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AMERICAN NATIONAL STANDARD
Specification for Sound Level Meters

ABSTRACT

This standard is a revision of the American National Standard Specification for Sound Level Meters, S1.4–1971. It conforms as closely as possible to the IEC Standard for Sound Level Meters, Publication 651, First Edition issued in 1979. This revision represents a significant improvement over ANSI S1.4–1971, particularly in its specifications relating to measurement of transient sound signals. It also permits the use of digital techniques and displays. The principal changes from ANSI S1.4–1971 are: inclusion of an optional impulse exponential-time averaging characteristic, inclusion of an optional peak characteristics, more rigorous definition of the dynamic characteristics for the Fast and Slow exponential-time-averaging, increase in the crest factor requirement to ten for type 1 instruments, specification of a type 0 laboratory instrument with generally smaller tolerance limits than those previously specified for type 1, and deletion of the type 3 survey instrument.

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AMERICAN NATIONAL STANDARDS ON ACOUSTICS

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These standards are developed 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 S1.4-1983 on 17 February 1983.

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FOREWORD

[This Foreword is for information only and is not a part of American National Standard Specification for Sound Level Meters, S1.4–1983, a revision of S1.4–1971 (ASA Catalog No. 47-1983).]

This standard comprises a part of a group of definitions, standards, and specifications for use in acoustical work. It has been developed under the American National Standards Institute by the Standards Committee Method of Procedure under the Secretariat of the Acoustical Society of America.

American National Standards Committee S1, under whose jurisdiction this standard was developed, has the following scope:

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

This standard is a revision of the American National Standard Specifications for Sound Level Meters, S1.4–1971. It conforms as closely as possible to the IEC Standard for Sound Level Meters, Publication 651, First Edition, issued in 1979. The principal deviations from publication 651 are: requirement for random-incidence calibration, as has been the United States custom, rather than the free-field method, requirement that the crest factor capability for type 1 instruments be the same, regardless of the inclusion of an impulse exponential-time-averaging characteristic, deletion of the type 3 survey instrument.

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

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Suggestions for improvements in this standard will be welcomed. They should be sent to the Standards Secretariat, Acoustical Society of America, 335 East 45th Street, New York, NY 10017.

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ANSI S1.4A-1985

Amendment to ANSI S1.4-1983 can be found on pages 19 and 20. The amendment was approved on 26 June 1985, two years after the standard was approved.

American National Standard Specification for Sound Level Meters

0 INTRODUCTION

A sound level meter satisfying this specification will consist, in general, of the following elements: a microphone to convert sound pressure signals to electrical signals, an amplifier to raise the microphone output to a useful level, a level range control, frequency weighting to shape the frequency response, specified exponential time averaging, and an indicating system to display the measured sound level. It will also contain a sensitivity control to allow adjustment of amplification so that an indicated sound level is equal to the sound level produced by an acoustical calibrator and may have output connection to accommodate additional measuring equipment.

Although the chief use of a sound level meter is to measure the frequency-weighted level of sound in air, sound level meters often provide for other uses, such as measuring the sound pressure level of many kinds of sound-generating devices in various media. The variety of uses for sound level meters includes: precision measurement of the output of sound sources and the characteristics of sound environments, and routine measurment of the sound produced by machines, equipment, and vehicles. In general, the more precise measurements often require more detailed analysis than can be made with the sound level meter. The more detailed analyses require auxiliary equipment which is the subject of other American National Standards, e.g., ANSI S1.11–1966 (R1971), "American National Standard Specification for Octave, Half-Octave and Third-Octave Band Filter Sets," and ANSI S1.13–1971 (R1976), "American National Standard Method for Measurement of Sound Pressure Levels."

In order to meet diverse user needs, the standard provides three standard frequency weightings, A, B, and C, and three exponential-time-averaging characteristics, slow, fast, and an optional impulse. An instrument may contain additional frequency weightings, e.g., "flat," and other time related exponential averaging characteristics, e.g., "peak."

The standard provides for three grades of instruments, types 0, 1, and 2, and for a special-purpose limited-function instrument, type S. The type 0 instrument, or system, designated Laboratory Standard, was not described in ANSI S1.4–1971 and is intended for use primarily in the laboratory as a reference standard, and accordingly is not required to satisfy the environmental requirements for field instruments. The type 1 instrument, designated Precision, is intended for accurate sound measurements in the field and laboratory. The type 2 instrument, designated General Purpose, is intended for general field use, i.e., measurement of typical environmental sounds when high frequencies do not dominate. The type S, designated Special Purpose, may be designed for any of the three grades but is not required to contain all of the functions required of a nonspecial-purpose sound level meter. The standard does not include the type 3 survey instrument that was included in ANSI S1.4–1971.

The overall accuracy is a function of the sound level meter type (0, 1, or 2), frequency, angle of incidence of the sound relative to the microphone, and the time variation of the sound pressure. Because of the wide range of those variables, a specific accuracy appropriate to all conditions cannot be given. However, the expected total allowable error for a sound level meter measuring steady broadband noise in a reverberant sound field is approximately $\pm$ 1.5 dB for a type 1 instrument and $\pm$ 2.3 dB for a type 2 instrument. For steady sinusoidal sounds in a diffuse field at a specific frequency in the range from 100 to 1250 hertz, the expected total allowable error based on most of the allowable tolerances is $\pm$ 1.6 dB for a type 1 instrument and $\pm$ 2.3 dB for a type 2 instrument (see Appendix A). The error for a specific instrument may be demonstrated to be less than these values.

Selection of a sound level meter type for a specific measurement purpose should be made after reviewing the need for accuracy as well as the frequency and temporal characteristics of the sound to be measured. For steady sounds having few spectral components above 3000 Hz, the tighter tolerances of type 0 or type 1 instruments may not be required. However, for sounds with significant spectral content above 3000 Hz, or rapidly varying temporal characteristics, or both, a type 0 or type 1 instrument may be required for laboratory or field use, as appropriate.

Because the response of all practical measurement microphones is directional, particularly at high frequencies, care must be taken to minimize errors resulting from the directional characteristics. Since, for this standard, the calibration of a sound level meter with its microphone is referred to random-incidence response, measurements of directional sounds should be made at an angle at which the response of the microphone approximates its response to random-incidence sounds. That angle is typically 70° from normal incidence.

A sound level meter is used to measure many types of sound under many different conditions and for a variety of reasons. For each particular application of a sound level meter, the measurement technique should be carefully chosen and controlled to obtain valid and consistent results, see ANSI S1.13–1971 (R1976). Note, however, that the method of using the instrument has at least as much effect on the outcome of the measurement as the quality of the instrument itself. For this reason this standard requires the manufacturer to provide a comprehensive instruction book which contains extensive information on the capabilities, limitations, and recommended use procedures for the instrument.

1 PURPOSE AND SCOPE

1.1 Purpose

The purpose of this American National Standard Specification for Sound Level Meters is to ensure maximum practical accuracy in any particular sound level meter and to reduce to the lowest practical minimum any difference in corresponding measurements obtained when various makes and models of sound level meters are used that meet the standard.

1.2 Design Goal

A sound level meter is intended to be equally sensitive to sounds arriving at various angles and to provide an accurate measurement of sound level with certain standardized frequency and exponential-time weightings for sounds within stated ranges of level and durations.

1.3 Scope

Various degrees of accuracy are required for the practical measurement of sounds of various kinds for different purposes. Hence, this standard specifies minimum requirements for three basic types of sound level meters, types 0, 1, and 2, with performance requirements that becomes progressively less stringent, proceding from type 0 to type 2. For each type, the standard requires three frequency weightings, A, B, and C; and two exponential-time-averaging characteristics, slow and fast. Also it defines a so-called impulse-response characteristic which is optional for any type. The standard permits special features in a sound level meter, such as peak-measuring capabilities, wide ranges for the display of sound level on an analog indicator, digital displays, recording displays, and automatic range changing.

Because sound level meters may be needed for special purposes that do not require the complexity of any of the three basic types, provision is made for a special purpose sound level meter, type S. The type S meter may be qualified to the performance of any of the basic types (0, 1, and 2), but is not required to have all three frequency-weighting networks, or more than one exponential-time-averaging characteristic.

1.4 Limitations

If a sound level meter that conforms with the requirements of this standard is modified, it shall be demonstrated that the modified sound level meter also conforms with this standard providing the measurements are to be reported as sound levels and said to be measured by an instrument that complies with the requirements of this standard.

2 DEFINITIONS

2.1 sound pressure level: In decibels, 20 times the logarithm to the base ten of the ratio of the sound pressure, in a stated frequency band, to the reference sound pressure. The sound pressure is understood to be a time-period, root-mean-square sound pressure, unless another time-averaging process is indicated. For sound in air, the reference sound pressure is 20 micropascals (20 μPa). Abbreviation: SPL; quantity symbol: L_p.

2.2 exponential-time-average sound pressure level: In decibels, ten times the logarithm to the base ten of the ratio of an exponential-time-average squared frequency-weighted sound pressure to the square of the reference sound pressure. Quantity symbol, $L_{p\tau}$; unit, decibel; unit symbol, dB.

NOTES:

(1) In symbols, exponential-time-average sound level at any time t is

$$L_{p\tau}(t) = 10 \log\left(\frac{1}{\tau} \int_{-\infty}^{t} \frac{p^2(\xi)}{p_0^2} e^{-(t-\xi)/\tau} d\xi \right), \tag{1}$$

where τ is the exponential time constant in seconds, $p(\xi)$ is the instantaneous time-varying sound pressure with stated frequency weighting, ξ is a dummy variable of integration, and p_0 is the reference sound pressure. Running integration of squared frequency-weighted sound pressure with exponential time weighting occurs from some time in the past (as noted by the $-\infty$ at the start of the integration period) to the present at the time t. Division by the exponential time constant τ yields a running time average.

(2) Exponential time constants standardized in acoutics are 35, 125, and 1000 ms: the resulting exponential-time-average sound pressure levels are identified respectively by Impulse, Fast, and Slow.

2.3 sound level: Sound pressure level in decibels measured by use of the A, B, or C frequency weighting and fast (F), slow (S), or impulse (I), exponential-time-averaging, or peak (pK) time-related-characteristic, as specified in this standard. The frequency weighting and exponential-time-averaging constant shall be specified, otherwise the standarized fast (125 milliseconds) exponential-time-averaging and A-frequency weighting are understood. The reference sound pressure is 20 micropascals. Abbreviation for fast A-weighted sound level, FAL; quantity symbol: L_{AF}. Abbreviations and symbols for other weightings have the same stucture, but with the substitution of letters appropriate to the actual frequency and time averaging, e.g., SAL and L_{AS}, FCL and L_{CF}.

2.4 maximum sound level: Greatest sound level in decibels for a specific exponential-time-averaging constant during a given time period. Abbreviation for maximum fast A-weighted sound level: MXFAL; quantity symbol: $L_{AF\,max}$.

2.5 peak sound level: In decibels, 20 times the logarithm to the base ten of the ratio of the greatest instantaneous sound pressure during a given time period to the reference pressure of 20 micropascals. Abbreviation for peak A-weighted sound level: PkAL; quantity symbol: L_{Apk}.

2.6 slow sound level: Sound level in decibels measured by the use of the standarized slow (1000 ms) exponential-time-averaging. Abbreviation for slow A-weighted sound level: SAL; quantity symbol: L_{AS}.

2.7 impulse sound level: Sound level in decibels measured by the use of the standard impulse (35 ms) exponential-time-averaging for increasing portions of the signal and 1500-ms time constant for decreasing portions of the signal. Abbreviation for impulse A-weighted sound level: IAL; quantity symbol: L_{AI}.

2.8 time constant: Time required for a quantity that varies exponentially with time, but less any constant component, to change by the factor $1/e(1/e = 0.36787...)$. Quantity symbol: τ.

2.9 crest factor: Ratio of the peak sound pressure in a stated frequency band to the square root of the one-second exponential-time-average squared sound pressure in the same frequency band. Measured during a specified time interval and with the instantaneous values of sound pressure being measured with respect to the arithmetic mean value during the time interval.

2.10 indicator range: The range in decibels of sound levels that can be indicated on the display or other output device.

2.11 primary indicator range: A specified part of the indicator range in decibels for which the measurements of sound level are within particularly close tolerances.

2.12 calibration frequency: A frequency in hertz specified by the manufacturer in the nominal range from 200 to 1000 hertz and used for calibration of the absolute sensitivity level of a sound level meter. A nominal calibration frequency of 1000 hertz is preferred.

2.13 calibration sound pressure level: A sound pressure level in decibels specified by the manufacturer to be used for calibrating the absolute sensitivity level of a sound level meter.

2.14 calibration range: A sound level measuring range in decibels specified by the manufacturer for calibration which includes the calibration sound pressure level.

2.15 calibration angle of incidence: Angle of incidence from axis of symmetry that for plane waves in a free field, provides a frequency response most closely approximating that for random incidence.

2.16 relative response level: Amount, in decibels, by which the frequency-weighted sound level exceeds the sound pressure level. Relative response level of a sound level meter is usually negative.

3 GENERAL CHARACTERISTICS

3.1 General

A sound level meter can be generally described as a combination of a microphone, an amplifier with a standardized frequency weighting, a standardized exponential-time-averaging device, a logarithm taker, and a means to display the results in decibels. In Secs. 4, 5, and 6 specifications are given for those components of a sound level meter along with tolerance limits for the three types of sound level meters. Additional items necessary to meet any of the requirements (such as extension rods or cables or a special correction grid or cap on the microphone to approximate random-incidence response) are regarded as integral parts of a sound level meter.

3.2 Accuracy

For sounds incident on the microphone with random incidence and after any warmup period less than 10 minutes specified by the manufacturer, a sound level meter shall be able to measure the sound level of a sinusoidal signal at the calibration frequency, for each frequency weighting provided, within an accuracy of ± 0.4, ± 0.7, and ± 1.0 dB, for types 0, 1, and 2 instruments, respectively. The overall accuracy requirement shall be demonstrated at the calibration sound pressure level for the standard reference atmospheric pressure of 1 atm = 101.3 kPa, a reference air temperature of 20° C, and a reference relative humidity of 65%. A means shall be available to check and maintain calibration at the calibration frequency. The means shall include the use of an acoustical calibrator, whose characteristics are specified by the manufacturer, and may include an electrical signal or signals. The manufacturer shall state any corrections required to account for differences, if any, between the pressure response and the random incidence response.

3.3 Omnidirectional Response

A sound meter shall be designed to be equally responsive to sounds arriving at all angles of incidence. The entire instrument, when operated as it is designed to be used, shall satisfy the requirements of Sec. 4.

3.4 Frequency Weighting

The signal sensed by the microphone shall be frequency weighted to produce A, B, or C frequency-weighted sound levels. Frequency weighting and amplifier circuit shall satisfy the requirements of Sec. 5.

In addition to the frequency-weighting characteristics A, B, and C, a flat response may be provided to allow the sound level meter to measure sound pressure level (unweighted) or to function as a preamplifier for an auxiliary device. When a flat response is provided, the manufacturer shall specify its frequency response charateristics and tolerance limits. Tolerance limits in the applicable frequency range shall not be greater than those in Table V for the frequency-weighting characteristics of the complete instrument.

3.5 Time-Averaging Characteristics

The frequency-weighted signal shall be averaged over time in accordance with one or more of the exponential-time-averaging characteristics designated slow (S), fast (F), and impulse (I) as specified in Sec. 6. Sound level meters with the impulse and/or peak characteristics shall also include the fast and slow exponential-time-averaging characteristics.

3.6 Tests of Complete Instrument

Although the frequency-weighting and exponential-time-averaging characteristics may be associated with particular circuits within the sound level meter, the tests in Sec. 8 of this standard shall be made on the complete instrument, including microphone, except where it is not required. In that way, any interactions among the various components of the instrument are taken into account.

3.7 Electrical Test Adaptor

The manufacturer shall have available the means (instructions and adaptor) to substitute an electical signal for the output from the microphone for the purpose of performing electrical tests on the complete instrument without the microphone.

3.8 Peak Characteristic

In addition to the exponential-time-averaging characteristics slow, fast, and impulse, the peak characteristic may be provided. A procedure for testing the peak characteristic is given in 8.4.4.

3.9 Battery Check

If a sound level meter is battery operated, suitable means shall be provided to check that the battery voltage is adequate to ensure that the accuracy of the measurments continues to conform with specifications.

3.10 Stability

After a warmup period to be specified by the manufacturer, but less than 10 minutes in duration, the meter indication shall not change within one hour of continuous operation, when monitoring a stable source at the calibration frequency and level, by more than the value shown in Table I.

4 DIRECTIONAL CHARACTERISTICS OF THE MICROPHONE AND INSTRUMENT CASE

4.1 Omnidirectional Respones

The frequency-weighting characteristics and tolerance limits given in Sec. 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 in different directions, e.g., see Appendix B. A free-field calibration may be accomplished in comparison, under the general principles set forth in 7.2.1 of ANSI S1.10–1966 (R1976) "American National Standard Method for the Calibration of Microphones," except that sound level is to be measured instead of the output voltage level. One method of approximating the relative response level for random incidence is given in Appendix B.

4.2 Calibration Angle and Directional Tolerances

Directional characteristics of the instrument shall be controlled. To accommodate needs for measuring sounds that arrive at the microphone at a known angle

TABLE I. Maximum change of meter indication, in decibels, within one hour of operation.

Type	0	1	2
Change in meter indication	0.2	0.3	0.5

TABLE II. 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° from the 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	[a]
10 000 to 12 500	± 3	+ 4, − 6.5	[a]

[a] None specified.

TABLE III. Maximum allowable deviation of free-field relative 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	[a]
10 000 to 12 500	± 4.5	+ 8, − 11	[a]

[a] None specified.

of incidence, e.g., in a free field, the manufacturer shall state a 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 Sec. 5 be met at that angle of incidence. However, if those tolerance limits are met, the manufacturer shall state that fact and define the calibration angle and microphone required. In any case, the manufacturer shall show in the Instruction Manual the difference as a function of frequency between the response at the calibration angle and the random-incidence response. Directional error shall be measured relative to the stated calibration angle of incidence and shall meet the limits given in Table II for the complete instrument with the microphone mounted as it normally is for hand-held operation, if the sound level meter is designed for hand-held operation. Directional error shall also meet the limits in Table III. The microphone may be mounted at the end of an extension rod or cable in order to satisfy the requirements in Table III, see 8.2.2. 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 requirements of this standard.

5 FREQUENCY-WEIGHTING AND AMPLIFIER CHARACTERISTICS

5.1 Frequency-Weighting Characteristics and Tolerances

Frequency-weighting characteristics for the instrument are given in Table IV. Overall tolerance limits on relative response levels for the entire instrument are given in Table V for random-incidence sound. Tolerance limits in Table V are identical for all frequency-weighting characteristics included in the instrument. The tolerance on relative response level shall be zero at the calibration frequency.

5.2 Weighting Networks

The values given in Table IV correspond to the pole-zero specifications that follow. The C-weighting characteristic is realized ideally with two poles in the complex frequency plane situated on the real axis at 20.6 Hz to provide the rolloff at low frequencies and two poles on the real axis at 12.2 kHz to provide the high-frequency rolloff. The low-frequency half-power (or 3 dB down) point with respect to the 1 kHz response is at $10^{1.5}$ (or 31.62) Hz, and the high-frequency half-power point is at $10^{3.9}$ (or 7943) Hz.

The B-weighting characteristic is realized ideally by adding a pole on the real axis at a frequency of $10^{2.2}$ (or 158.5) Hz to the C-weighting characteristic.

The A-weighting characteristic is realized ideally by adding two poles on the real axis, at frequencies of 107.7 and 737.9 Hz (see Appendix C for more precise numbers), to the C-weighting characteristic.

The A-, B-, and C-weighting characteristics are realizable with passive resistor–capacitor circuits. Above 20 000 Hz, the relative response level shall decrease by at least 12 dB per octave for any frequency-weighting characteristic.

Appendix C contains equations for the relative magnitude response level for the A-, B-, and C-weighting characteristics.

TABLE IV. Random incidence relative response level as a function of frequency for various weightings

Nominal frequency[a] Hz	Exact frequency[a] in	A Weighting dB	B Weighting dB	C Weighting dB
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	10 000	− 2.5	− 4.3	− 4.4
12 500	12 590	− 4.3	− 6.1	− 6.2
16 000	15 850	− 6.6	− 8.4	− 8.5
20 000	19 950	− 9.3	− 11.1	− 11.2

[a] Nominal frequencies are as specified in ANSI S1.6–1967 (R1976), 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 $N = 0$).

5.3 Level-Range-Control Tolerance Limits

When a level range control is included, it shall introduce errors less than those given in Table VI for all settings with reference to the calibration range.

5.4 Level Range Overlap

When a manual level range control is included in a sound level meter, ranges shall overlap by at least 5 decibels if the step of the level range control is 10 decibels and by at least 10 decibels if the step is greater.

5.5 Crest Factor

The amplifier shall have a crest factor capability sufficient to meet the requirements of 6.2. For type 0 and type 1 instruments, and any impulse sound level meter, overload detectors shall be placed in the amplifier output chain and shall indicate when the crest factor capability has been exceeded see (8.3.1). An overload detector should also be incorporated in type 2 instruments.

TABLE V. Tolerance limits on relative response levels for sound at random incidence measured on an instrument's calibration range.

Nominal frequency Hz	Type 0 dB	Type 1 dB	Type 2 dB
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	± 2
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, − ∞

TABLE VI. Tolerance limits on level range control accuracy in two frequency ranges.

Frequency range, Hz	Instrument type		
	Type 0	Type 1	Type 2
31.5–8000	±0.3	±0.5	±0.7
20 –12 500	±0.5	±1	...

5.6 Internal Noise

When the microphone is replaced by an equivalent electrical impedance, the indicated sound level shall be at least 5 decibels below the minimum sound level specified by the manufacturer to be measurable for each frequency weighting.

5.7 Signal Distortion

If signals are available at filter connections and at an output for alternating-current signals, the total harmonic distortion for sinusoidal electrical-input test signals in the frequency range between 31.5 Hz and 8 kHz shall be less than one percent when the level of the test signal is 10 decibels or more below the equivalent upper limit of the sound level which the instrument is designed to measure and which shall be specified by the manufacturer for any type of sound level meter.

At the upper limit of sound pressure level for any type of sound level meter, the total harmonic distortion generated between the input and output terminals, where the latter are provided, shall be less than 10% for electrical test signals at any frequency in the range between 200 and 1000 Hz.

5.8 Overload Minimization

In order to minimize the chance of overload and to permit the measurement of the widest range of high sound pressure levels, dual independently adjustable range controls that operate attenuators situated before and after the weighting circuits may be used. When dual controls are used, an instruction plate that clearly describes the method of operation of the controls shall be affixed to the instrument. If an automatic range control system is used the manufacturer shall provide information stating the conditions in which errors in the measurement of sound level may arise and their magnitudes due to time delays and response time characteristics in automatic range switching.

5.9 Nonlinear Distortion

At the upper limit of any primary indicator range, the error resulting from nonlinear distortion generated between the sound input and the output on the display device or at the electrical output terminals should be less than ±1 dB at all frequencies greater than or equal to 31.5 Hz. If this recommendation cannot be met at all frequencies, the manufacturer shall state the lowest frequency for which the ±1-dB tolerance limit is maintained. The above recommendation applies for all frequency weightings.

With the indicator replaced by an equivalent impedance, the response on the C-weighting (and optional flat weighting) to electrical sinusiodal signals in the frequency range of 31.5 to 11 200 Hz shall be linear within 1 decibel up to 10 decibels above the voltage equivalent to the maximum scale reading.

6 EXPONENTIAL-TIME-AVERAGING CHARACTERISTICS

6.1 Exponential-Time-Average Sound Level

The indication of the sound level meter with either the fast or slow exponential-time-averaging characteristic in operation shall be the exponential-time-average sound level, the averaging being done by dividing the time integral of the (analog of) exponentially-time-weighted, squared, frequency weighted sound pressure by the applicable time constant. The impulse exponential-time-averaging characteristic is achieved by first mean square averaging with a 35-ms averaging time constant and then detecting the peak value of that result. The peak detector has an exponential decay time constant of 1500 ms.

6.2 Fast and Slow Exponential-Time-Averaging Characteristics

In principle, an instrument possessing the fast and slow exponential-time-averaging characteristics corresponds to the block diagram in Fig. 1. The time con-

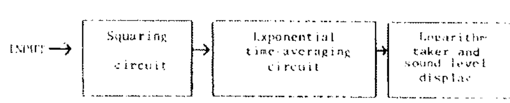

FIG. 1. Block diagram of the exponential-time-averaging system.

TABLE VII. Maximum allowable errors in decibels for exponential time averaging.

Instrument type	Crest factor <3	Crest factor >3 and ≤10
Type 0	±0.5	±1.0
Type 1	±0.5	±1.5
Type 2	±1.0	Not required

TABLE IX. Maximum overshoot for fast and slow exponential time weighting.

Exponential time weighting	Maximum overshoot for instrument type dB 0	1	2
Fast	0.5	1.1	1.1
Slow	1.0	1.6	1.6

stant for fast shall be 125 milliseconds and that for slow shall be 1000 milliseconds.

Tests for exponential-time-averaging characteristics are given in Sec. 8. Allowable errors in exponential time averaging are shown in Table VII for steady signals of various crest factors. In addition, the test for the type 0, type 1, and type 2 instruments shall be conducted for steady signals having increasingly higher crest factors than that for which tolerance limits are given in Table VII (i.e., >10 for type 0 and type 1 and >3 for type 2) to determine the crest factor at which the error first exceeds ±3 dB. That crest factor value shall be stated by the manufacturer in the Instruction Manual. The response characteristics of the exponential-time-averaging system shall be such that it responds to tone bursts as specified in Table VIII and to a suddenly applied signal, or step in signal level, with the maximum overshoot as specified in Table IX. When the suddenly applied signal is turned off, the meter indication shall decay by 10 dB in 0.5 seconds, or less, for fast and 3.0 seconds or less, for slow.

Where there are no tolerances given in Table VIII the manufacturer shall state the nominal values for each tone-burst duration.

6.3 Impulse Exponential-Time-Averaging Characteristic

In principle, an instrument possessing the impulse exponential-time-averaging charactristic corresponds to the block diagram in Fig. 2. The components of the impulse exponential-time-averaging system are similar to those for fast and slow except that a peak detector is introduced into the circuit. For sound pressure that increases with increasing time, the time constant shall be 35 milliseconds. For sound pressure that decreases

TABLE VIII. Tone-burst response and tolerance limits for fast and slow exponential-time-averaging characteristics.

Exponential time weighting	Duration of test tone burst ms	Maximum response to test tone burst referred to response to a continuous signal[a] dB	Tolerance limits on max. response for each instrument type dB 0	1	2
	Continuous	0			
	200	−1.0	±0.5	±1	+1, −2
Fast	50	−4.8	±2	...	...
(τ = 125 ms)	20	−8.3	±2	...	...
	5	−14.1	±2	...	...
	2000	−0.6	±0.5	...	...
Slow	500	−4.1	±0.5	±1	±2
(τ = 1000 ms)	200	−7.4	±2	...	...
	50	−13.1	±2	...	...

[a] See Appendix D.

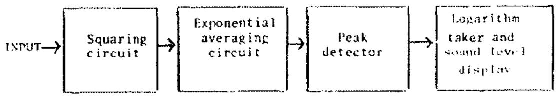

FIG. 2. Block diagram of the impulse exponential-time-averaging system.

with increasing time, the peak detector introduces a decay time constant of 1500 milliseconds.

The rise time constant of the peak detector shall be small (e.g., 1 ms or less) compared with the 35 millisecond time constant and its decay rate shall be 2.9 ± 0.5 dB per second for types 0 and 1 instruments and 2.9 ± 1.0 dB per second for a type 2 instrument. That decay rate and tolerances correspond approximately to a time constant of 1500 ± 250 milliseconds for types 0 and 1 instruments and 1500 ± 500 milliseconds for type 2 instruments. The accuracy of the indicated impulse sound level for both single sinusoidal tone bursts and a continuous sequence of bursts shall be tested as described in Sec. 8. Responses with tolerance limits are given in Table X and XI.

6.4 Steady-State Response

Indications according to the slow and fast exponential-time-averaging characteristics shall not differ by more than 0.1 dB for steady-state sinusoidal signals at any frequency in the range between 31.5 Hz and 8 kHz. This requirement shall apply to the impulse characteristic at any frequency in the range between 315 Hz and 8 kHz.

6.5 Peak Characteristic

In the optional peak mode, the instrument shall be capable of measuring peak sound level. The accuracy of the measurement is tested by the method in 8.4.4. For type 1 and type 2 instruments, it is recommended that the rise time be such that a single pulse of 100 microseconds duration produces a deflection no more than 2 dB below the deflection produced by a pulse having a duration of 10 milliseconds and equal peak amplitude. This test shall be repeated with pulses of both positive and negative polarities. A type 0 instrument shall be designed so that a single pulse of 50 microseconds duration produces an indication no more than 2 dB below that produced by a pulse having a duration of 10 milliseconds and equal peak amplitude.

6.6 Indicator Range

The range of the indicator, whether analog or digital shall be at least 15 dB. At least 10 dB of it shall be specified as the primary indicator range by the manufacturer.

6.7 Analog Indicator Scale

When an analog indicator (meter or recorder) is provided, its scale shall be graduated in intervals not greater than 1 dB over a range of at least 15 dB. Each decibel interval shall be at least 1 mm wide. When a discontinuous analog display is used, reduced resolution is permitted. Resolution shall be equal to or better than 0.2 dB for types 0 and 1 instruments and 1 dB for type 2 instruments. Because of the low resolution, special test methods may be required in order to demonstrate that the requirements of this standard are met.

6.8 Digital Indicator

When a digital indicator or other indicator with discontinuous display (e.g., lamps with level steps) is provided, the sound level meter shall include a mode in which the maximum sound level in a measuring inter-

TABLE X. Single tone-burst response and tolerance limits for impulse exponential-time-averaging characteristic.

Duration of tone burst ms	Maximum response to test tone burst referred to response to a continuous signal[a] dB	Tolerance limit, dB types 0 and 1	type 2
Continuous	0		
20	− 3.6	± 1.5	± 2.0
5	− 8.8	± 2.0	± 3.0
2	± 12.6	± 2.0	no test

[a] See Appendix D.

TABLE XI. Response and tolerance limits of impulse exponential-time-averaging characteristic for a continuous sequence of 5-millisecond-duration bursts of 2000 Hz sinusoidal signals.

Repetition frequency, Hz	Maximum response to test tone bust referred to response to a continuous signal[a] dB	Tolerance limit, dB types 0 and 1	type 2
Continuous	0		
100	− 2.7	± 1.0	± 2.0
20	− 7.6	± 2.0	± 2.0
2	− 8.8	± 2.0	± 3.0

[a] See Appendix D.

val is held (stored) in the display. Additional modes in which the display is held automatically in fixed intervals or on command may also be included. When an instrument includes automatic display modes, the cycle time of one of the modes should be once per seconds. When results in digital format are made available at an electrical output, the output rate shall be stated in the Instruction Manual. A digital display shall have a resolution equal to or better than 0.1 dB.

6.9 Linearity

The linearity of the sound level meter, including the time-averaging circuits plus any manual or automatic level-range controls, and the logarithm taker and display, shall be tested and shall satisfy the requirements of Table XII. The reference level for testing linearity is the indicated sound level when tested at the calibration sound pressure level.

NOTE: In previous standards for sound level meters based only on analog indicating instruments, the level linearity tolerance was given by the sum of the tolerances of the level range control and the meter scale graduation. Since this standard permits various other indicating systems, level linearity has been specified in a manner intended to produce equivalent results.

6.10 Differential Level Linearity

The instrument shall satisfy a test for differential level linearity in addition to the linearity test given in 6.9. Differential level linearity error is measured between any two arbitrarily chosen sound levels which are as much as 10 dB apart, in the range of the display. The maximum error, both inside and outside the primary indicator range, permitted for each type of sound level meter for levels separated by 1 dB and for levels separated by as much as 10 dB is given in Table XIII.

TABLE XII. Tolerance limits on linearity, in decibels, referred to the indicated sound level when tested at the calibration sound pressure level in the frequency range 31.5–8000 Hz (20–12 500 Hz for type 0).

Ranges for sound levels	Instrument type 0	1	2
In primary indicator range	± 0.4	± 0.7	± 1
Outside primary indicator range	± 0.6	± 1	± 1.5

TABLE XIII. Tolerance limits on differential level linearity, in decibels, in the frequency range 31.5 to 8000 Hz (20–12 500 Hz for type 0).

Ranges for sound level	Instrument type 0	1	2
Inside primary indicator range for levels separated by 1 dB	± 0.2	± 0.2	± 0.3
Inside primary indicator range for levels separated by as much as 10 dB	± 0.4	± 0.4	± 0.6
Outside primary indicator range for levels separated by 1 dB	± 0.3	± 0.3	± 0.4
Outside primary indicator range for levels separated by as much as 10 dB	± 0.6	± 1	± 1.5

7 SENSITIVITY TO VARIOUS ENVIRONMENTS

7.1 Atmospheric Pressure

For a variation of ± 10% in static pressure, the sensitivity of the complete instrument shall change by not more than ± 0.3 dB for types 0 and 1 instruments, nor more than ± 0.5 dB for type 2 instruments when tested with sounds for a frequency between 200 and 1000 Hz.

7.2 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 below the reading which would be obtained with the microphone installed. The requirement shall be fulfilled using a sinusoidal sound at a test 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 all frequencies 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.

7.3 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 and 1000 Hz shall be indicated by the manufacturer 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 an rms acceleration of 1 m/s^2. A reference sound level meter that is not being vibrated shall be used to measure 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. The instrument shall be mounted using 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 manufacturer 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.

7.4 Magnetic and Electrostatic Fields

The effects of magnetic and electrostatic 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.

7.5 Air Temperature

The air temperature range over which the calibration of the complete instrument, including the microphone, is not affected by more than 0.5 dB, referred to the indication at 20° C shall be specified by the manufacturer. If the change in calibration of a type 1 or type 2 instrument exceeds ± 0.5 dB in the temperature range between $-10°$ and $+50°$ C, correction information shall be provided in the Instruction Manual. The test shall be performed at a frequency between 200 and 1000 Hz.

7.6 Humidity

The manufacturer shall state the range of humidity over which the complete instrument, including the microphone, is intended to operate continuously. For types 1 and type 2 instruments, the sensitivity shall not change by more than ± 0.5 dB, referred to the indication at a relative humidity of 65%, in the range of relative humidity from 30% to 90%. The test shall be conducted at a temperature of 40° C with a sound signal having a frequency in the range between 200 and 1000 Hz.

8 TESTS TO VERIFY THE BASIC CHARACTERISTICS OF THE SOUND LEVEL METERS

8.1 General

The tests described in the following paragraphs shall be used to check that the requirements of Secs. 3, 4, 5, and 6 are met. All tests shall be made at, or referred to, the standard reference conditions of 20° C, 65% relative humidity, and 101.3 kPa atmospheric pressure. If not otherwise stated, the tests shall be performed using minimally distorted sinusoidal signals. The observer shall not disturb the sound field at the microphone; preferably the observer shall not be present.

8.2 Calibration of Entire Instrument

Calibration procedure and tests related to the complete sound level meter are described in 8.2.1 and 8.2.2. The tests may be divided into acoustical and electrical tests if no loss in accuracy results. The manufacturer shall provide basic information as to how the tests were performed.

8.2.1 The free-field relative response level shall be determined with a sufficient number of frequencies and directions to establish (see Appendix B) that the random incidence response level of the sound level meter meets the frequency response characteristics and tolerance limits given in Tables IV and V. At the calibration frequency, the level of the unweighted sound pressure of the sound waves shall be at the calibration sound level or in a range not more than 20 dB below that level.

8.2.2 The maximum deviation of the free-field relative response level as a function of angle of incidence with respect to that at the calibration angle of incidence shall not exceed the values given in Tables II and III. Table II applies for sound incident on the complete instrument; an extension cable may be used to satisfy the requirements of Table III.

Demonstration that the response of the sound level meter is within the tolerance limits may not be possible for all types of sound level meters unless the microphone is detached from the meter, or the observer is remote from the meter. Such limitations shall be stated clearly in the Instruction Manual to reduce the possibility of inadvertent misuse.

8.3 Amplifier

Tests of the amplifier characteristics are described.

8.3.1 If overload detectors are included, they shall meet the requirements of the following tests.

An overload indication for instruments with an A weighting shall occur according to the following test when the indication of the instrument exceeds the tolerances in Table V 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 sine wave signal is fed to the instrument with an amplitude giving a reading that is 5 dB below the maximum A-weighted sound level that the instrument is designed to measure. The frequency of the input signal is lowered in steps in accordance with the nominal frequencies in Table IV 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 IV. Dual independently adjustable range controls shall be set according to the manufacturer's instructions.

An overload indication shall also occur for rectangular tone burst pulses when the indication of the instrument deviates by more than the tolerance limits given in Table VII for the various crest-factor test signals; see Appendix E. The testing shall be performed at a level 2 dB below the upper limit of the primary indicator range. The overload detectors shall be equally responsive to single rectangular impulses of either polarity and of a duration in the range between 200 μs to 10 ms.

8.3.2 When a level range control is included, it shall meet the requirements of 5.3, 6.9, and 6.10.

8.3.3 The equivalent sound level resulting from internal noise shall be measured to demonstrate compliance with 5.6.

8.4 Time-Averaging Characteristics

Tests of the exponential-time-averaging characteristics are described in 8.4.1 to 8.4.4. The tests may be carried out by using an electrical signal and equivalent electrical impedence substituted for the microphone. The linearity of the time-averaging shall meet the requirements of 6.9 and 6.10.

8.4.1 The exponential time constants for fast and slow exponential-time-averaging characteristics shall be tested using single sinusoidal tone bursts at a frequency in the range from 1000 to 2000 Hz. For a single tone burst with a specified duration and an amplitude that produces an indication 4 dB below the upper limit of the primary indicator range when the signal is continuous, the response for the tone burst signal is given in Table VIII relative to that for the continuous signal. The relative response shall be within the tolerance limits in Table VIII for all level ranges of the sound level meter. For test signals of short duration, it may be necessary to increase the level of the input signal by 10 dB to get a reading in the range of the indicator. The exponential time constant should also be tested for an indication of the steady level 5 dB above the lower limit of the indicator range at 200 milliseconds for fast and 500 milliseconds for slow. The overshoot for the fast and slow exponential-time-averaging characteristics shall be tested using a step in amplitude that is suddenly applied and thereafter held constant. The maximum shall not exceed the final steady reading by more than the amounts given in Table IX for test signals having frequencies between 100 Hz and 8 kHz. When the range of the display is 20 dB or less, the test shall be met for a steady-state level corresponding to 4 dB below the upper limit of the primary indicator range; the test should also be met at other levels. When the range of the display is more than 20 dB, the tests for the exponential time constant and overshoot shall be conducted using signals that step in amplitude by 20 dB. The tests shall be performed at 4 dB below the upper limit of the primary indicator range and at intervals of 10 dB below that level for all signals that produce an indication. When a digital indicator is used, the tests for exponential time constant and overshoot shall be performed with the instrument set to the maximum hold mode.

The decay times for the fast and slow exponential-time-averaging characteristics shall be tested by turning off the signal used to test overshoot, see 6.2.

8.4.2 The rms accuracy of the exponential-time-averaging characteristic shall be determined by comparing the indications for two test signals, a continuous sequence of rectangular pulses and a sequence of tone bursts, to that for a reference sinusoidal signal; see Appendix E. It is recommended that the reference sinusoidal signal have a frequency of 2 kHz. The rectangular test pulses shall have durations of 200 μs and rise times of less than 10 μs. The tone burst test signal shall consist of an integral number of 2-kHz sine waves starting and ending at zero crossings. The repetition frequency shall be 40 Hz for both rectangular pulse and tone-burst test signals.

The test signals shall have exponential-time-average mean square values identical to that of the reference sinusoidal signal. Signals are to be measured by a device that introduces the standardized frequency weighting corresponding to that in the sound level meter being tested, within the tolerance limits given in Table V; see Appendix E. The C-weighting or flat characteristic, if any, shall be used. If the instruent has only A or B weighting, then only the tone burst test shall be performed.

The test signal shall be fed through an equivalent electrical input to the sound level meter and the test performed for the slow exponential-time-averaging characteristic or for the fast characteristic if slow is not available in the sound level meter being tested.

The rectangular pulse test shall be performed using both positive-going and negative-going pulses. The test shall be performed at a level 2 dB below the upper limit of the primary indicator range and at intervals of 10 dB below that level down to the lowest level that produces an indication of more than 3 dB above the lower limit of the primary indicator range.

The tolerance limits in Table VII shall be met over the entire range of sound levels which the instrument is designed to measure.

8.4.3 The impulse exponential-time-averaging characteristic shall be tested with a single sinusoidal tone burst having a frequency of 2000 Hz, a specified duration, and an amplitude that produces a full range indication when the signal is continuous. The response relative to the indication for the continuous signal is given in Table X for the specified tone-burst durations and corresponding tolerance limits.

When the burst duration is held constant at 2 ms and the amplitude is increased by 10 dB, the indication of the sound level meter shall increase by 10 dB $\pm$ 1 dB for type 0 and type 1 instruments. For a type 2 instrument, the test shall be performed with a burst duration of 5 milliseconds and an amplitude step of 5 dB. The indication shall increase by 5 dB $\pm$ 1 dB.

The decay rate for the impulse exponent-time-averaging characteristic specified in 6.3 shall be tested by turning off a continuous signal providing a reading at the upper end of the primary indicator range and observing the decay.

For a continuous sequency of sinusoidal bursts having a frequency of 2000 Hz, a duration of 5 milliseconds, the specified repetition frequency and an amplitude that produces a full range indication when the signal is continuous, the indication of the sound level meter relative to that for the continuous signal shall be in accordance with the requirements of Table XI.

For the continuous sequence of sinusoidal tone bursts, when the repetition frequency is held constant at 2 Hz and the amplitude is increased by 5 dB, the indication of the sound level meter shall increase by 5 $\pm$ 1 dB.

The above requirements shall be met over the entire range of sound levels which the instrument is designed to measure.

When the range of the display is more than 20 dB, the requirements of the tests with a single tone burst and a continuous sequence of tone bursts shall be met at intervals of 10 dB below full range down to the lowest level that produces an indication.

8.4.4 If the sound level meter is equipped for measuring peak sound levels, the rise time of the peak detector shall be tested by comparing the response of a short duration rectangular pulse with that for a pulse of 10 milliseconds duration, see 6.5.

The rise time to be specified by the manufacturer shall be equal to the duration of the pulse that produces an indication 2 dB below that of the 10-ms reference pulse. Both pulses shall have the same peak amplitude. The amplitude of the 10-ms reference pulse shall be such as to produce an indication 1 dB below the upper limit of the primary indicator range. The test shall be repeated with both positive-going and negative-going pulses. The test should also be performed at other levels.

9 PROVISIONS FOR USE WITH AUXILIARY EQUIPMENT

9.1 Corrections for Accessories

If the sound level meter can be used with a cable between the microphone and the amplifier, the corrections corresponding to that method of use shall be stated by the manufacturer. Corrections resulting from the use of other accessories that may be available should also be stated. The accessories may include, for example, windscreens and rain protectors.

9.2 Output Impedance

A sound level meter is often provided with one or more outputs for use in driving headphones, analyzers, and other equipment. When an electrical output signal is provided, it should be possible to terminate the output in any electrical impedance without affecting either the sound-level display or the linear operation of the output circuits. If connection of external equipment having a specified electrical impedance will affect the display, by more than 0.1 dB for type 0, 0.2 dB for type 1, and 0.5 dB for type 2, then the display shall be automatically muted or disconnected. Full details relating to the electrical output characteristics of the signal shall be given in the Instruction Manual.

9.3 External Filters

Connections may be provided to permit an external filter to replace the internal frequency-weighting networks of the sound level meter. The Instruction Manual shall state clearly how the connections are to be used. When external filter connectors are provided, the sound level meter should be equipped with dual attenuators or have sufficient dynamic range to void overload when an external filter is used.

10 NAMEPLATE DATA AND INSTRUCTION MANUAL

10.1 Nameplate Data

An instrument which complies with this specification shall be marked "Sound Level Meter Type 0, 1, or 2, S1.4–1983," or "Sound Level Meter type S (0, 1, or 2), S1.4–1983," as applicable. The descriptive names, "Laboratory Standard," "Precision," "General Purpose," or "Special Purpose" may be included, as applicable. The instrument shall also be marked with the name of the manufacturer, the model, and serial number.

10.2 Instruction Manual Information

An Instruction Manual shall be supplied with the sound level meter; it shall include at least the information listed below.

(1) The kind of microphone (piezoelectric, condenser, etc.) and method of mounting in order to ensure that the instrument is within all tolerance limits required for the particular type of sound level meter.

(2) The calibration angle of incidence, and the difference in response between the response at the calibration angle of incidence to plane waves and the random incidence response as required in 4.2.

(3) The range (minimum to maximum) of sound levels which the instrument is designed to measure within the tolerance limits of this standard. The limits shall be stated separately for each frequency-weighting characteristic as necessary.

(4) The calibration sound pressure level as defined in 2.13.

(5) The applicable nominal frequency weighting from Table IV.

(6) A description of the exponential-time-averaging characteristics fast, slow, and impulse, and if applicable peak time characteristic, relative to the specifications in Secs. 6 and 8. The description shall include a statement of the range of durations and sound levels over which transient sounds may be reliably measured as applicable to each exponential-time-averaging characteristic available in the instrument.

(7) The effect of vibration on the operation of the sound level meter as tested in accordance with 7.3.

(8) The effect of magnetic and electrostatic fields as tested in accordance with 7.4.

(9) The effects of air temperature as tested in accordance with 7.5.

(10) The effect of the presence of an operator on measurements outdoors or in an approximately diffuse sound field.

(11) The effects of humidity as tested in accordance with 7.6.

(12) The limits of temperature and humidity beyond which irreversible damage may result to the sound level meter and any of its components.

(13) Any correction to calibration required when microphone extension cables of various lengths are used.

(14) The effect on accuracy caused by the use of recommended microphone accessories such as windscreens.

(15) The calibration procedure, including corrections, necessary to verify the accuracy as specified in 3.2.

(16) The position of the instrument case and observer relative to the microphone in order to minimize their influence on the measured sound field, see item 10 above.

(17) A procedure to ensure optimum operating conditions when the sound level meter is used with external filters or analyzers, if applicable.

(18) The limitations required by 9.2 on the electrical impedance that may be connected to the output connectors if provided.

(19) The calibration frequency as defined in 2.12.

(20) The calibration range as defined in 2.14.

(21) The "warm-up" time before valid readings can be made at any air temperature in the operating range.

(22) For the type 0 and type 1 instruments, continuous frequency response curves from at least 10 Hz to at least 20 kHz and at several sound pressure levels within the instrument's capability.

(23) Correction information as a function of frequency between the sensitivity to random-incidence sound and the sensitivity in a free field at the calibration angle of incidence that approximates random incidence.

(24) The directional response of the sound level meter at various angles in the plane through the axis of symmetry at frequencies, including at least at 1, 2, 4, 8, and 12.5 kHz (12.5 kHz for type 0 and type 1 only).

(25) The nominal electrical impedance (or circuit diagram) indicating nominal values of its elements which shall be substituted for the microphone for tests in accordance with this standard.

(26) The primary indicator range as required by 6.6.

(27) The results of tests conducted with tone bursts in accordance with the requirements of 8.4 for the exponential-time-averaging characteristics given in 6.2 and 6.3.

(28) The errors resulting from automatic ranging as required in 5.8.

(29) As stated in 5.9, the lowest frequency for which the error resulting from nonlinear distortion is less than ± 1 dB.

(30) Procedure and frequency for acoustical and electrical sensitivity checks in accordance with 3.2.

(31) The output rate of results in digital format, if applicable, as required in 6.8.

11 REFERENCES TO RELATED ANSI STANDARDS

When the following American National Standards referred to in this document are superseded by a revision approved by the American National Standards Institute the revision shall apply:

S1.6-1967 (R1976)

S1.10-1966 (R1976)

S1.11-1966 (R1971)

S1.13-1971 (R1976)

12 REFERENCES TO RELATED INTERNATIONAL STANDARDS

IEC651-1979

ISO266-1975

APPENDIX A: EXPECTED TOTAL ALLOWABLE ERROR IN A MEASUREMENT OF CONTINUOUS SOUND AS A RESULT OF ALLOWABLE TOLERANCES ON SOUND LEVEL METER CHARACTERISTICS

[This Appendix is not a part of American National Standard Specification for Sound Level Meters S1.4-1983, but is included for information purposes only.]

The overall accuracy of a sound level meter will be a function of the sound level meter type (0, 1, or 2), frequency, angle of incidence of the sound relative to the meter, the exponential-time-averaging characteristics (*S*, *F*, or *I*) and whether or not the sound is continuous (steady) or transient. Tolerance limits for those quantities for continuous sound are summarized in Table AI. It should also be noted that errors caused by those characteristics 1 through 5 may be minimized by calibrating or applying appropriate corrections.

If it is assumed that each error is independent of every other error, then a useful estimate of the instrument error can be obtained from the following formula. (If the assumption is not met, larger errors may result.)

If E is the expected total error in decibels, then

$$E = \pm \left(\sum_{i=1}^{N} T_i^2 \right)^{1/2}, \quad \text{(A1)}$$

where T_i are the largest absolute values of the tolerance limits found in Table AI for a given sound level meter type. It should be noted that characteristics 7, 8,

TABLE AI. Summary of principal allowable tolerance limits on sound-level-meter characteristics for measurement of continuous sound.

Characteristic	Tolerance limits (dB) Type 0	Type 1	Type 2
1. Accuracy at reference frequency and reference sound level (Sec. 3.2)	± 0.4	± 0.7	± 1.0
2. Environmental: ± 10% change in static pressure (7.1)	± 0.3	± 0.3	± 0.5
3. Environmental: Change in ambient temperature *re*: 20° C from − 10 to 50° C (7.5)	± 0.5	± 0.5	± 0.5
4. Environmental: Change in percent relative humidity *re*: 65% from 30% to 90% (7.6)	± 0.5	± 0.5	± 0.5
5. Maximum change in sensitivity 1 hour after warmup (Table I)	± 0.2	± 0.3	± 0.5
6. Linearity referred to indicated sound level when tested at the calibration sound pressure level (Table XII)			
Primary indicator range	± 0.4	± 0.7	± 1.0
Outside primary indicator range	± 0.6	± 1	± 1.5
7. Accuracy of complete instrument for random incidence sound (Table V) (frequency dependent)	± 0.7[b]	± 1.0[c]	± 1.5[e]
8. Directional error ± 22.5° *re*: reference angle of incidence (Table II) (frequency dependent and without oprator present)	± 0.5[d]	± 1.0[d]	± 2[d]
9. Directional error for any angle of incidence (Table III) (frequency dependent and without operator present)	± 1.0[d]	+ 1.5,[d] − 1.0[d]	± 3[d]
10. Accuracy of exponential-time-averaging (Table VII) for: crest factor < 3	± 0.5	± 0.5	± 1.0
Crest factor > 3 and < 10	± 1.0	± 1.5	not specified

[a] Frequency range: 31.5–8000 Hz.
[b] Frequency range: 100–4000 Hz.
[c] Frequency range: 100–1250 Hz.
[d] Frequency range: 31.5–2000 Hz.
[e] Frequency range: 50–4000 Hz.

and 9 are mutually exclusive quantities, and only one of them may be used at any one time to estimate the accuracy of a given measurement.

For example, Eq. (A1) can be used to estimate the expected total allowable instrument error for continuous steady sinusoidal sound between 100 and 1250 Hz in a reverberant environment using a type 2 meter in its primary indicator range. From Table AI we have for factors 1–7;

$E = \pm(1^2 + 0.5^2 + 0.5^2 + 0.5^2 + 0.5^2 + 1.0^2 + 1.5^2)^{1/2}$,

$E = \pm 2.3$ dB (100 to 1250 Hz).

The same type of calculation may be used to estimate the total allowable errors for other types of sound level meters and for various assumptions on the characteristics of the sound field and minimization of environmental and warmup errors. For the same assumptions as used in the preceding example, a type 1 instrument has an expected allowable total error of ± 1.6 dB, or ± 1.4 dB, if it is assumed the factors 2, 3, 4, and 5 are zero after correction. In this case for steady broadband noise with a crest factor less than three and a diffuse field, a type 1 instrument should have an expected total allowable error of 1.5 dB and a type 2 instrument, an error of 2.3 dB [factors 1, 6 (primary), 7, and 10]. These expected values of total allowable errors apply to an instrument of a given type selected at random. They may be reduced for a specific instrument through careful calibration and adjustment.

APPENDIX B: APPROXIMATION OF THE RANDOM-INCIDENCE RELATIVE RESPONSE LEVEL

[This Appendix is not a part of American National Standard Specification for Sound Level Meters S1.4–1983, but is included for information purposes only.]

This Appendix reviews the concept of the random incidence calibration required in 4.1 and suggests a method for determination of the random-incidence relative response level. [See Sec. 8 of American National Standards S1.10–1966 (R1976).]

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

$$S_d^2(f) = \frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi} S_0^2(\theta,\phi,f)\sin\theta\, d\theta\, d\phi, \qquad \text{(B1)}$$

where $S_0(\theta, \phi, f)$ = the free-field sensitivity to sound incident at the angles θ and ϕ (where θ is measured from the 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 units, for example, V/Pa.

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 level for random incidence may be calculated in a manner similar to the aforementioned from Eq. (B2):

$$R_{rf} = 10\log\left[\frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi}\text{antilog}\left(\frac{R(\theta,\phi,f)}{10}\right) \times \sin\theta\, d\theta\, d\phi\right], \qquad \text{(B2)}$$

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

For the purpose of satisfying the specification of 4.1, 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

$$\Delta K(\theta_r,\phi_s,f) = \frac{1}{4\pi}\int_{\phi_s-\Delta\phi/2}^{\phi_s+\Delta\phi/2}\int_{\theta_r-\Delta\theta 2}^{\theta_r+\Delta\theta/2}\text{antilog}\left(\frac{R(\theta,\phi,f)}{10}\right) \times\sin\theta\, d\theta\, d\phi$$

$$\cong\frac{1}{4\pi}\text{antilog}\left(\frac{R(\theta_r,\phi_s,f)}{10}\right) \times\left[\cos\left(\theta_r-\frac{\Delta\theta}{2}\right)-\cos\left(\theta_r+\frac{\Delta\theta}{2}\right)\right]\Delta\phi, \qquad \text{(B3)}$$

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

Then, the relative response level for random incidence is given by

$$R_{rf} \cong 10\log\sum_n \Delta K(\theta_r,\phi_s,f), \qquad \text{(B4)}$$

where n is the number of elemental areas.

For the purpose of this Appendix, the sphere is divided into nonoverlapping areas that cover the sphere completely. In no case should n be less than eight. The angular orientation should be chosen such that the elemental areas are equal.

In general, for equal areas and cylindrical symmetry, the angles are selected by setting

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

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

When n is chosen as 7, the values of θ which give equal area contributions are

31°0′, 55°9′, 73°24′, 90°0′, 106°36′, 124°51′, 149°0′,

and

$$\Delta K(\theta,f) = (1/7)10^{0.1R(\theta,f)]} \qquad \text{(B5)}$$

APPENDIX C: RELATIVE RESPONSE OF FREQUENCY WEIGHTING CHARACTERISTIC

[This Appendix is not a part of American National Standard Specification for Sound Level Meters S1.4–1983, but is included for information purposes only.]

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

C Weighting

$$W_C = 10\log\left(\frac{K_1 f^4}{(f^2+f_1^2)^2(f^2+f_4^2)^2}\right). \qquad \text{(C1)}$$

Note: K_1 has the dimension $\sec^{-4}$.

B Weighting

$$W_B = 10\log\left(\frac{K_2 f^2}{f^2+f_5^2}\right) + W_C, \qquad \text{(C2)}$$

A Weighting

$$W_A = 10\log\left(\frac{K_3 f^4}{(f^2+f_2^2)(f^2+f_3^2)}\right) + W_C, \qquad \text{(C3)}$$

where f is frequency in hertz and K_1, K_2, and K_3 are scale factors chosen such that N_C, N_B, and N_A are zero decibels at 1000 Hz. The values for f_1 through f_5 and K_1, K_2, K_3 are given below:

$f_1 = 20.598997, \quad K_1 = 2.242881\times10^{16},$

$f_2 = 107.65265, \quad K_2 = 1.025119,$

$f_3 = 737.86223, \quad K_3 = 1.562339.$

$f_4 = 12194.22,$

$f_5 = 158.48932,$

APPENDIX D: THEORETICAL RESPONSE TO TONE BURSTS

[This Appendix is not a part of American National Standard Specification for Sound Level Meters S1.4–1983, but is included for information purposes only.]

The theoretical response values given in Tables VIII, X, and XI were obtained using the following formulae:

For the single tone bursts in Table VIII and X

$$\Delta L = 10\log[1-\exp(-t_i/\tau)]. \qquad \text{(D1)}$$

For the continuous sequence of bursts given in Table XI

$$\Delta L = 10\log\{[1-\exp(-t_i/\tau)]/[1-\exp(-T/\tau)]\}, \qquad \text{(D2)}$$

where t_i is the tone-burst duration in seconds, τ is the exponential time constant is seconds, and $T=(1/f_p)$ in seconds, where f_p is the repetition frequency of the bursts in hertz.

NOTE: These equations are exact for an instrument with an infinite bandwidth frequency response, and are sufficiently accurate for the purpose of this standard for tests on all specified frequency-weightings at test frequencies between 1000 and 2000 Hz.

APPENDIX E: TESTS OF ROOT MEAN SQUARE CHARACTERISTICS

[This Appendix is not a part of American National Standard Specification for Sound Level Meters S1.4–1982, but is included for information purposes only.]

Tests of the root mean square characteristics (rms) of the instrument are carried out with rectangular pulse sequences and with tone bursts.

E.1 Rectangular Pulse Test

Apply the 2000 Hz sinusoidal reference signal to the instrument under test and simultaneously to a reference system having a true rms response, within ± 0.1 dB tolerance, that follows a frequency network N corresponding to that in the sound level meter being tested and that is within the tolerances given in Table V. Note the indication of the reference meter.

Apply the rectangular pulse sequence (either positive or negative going pulses) and adjust its amplitude to give an indication on the reference true rms meter identical to that for the reference sinusoidal signal. The instrument under test shall then give an indication that differs from its indication with the reference sinusoidal signal by no more than the tolerances specified in this standard. (Note this test is specified in 8.4 to be accomplishd on the Flat or C weighting. If the instrument has only a B or A weighting the test in E.2 is used.) For the rectangular pulse shown, the relation between crest factor ($\hat{\mu}/\mu$) and pulse duty factor (t_i/T)

is given by

$$(\hat{\mu}/\mu) = [(T/t_i) - 1]^{1/2}, \quad \text{(E1)}$$

where $\hat{\mu}$ is the peak value of the signal measured with reference to the arithmetic mean. μ is the mean square value of the signal, the instantaneous value being measured with reference to the arithmetic mean. T is the fundamental period of the signal. t_i is the time during which the signal is at its peak value.

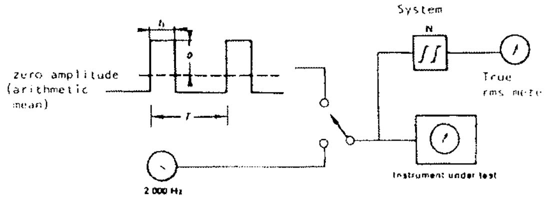

FIG. E1. Schematic diagram of the rectangular pulse test apparatus illustrating positive-going pulses. The zero of the amplitude scale is taken as the arithmetic mean value of the wave form.

E.2 Tone Burst Test

The rectangular pulse generator in Fig. E1 above is replaced by a tone burst generator and the procedure described above is repeated using the appropriate crest factor. The relation between crest factor and tone burst duty factor for this case is given by

$$(\hat{\mu}/\mu) = (2T/t_i)^{1/2}, \quad \text{(E2)}$$

where $\hat{\mu}$, μ, and T are as described above and where t_i is the duration of each tone burst.

AMERICAN NATIONAL STANDARD
Specification for Sound Level Meters
ANSI S1.4A-1985 AMENDMENT to ANSI S1.4-1983

This amendment to ANSI S1.4-1983 was approved by Accredited Standards Committee S1, Acoustics, under Chairmanship of Dr. T. F. W. Embleton, and by the American National Standards Institute (ANSI). The Secretariat of Accredited Standards Committee S1 is held by the Acoustical Society of America. The date of the ANSI approval of this Amendment is 26 June 1985.

Dr. G. S. K. Wong, Individual Expert on Accredited Standards Committee S1, assisted Standards Committee S1 in preparation of this amendment (ANSI S1.4A-1985) to ANSI S1.4-1983.

CONTENTS

0 INTRODUCTION

The use of A-weighting for analyzing acoustical signals has been standardized since the early 1930s. Various sound level meter standards[1,2] have provided specifications and tolerances on the frequency response of the A-weighting up to 20 kHz. For measurements of short-duration transient signals, it has been shown[3] that the uncertainty allowed in the A-weighted frequency response in the region above 16 kHz leads to an error which may exceed the intended tolerances for the measurement of A-weighted sound level by a precision (type 1) sound level meter. The intent of this amendment is: (a) to specify the electrical design goal for the relative response characteristics of the A-weighted frequency response up to 100 kHz and (b) to specify type 0 and type 1 tolerance limits on relative electrical response for frequencies between 16 kHz and 100 kHz.

The frequency range over which an instrument complies with the specification for A-weighting shall be stated by the manufacturer in the Instruction Manual, and, if practical, labeled on the instrument.

For some acoustical measurements it is undesirable for the instrument to respond to sound at frequencies above about 10 kHz to 20 kHz, i.e., beyond the normal range of human hearing. If the instrument does not provide a high-frequency cutoff at such frequencies, the user may need to employ additional narrow-band filters or filters with cutoff frequencies which are determined by the specific application.

1 DESIGN GOAL

The design goals of the random incidence relative response level for A-frequency weighting are tabulated from 10 Hz to 20 kHz in Table IV of ANSI S1.4-1983. That table is repeated, for completeness, as Table AI(a) of this amendment. The electrical design goal of the A-weighted frequency response is given in Table AI(b) for nominal frequencies to 100 kHz.

2 TOLERANCE LIMITS

Acoustical tolerance limits from 10 Hz to 20 kHz, given in Table V of ANSI S1.4-1983, are not changed; the limits are repeated here in Table AII(a) for type 0 and type 1 instruments. Electrical tolerance limits for type 0 and type 1 are given in Table AII(b) for frequencies from 16 kHz to 100 kHz.

Electrical tests to demonstrate conformance with the requirements of this amendment may be carried out by use of sinusoidal electrical signals with an equivalent electrical impendence substituted for the microphone.

3 REFERENCES

[1]American National Standard Specification for Sound Level Meters, ANSI S1.4-1983.

[2]"Sound Level Meters," International Electrotechnical Commission, Publication 651(1979).

[3]G. S. K. Wong, "Influence of A-weighting tolerances and frequency-band limits on level measurements," J. Acoust. Soc. Am. **68**, 1578–1583 (1980).

TABLE AI. Relative frequency response for A-weighting.

(a) Random incidence relative response level for A-weighting

Nominal frequency[a] Hz	Exact frequency[a] Hz	A-weighting dB
10	10.00	− 70.4
12.5	12.59	− 63.4
16	15.85	− 56.7
20	19.95	− 50.5
25	25.12	− 44.7
31.5	31.62	− 39.4
40	39.81	− 34.6
50	50.12	− 30.2
63	63.10	− 26.2
80	79.43	− 22.5
100	100.0	− 19.1
125	125.9	− 16.1
160	158.5	− 13.4
200	199.5	− 10.9
250	251.2	− 8.6
315	316.2	− 6.6
400	398.1	− 4.8
500	501.2	− 3.2
630	631.0	− 1.9
800	794.3	− 0.8
1000	1000	0
1250	1259	+ 0.6
1600	1585	+ 1.0
2000	1995	+ 1.2
2500	2512	+ 1.3
3150	3162	+ 1.2
4000	3981	+ 1.0
5000	5012	+ 0.5
6300	6310	− 0.1
8000	7943	− 1.1
10 000	10 000	− 2.5
12 500	12 590	− 4.3
16 000	15 850	− 6.6
20 000	19 950	− 9.3

(b) Electrical response level relative to that at 1000 Hz for A-weighting

1000	1000	0
16 000	15 850	− 6.6
20 000	19 950	− 9.3
25 000	25 120	− 12.4
31 500	31 620	− 15.8
40 000	39 810	− 19.3
50 000	50 120	− 23.1
63 000	63 100	− 26.9
80 000	79 430	− 30.8
100 000	100 000	− 34.7

[a] Nominal frequencies are as specified in ANSI S1.6-1984 [A revision of S1.6-1967 (R1976)], American National Standard Preferred Frequencies, Frequency Levels, 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 50 (1 hertz corresponds to $N = 0$).

TABLE AII. Tolerance limits on relative frequency response for A-weighting.

(a) Tolerance limits on relative response levels for sound at random incidence measured on an instrument's calibration range

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

(b) Tolerance limits on electrical relative response level for A-weighting measured when the instrument is set on its calibration range (defined in Sec. 2.14 of ANSI S1.4-1983).

16 000	+ 2, − 3	+ 3, − 7.4
20 000	+ 2, − 3	+ 3, − 8.7
25 000	+ 2.4, − 4.5	+ 3.5, − 9.6
31 500	+ 2.8, − 6.2	+ 4.3, − 10.7
40 000	+ 3.3, − 7.9	+ 5, − 11.7
50 000	+ 4.1, − 9.3	+ 6, − 12.8
63 000	+ 4.9, − 10.9	+ 6.9, − 13.9
80 000	+ 5.1, − 12.2	+ 7.9, − 15.2
100 000	+ 5.6, − 14.3	+ 8.9, − 16.8

NOTES

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