertion Loss of Outdoor Noise Barriers

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

• **ANSI S12.9-1992/Part 2** American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 2: Measurement of Long-Term, Wide-Area Sound

• **ANSI S12.9-1993/Part 3** American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 3: Short-Term Measurements with an Observer Present

• **ANSI S12.9-1996/Part 4** American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 4: Noise Assessment and Prediction of Long-Term Community Response

• **ANSI S12.9-1998/Part 5** American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 5: Sound Level Descriptors for Determination of Compatible Land Use

• **ANSI S12.10-1985 (R 1997)** American National Standard Methods for the Measurement and Designation of Noise Emitted by Computer and Business Equipment (Revision of ANSI S1.29-1979)
• **ANSI S12.11-1987 (R 1997)** American National Standard Methods for the Measurement of Noise Emitted by Small Air-Moving Devices
• **ANSI S12.12-1992 (R 1997)** American National Standard Engineering Method for the Determination of Sound Power Levels of Noise Sources Using Sound Intensity
• **DRAFT ANSI S12.13-1991** Draft American National Standard Evaluating the Effectiveness of Hearing Conservation Programs
• **ANSI S12.14-1992 (R 1997)** American National Standard Methods for the Field Measurement of the Sound Output of Audible Public Warning Devices Installed at Fixed Locations Outdoors
• **ANSI S12.15-1992 (R 1997)** American National Standard for Acoustics—Portable Electric Power Tools, Stationary and Fixed Electric Tools, and Gardening Appliances—Measurement of Sound Emitted
• **ANSI S12.16-1992 (R 1997)** American National Standard Guidelines for the Specification of Noise of New Machinery
• **ANSI S12.17-1996** American National Standard Impulse Sound Propagation for Environmental Noise Assessment
• **ANSI S12.18-1994** American National Standard Procedures for Outdoor Measurement of Sound Pressure Level
• **ANSI S12.19-1996** American National Standard Measurement of Occupational Noise Exposure
• **ANSI S12.23-1989 (R 1996)** American National Standard Method for the Designation of Sound Power Emitted by Machinery and Equipment
• **ANSI S12.30-1990 (R 1997)** American National Standard Guidelines for the Use of Sound Power Standards and for the Preparation of Noise Test Codes (Revision of ANSI S1.30-1979)
• **ANSI S12.31-1990 (R 1996)** American National Standard Precision Methods for the Determination of Sound Power Levels of Broad-Band Noise Sources in Reverberation Rooms (Revision of ANSI S1.31-1980)
• **ANSI S12.32-1990 (R 1996)** American National Standard Precision Methods for the Determination of Sound Power Levels of Discrete-Frequency and Narrow-Band Noise Sources in Reverberation Rooms (Revision of ANSI S1.32-1980)
• **ANSI S12.33-1990 (R 1997)** American National Standard Engineering Methods for the Determination of Sound Power Levels of Noise Sources in a Special Reverberation Test Room (Revision of ANSI S1.33-1982)
• **ANSI S12.34-1988 (R 1997)** American National Standard Engineering Methods for the Determination of Sound Power Levelsof Noise Sources for Essentially Free-Field Conditions over a Reflecting Plane (Revision of ANSI S1.34-1980)
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• **ANSI S12.36-1990 (R 1997)** American National Standard Survey Methods for the Determination of Sound Power Levels of Noise Sources (Revision of ANSI S1.36-1979)
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• **ANSI S12.43-1997** American National Standard Methods for Measurement of Sound Emitted by Machinery and Equipment at Workstations and Other Specified Positions
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