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Standard Guide for Applying Environmental Noise Measurement Methods and Criteria[1]

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1. Scope

1.1 This guide covers many measurement methods and criteria for evaluating environmental noise, some of which are required to be used for specific purposes by governmental regulations. It is intended to provide users who may not be familiar with them with an overview of the wide variety of available methods and criteria. It includes the following:

1.1.1 The use of weightings, penalties, and adjustment or normalization factors;

1.1.2 Types of noise measurements and criteria, indicating their limitations and best uses;

1.1.3 Sources of criteria;

1.1.4 Recommended procedures for criteria selection;

1.1.5 A catalog of sources of selected available criteria; and

1.1.6 Suggested applications of sound level measurements and criteria.

1.2 *Criteria Selection*—Thorough evaluation of noise issues requires consideration of many characteristics of both the sound and the environment into which it is introduced. This guide will assist users in selecting criteria for the following:

1.2.1 Evaluating the effect of existing or potential outdoor sounds on a community considering the magnitude and other characteristics of the sound and environment;

1.2.2 Establishing or revising local noise ordinances, codes, or bylaws, including performance standards in zoning regulations; and

1.2.3 Identifying and evaluating compliance with regulatory requirements that do not specify an acoustical measurement method or criterion or which are unclear.

1.3 *Reasons for Criteria*—This guide discusses the many reasons for noise criteria, ways sound can be measured and specified, and advantages and disadvantages of the most widely used types of criteria. The guide refers the user to appropriate documents for more detailed information and guidance. Users needing further general background on sound and sound measurement are directed to the books listed in the References section.

1.4 *Criteria in Regulations*—Certain criteria are specified to be used by government regulation, law, or ordinance for specific purposes. Any investigation or evaluation of a community noise issue must start with identifying applicable regulations and evaluating compliance with them. This document discusses but is not limited to regulations and ordinances. Due to the wide variation in local regulations, those are discussed more generally, and specific criteria are provided only from national government regulations. Regulations typically specify measurement methods and criteria for purposes of the regulation. Local ordinances must be written for ease of enforcement and cannot address all situations satisfactorily without becoming too complex. Such ordinances are also often prepared without competent guidance and can be too restrictive in some cases and not restrictive enough in others. Other regulations that determine government spending for noise control must balance that cost to the general public against impacts on individuals.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C634 Terminology Relating to Building and Environmental Acoustics

[1] This guide is under the jurisdiction of ASTM Committee E33 on Building and Environmental Acoustics and is the direct responsibility of Subcommittee E33.09 on Community Noise.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

E966 Guide for Field Measurements of Airborne Sound Attenuation of Building Facades and Facade Elements
E1014 Guide for Measurement of Outdoor A-Weighted Sound Levels
E1503 Test Method for Conducting Outdoor Sound Measurements Using a Statistical Sound Analysis System

2.2 *ASA/ANSI Standards:*[3]

ASA/ANSI S1.1 Acoustical Terminology
ASA/ANSI S1.4/Part 1/IEC 61672-1 Electroacoustics – Sound Level Meters – Part 1: Specifications
ASA/ANSI S1.4-1983 Specifications for Sound Level Meters
ASA/ANSI S1.11/Part 1/IEC 61260-1 Electroacoustics – Octave-Band and Fractional-Octave-Band Filters – Part 1: Specifications
ASA/ANSI S1.13 Measurement of Sound Pressure Levels in Air
ANSI S1.43 Specifications for Integrating-Averaging Sound Level Meters
ASA/ANSI S3.4 Procedure for the Computation of Loudness of Steady Sounds
ASA/ANSI S3.14 Rating Noise with Respect to Speech Interference
ASA/ANSI S12.4 Method for Assessment of High-Energy Impulsive Sounds with Respect to Residential Communities
ASA/ANSI S12.7 Methods for Measurement of Impulse Noise
ASA/ANSI S12.9 Quantities and Procedures for Description and Measurement of Environmental Sound – Part 1: Basic Quantities and Definitions; Part 2: Measurement of Long-Term, Wide-Area Sound; Part 3: Short Term Measurements with an Observer Present; Part 4: Noise Assessment and Prediction of Long-Term Community Response; Part 5: Sound Level Descriptors for Determination of Compatible Land Use
ASA/ANSI S12.65 Rating Noise with Respect to Speech Interference
ASA/ANSI S12.100 Methods to Define and Measure the Residual Sound in Protected Natural and Quiet Residential Areas

2.3 *ISO Standards:*[3]

ISO 532-1 Acoustics — Methods for calculating loudness — Part 1: Zwicker method
ISO 532-2 Acoustics — Methods for calculating loudness — Part 2: Moore-Glasberg method
ISO 1996-1:2016 Acoustics — Description, measurement and assessment of environmental noise — Part 1: Basic quantities and assessment procedures

2.4 *IEC Standards:*[4]

IEC 61260-1 Electroacoustics – Octave-band and fractional-octave-band filters – Part 1: Specifications
IEC 61672-1: 2002 Electroacoustics – Sound level meters – Part 1: Specifications
IEC 61672-1: 2013 Electroacoustics – Sound level meters – Part 1: Specifications

2.5 *DIN Standard:*[5]

DIN 45692 Measurement technique for the simulation of auditory sensation of sharpness (in German)

2.6 *United States Military Standard:*[6]

MIL STD 1474E Department of Defense Design Criteria Standard Noise Limits

3. Terminology

3.1 *General*—This guide provides guidance for various measurement methods and criteria initially defined in other documents. Most acoustical terms used in this standard are defined in either Terminology C634 or within this standard with their abbreviations and symbols for use in equations. The definition of terms explicitly given within this standard take precedence over definitions given in Terminology C634. For interpretation of this document, the definitions within Terminology C634 and this standard take precedence over any other definitions of defined terms found in any other documents, including other documents that are referenced in this standard.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *community noise equivalent level, CNEL, (dB), n*—see *day-evening-night average sound level*.

3.2.2 *day-evening-night average sound level, DENL, (dB),* L_{*den}—where * is a letter denoting the frequency weighting (understood to be A if deleted), *(dB), n*—a time-average sound level computed for an average calendar day period with the addition of 4.77 dB or 5 dB to all levels between 7:00 pm and 10:00 pm, and 10 dB to all levels after 10:00 pm and before 7:00 am. A-weighting is understood unless clearly stated otherwise.

3.2.2.1 *Discussion*—Various standards and regulations define both CNEL and DENL differently in terms of the level added to sound during the evening period. Earliest definitions indicated the average acoustic energy was to be multiplied by 3 which is equivalent to a 4.77 dB addition, but some more recent documents define the quantity with a 5 dB addition. In critical situations, the definition in a particular regulation or standard should be used.

3.2.3 *day-night average sound level, DNL,* $L*_{dn}$—where * is a letter denoting the frequency weighting (understood to be A if deleted), *(dB), n*—a time-average sound level computed for an average calendar day period with the addition of 10 dB to all sound after 10:00 pm and before 7:00 am. A-weighting is understood unless clearly stated otherwise.

3.2.4 *loudness, (sone), n*—that attribute of sound sensation for which sounds may be described on a scale from soft to loud or by a value in sones calculated from measured data.

3.2.4.1 *Discussion*—– One sone is the perceived loudness of a 1000 Hz tone of 40 dB sound pressure level. A sound that is n times as loud is n sones.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from International Electrotechnical Commission (IEC), 3 rue de Varembé, Case postale 131, CH-1211, Geneva 20, Switzerland, http://www.iec.ch.

[5] Available from Beuth Verlag GmbH (DIN-- DIN Deutsches Institut fur Normung e.V.), Burggrafenstrasse 6, 10787, Berlin, Germany, http://www.en.din.de.

[6] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

3.2.5 *normalization, n—as applied to the evaluation of noise in communities*, the practice of adjusting a measured sound level to compare to criteria that are based on conditions different from those present at the time or location of the measurement.

3.2.5.1 *Discussion*—This term originated in methods developed in the 1950's and was adopted by the US Environmental Protection Agency. Some current standards use the word "adjustment" for the same concept.

3.2.6 *residual sound, n*—the all-encompassing sound, being usually a composite of sound from many sources from many directions, near and far, remaining at a given position in a given situation when all uniquely identifiable discrete sound sources of particular interest or considered an interference, whether steady or intermittent, are eliminated, rendered insignificant, or otherwise not included.

3.2.6.1 *Discussion*—Residual sound is distinguished from background noise (which by definition also includes the self-noise of measurement systems), and from ambient noise which includes all sound present. It is also distinguished from a steady sound that is dominant between discrete events. The specific sounds excluded from the residual sounds should be identified. If the excluded sound is intermittent (such that it is on and off for periods), the residual sound may be approximated by the L90. If an excluded sound is steady and there are intermittent events, the L90 can be used to approximate the level of such steady sound and the residual sound must be measured with the steady source not operating or approximated by a measurement at a nearby location where the steady source is not dominant. Though "background noise" by definition includes instrument self-noise, the terms "background sound" and "background noise" are often used interchangeably with "residual sound" when it is known that instrument self-noise is not an issue.

3.2.7 *sound exposure level, *SEL,* L_{*E}—where * is a letter that denotes the frequency weighting (understood to be A if deleted), *(dB), n*—the sound energy over a stated period or event expressed as the sound level of the equivalent energy over a period of 1 s.

3.2.7.1 *Discussion*—The SEL can be computed as the time-average level of the sound over the event or stated period plus 10 times the base 10 logarithm of the event duration or stated period in seconds.

3.2.8 *speech interference level, SIL,* L_{SI}, *(dB), n*—one-fourth of the sum of the band sound pressure levels for octave bands with nominal mid-band frequencies of 500, 1000, 2000, and 4000 Hz.

3.2.9 *steady sound, n*—sound with negligible variations in level over the period of observation.

3.2.10 *time above (s or min per h or day), n*—the duration that the sound level or time-average sound level exceeds a corresponding specified level during a specified total measurement period.

3.2.10.1 *Discussion*—If sound level is used, then the time weighting shall be specified; if time-average sound level is used, then the measurement time interval for each sample shall be specified. The frequency weighting should be specified; otherwise, A-weighting will be understood. The unit for time in the ratio shall be stated, for example, as seconds or minutes per hour or day. **ASA/ANSI S12.9, Part 1**

3.2.11 *time weighting, n*—the exponential averaging of a time varying signal with a specified time constant.

3.2.11.1 *Discussion*—Exponential time weightings are applied to sound signals to obtain measurements of a sound level at a specific time that has not been time-averaged. The two currently standardized time weightings are "slow" with a time constant of 1 s and "fast" with a time constant of ⅛ s.

3.3 *Index of Terms*—The following commonly used terms are discussed in the sections referenced in this guide.

Term	Paragraph
A-weighting	6.2
C-weighting	6.2
community noise equivalent level	8.5.3
community tolerance level	8.5.2
day-evening-night average sound level	8.5.3
day-night average sound level	8.5.2
equivalent level	6.5 and 8.5.1
fast, time weighting or sound level	6.3
impulse, time weighting or sound level	6.3
loudness	8.11
maximum sound level	8.3
normalization or adjustment of DNL	7.4
octave band, or one-third octave band	6.6 and 8.9
peak sound pressure level	6.4 and 8.4
percentile level	8.6
slow, time weighting or sound level	6.3
sound exposure level	8.5.4
speech interference level	8.10
time above	8.7
time-average sound level	6.5 and 8.5.1

4. Significance and Use

4.1 *Evaluation of Environmental Noise*—Environmental noise is evaluated by comparing a measurement or prediction of the noise to one or more criteria. There are many different criteria and ways of measuring and specifying noise, depending on the purpose of the evaluation. Some evaluations are limited to determining compliance with existing regulations or ordinances. Others are done in the absence of such requirements or to supplement regulatory evaluations where the regulations do not address fully or at all the issues of concern.

4.2 *Selection of Criteria*—This guide provides information useful in selecting the appropriate criteria and measurement method to evaluate noise. In making the selection, the user should consider the following: regulatory or legal requirements for the use of a specific criterion; purpose of the evaluation (regulatory compliance, compatibility, activity interference, aesthetics, comfort, annoyance, health effects, hearing damage, etc.); types of data that are available or could be available (A-weighted, octave band, average level, maximum level, day-night level, calibrated recordings including .wav files from which various measurements could be made, etc.); and available budget for instrumentation and manpower to obtain that data. After selecting a measurement method, the user should consult appropriate references for more detailed guidance (**1**).[7]

4.3 *Objective versus Subjective Evaluations*—This guide discusses objective sound criteria based on measurements and

[7] The boldface numbers in parentheses refer to the list of references at the end of this standard.

regulations based on such. Some local noise ordinances are based solely or partially on subjective judgements of noise. Enforcement of these can be easily challenged and, in some jurisdictions, they are not permitted. These are not further considered in this guide. One way to address such situations is to evaluate the sound based on reasonable objective criteria.

4.4 *Soundscape Methodology*—The overall sound environment as perceived outdoors is often called a soundscape. Soundscapes have both objective (quantitative) and subjective (qualitative) attributes. A soundscape evaluation methodology is evolving which includes methods and criteria that rely extensively on qualitative factors, both acoustical and non-acoustical, while including requirements for quantitative sound measurement. Two basic tenets of quantitative soundscape measurements are that the ambient sound at a location is comprised of a combination of specific acoustic events that can be measured individually and in combinations; and that the sounds should be measured using methods that represent the ways in which they are perceived by people. Development of such measurement methods specifically for soundscape studies is a part of ongoing research and is not specifically discussed in this document.

5. Bases of Criteria

5.1 Most criteria for environmental noise are based on the prevention of problems for people. Historically the emphasis for noise evaluation in communities has been on annoyance, speech and sleep interference, and the effects of these on the usability of property. These effects occur at lower levels than typically required to damage hearing, influence task performance, or damage structures. Unless the scope of an evaluation is limited, it is important to recognize the many different problems that may be caused by noise. For example, Ref (**2**) provides a comprehensive discussion of the effects of noise in the context of aviation noise.

5.1.1 *Health Impacts*—Damage to human hearing is the best documented effect of noise on health, with the best-established criteria. Poor sleep or stress caused by annoyance can occur at much lower sound levels than required for hearing damage and can aggravate some non-auditory physical conditions. Research has shown some physical reactions of the human body related to sound exposure. These include cardiovascular effects such as elevation of blood pressure, mean respiratory volume, intestinal irritation, and endocrine system responses among others. Pyscho-social effects of noise including agitation, withdrawal, anxiety, and depression among others have also been identified in the literature. Communities with high noise levels also can have high levels of other pollutants that could cause physical problems. Thus, it is difficult to establish a direct connection between sound exposure and non-auditory health effects (**3**, **4**, **5**, **6**).

5.1.2 *Speech or Communication Interference*—Speech communication is essential to the daily activities of most people. There are criteria for the background sound levels needed to allow such communication.

5.1.3 *Sleep Interference*—High levels of sound and changes in sound level can affect the quality of sleep or awaken sleepers. Annoying sounds can interfere with the ability to go to sleep. Poor sleep can affect physical ailments and contribute to the potential for degrading task performance that could result in injuries from accidents when driving or operating machinery (**7**).

5.1.4 *Annoyance and Community Reaction*—Annoyance is the effect of a personal reaction to noise. Community reaction is the response to noise evidenced by complaints to authorities from multiple people. Some people are annoyed but do not complain. Some people use noise as an excuse to complain when they are not annoyed directly by a sound. Often annoyance and community reaction are related to speech or sleep interference, reduced environmental aesthetics, or the effect of these factors on the utility and value of property. Some of the criteria developed for noise in residential communities are based on survey studies of annoyance or on adverse community reaction directed to public officials.

5.1.5 *Noise Characteristics*—Certain quantitative criteria can be used to further restrict sounds that have been found to be particularly noticeable, intrusive, or to increase perceived annoyance especially if persistent. Often such sounds contain strong discrete tones or are otherwise unbalanced in spectral content. Spectral criteria such as octave band limits are used to specify or evaluate the aesthetic quality of the sound present. Some spectral criteria can be used to evaluate whether a sound is rumbly or hissy or has a perceptible or prominent tone. Other particularly noticeable sounds include information contained in speech or music as well as impulsive sounds from gunshots, bass music beats, hammering, etc. Such sounds are sometimes restricted to numerically lower A-weighted sound levels in ordinances and regulations. A major concern with music is often the bass beat because of its pulsating nature even if the level does not exceed normally acceptable criteria for steady low-frequency sound. In such cases, C-weighted limits or octave band limits in the low frequency bands set at a lower level than normal are sometimes applied specifically to the music. However, care must be used that such low limits are not inappropriately applied to steady sounds. When sound levels vary strongly from an average, such as with aircraft overflights or an occasional heavy truck pass by, criteria that identify the variation such as "time above" or statistical counts of the number of events above specified thresholds or within certain ranges of maximum levels can be used. Measures attempting to evaluate for perceived annoyance may take into consideration such factors as loudness, the time of day, and various recognized sound quality characteristics.

5.1.6 *Land Use Compatibility*—Noise compatibility criteria have been developed for land use planning. These are most useful in determining whether a certain type of development can be made compatible with existing noise. As discussed in ASA/ANSI S12.9 Part 5, these criteria set maximum long-term average sound levels with appropriate adjustments for full and marginal compatibility of various usages with normal construction plus in some cases a higher level in which the use is compatible with improved construction. The criteria for residential uses assume the community is populated by people of average sensitivity to annoyance regardless of sound level with no self-selection based on existing levels. The ranges are wide enough that noticeable and potentially significant changes in sound level could occur within a given compatibility category without exceeding the criteria. For these reasons as explained in the standard, these criteria do not predict community reaction to sudden significant increases in the average sound level.

5.1.7 *Preservation of Natural Quiet*—Some locations such as large park, wilderness, and rural areas are noted for the limited presence of man-made sounds. The preservation of such existing conditions is often an objective. Refs (**8**, **9**) discuss criteria for national parks and wilderness areas, Ref (**10**) discusses rural areas, and ASA/ANSI S12.100 discusses measurements of residual sound in such areas.

6. Basics of Sound Measurement

6.1 *Introduction*—A classification of the types of sounds by temporal, frequency, and spatial characteristics, as well as basic procedures for taking sound pressure level measurements at a single point in space based on these different characteristics, are found in ASA/ANSI S1.13. Various measurements discussed in Section 8 below are affected by capabilities built into the sound level meters used for measurements. This section discusses these capabilities and standards for instruments.

6.2 *Frequency Weightings*—Several frequency-weighting networks (filters) have been internationally standardized. These networks provide a better match between measured sound pressure and human perception. They adjust the relative strength of sounds occurring at different frequencies before the level is indicated by the meter. The two used most frequently are designated A-weighting and C-weighting.

6.2.1 A-weighting is the most used. Results are expected to indicate human perception or the effects of sound on humans, most closely correlating (though not exactly) with perceived loudness. A-weighting accounts for the reduced sensitivity of humans to low-frequency sounds, especially at lower sound levels. In addition to A-weighted sound levels, the weighting curve can be applied to spectra to evaluate the contribution of various frequencies to the A-weighted sound level.

6.2.2 C-weighting is sometimes used to evaluate sounds containing strong low-frequency components. A large difference between C and A weighted levels identifies the presence of strong low-frequency sound. It was originally devised to approximate human perception of high-level sounds.

6.2.3 B, D, and E weightings have been defined but are not in current instrument standards. The Z-weighting defines the frequency limits of the previously non-standardized "unweighted," "linear," or "flat" weighting.

6.3 *Exponential Time Weightings*—Sound levels often vary rapidly. It is not practical or useful for a meter to indicate every fluctuation of sound pressure. When it is desired to record the continuous variation in sound, the meter performs an exponential average process that emphasizes the most recently occurring sound. Three standard meter time-weighting characteristics are commonly used in sound measurements (slow, fast, and impulse). The exponential time weighting used in a measurement should always be stated. These are sometimes referred to as a "response" such as "slow response."

6.3.1 "Slow" is a commonly used time weighting especially in local ordinances because it provides a slowly changing level indication that is easy to read.

6.3.2 "Fast" more closely responds to human perception of sound variation. It provides a more rapid response to changing sound levels. Fast response is often used for short duration measurements such as motor vehicle drive-by tests.

6.3.3 "Impulse" allows a faster rise in indicated level than the fast weighting but causes a slower decrease in indicated level than the slow weighting so that one can read the maximum levels. The impulse time weighting is no longer required in sound level meters. As stated in Annex C of IEC 61672-1:2002, various investigations have concluded that it "is not suitable for rating impulsive sounds with respect to their loudness – nor for determining the 'impulsiveness' of a sound." Since impulse response has been used in some regulations such as for gunshot sound, the historical specifications for this time weighting were included in Annex C of IEC 61672-1:2002 but are not included in the 2013 version.

6.3.4 All of the above time weightings will yield different maximum and minimum levels for typical varying sound levels but yield the same level for a steady source.

6.4 *Peak Sound Pressure Level*—A peak indicator measures the true peak level of a very short duration signal. It is not normally used to measure steady sounds or slowly varying sounds. A peak detector responds to the absolute positive or negative instantaneous value of the waveform rather than its effective or "root mean square" (rms) value. In normal use, a peak measuring instrument will hold its indication for ease of reading until reset or will store it in a memory for later reference. The measured peak level is dependent on the frequency bandwidth of the microphone and both the frequency bandwidth and the rise time (microseconds/volt) of the associated electronic instrumentation. A reduced frequency bandwidth will reduce the effective rise time. Sound level meter standards specify tolerances for accuracy of the C-weighted peak level but not the rise time. When Z-weighting is used, it is important to validate the performance of the instrumentation using, for example, a method given in MIL STD 1474E section 4.7.4.3. Some criteria for gunshot sound are based on Z-weighted peak levels. Measuring such at points far from the source can be difficult because even low-speed wind blowing over a microphone can produce a signal below the frequency range of the gunshot that exceeds the level of the gunshot. C-weighting can function like a high-pass filter eliminating the wind effect and allowing the gunshot sound to be measured with little or no wind effect. Rise time can be an important factor in some cases such as measurements close to a firearm. In order to minimize confusion, the term "peak" should never be used to describe the maximum level measured with fast or slow time weighting since true peak levels can be more than 20 dB greater than maximum time-weighted levels.

6.5 *Time-Average Sound Level*—(Symbol L_*, where * is the measurement period. An additional subscript may indicate the frequency weighting. The name equivalent sound level, Symbol L_{eq}, and abbreviation LEQ are also commonly used.) Sometimes it is desirable to measure the average sound present over a specified period. This time-average sound level is often called the equivalent sound level or equivalent continuous sound level. It is the steady sound level whose sound energy is equivalent to that of varying sound in the measured period. The frequency weighting should be specified. Otherwise, for overall sound levels, it is understood to be A-weighting.

6.6 *Frequency Analysis*—Electronic filters can be used to separate sound into frequency bands so measurements with any of the methods described above can be made in specific frequency bands. When frequency analysis is performed for environmental noise, measurements are usually made in standardized octave or one-third octave bands (IEC 61260-1, ASA/ANSI S1.11/Part 1/IEC 61260-1). Octave band or one-third octave band data or criteria are understood to be Z weighted unless it is clearly stated otherwise. Frequency analysis can be a useful diagnostic tool to characterize, identify, and quantify individual sources of sound.

6.7 *Time History Analysis*—Plots of the time history of sound variation can demonstrate the variability of sound level and serve as a tool in identifying, separating, and quantifying individual components of the overall sound that are varying with time. Time history and frequency analysis are sometimes combined on the same three-dimensional plot. These analyses are usually based on calibrated recordings of the sound.

6.8 *Sound Level Meters and Filters*—Early sound level meters included the fast and slow time weightings and A and C frequency weightings and no ability to average over longer periods. Most newer instruments include the ability to make time- average sound level measurements. The sound level meter specification standard does not call for frequency analysis filters. However, such can be built into meters or attached. Other features such as percentile analysis, and long-term monitoring with measurements over selected periods are often found in modern instruments.

6.8.1 Sound level meters for field use are designated as either class 1 or class 2, with class 1 being more precise.

6.8.2 International specifications for sound level meters are provided in IEC 61672-1. This standard is often adopted by nations as a national standard, and this was done in the United States in 2014 as ASA/ANSI S1.4/Part 1/IEC 61672-1. This standard defines both a "time weighting" meter also called a "conventional" meter in ASA/ANSI S1.13 and the modern "integrating-averaging" meter with selectable averaging time. Prior to 2014, standards for sound level meters in the United States were specified in ASA/ANSI S1.4-1983 for conventional sound level meters and ANSI S1.43 for integrating-averaging sound level meters. These standards contained more stringent tolerances at low frequencies than the current standard or earlier IEC standards.

6.8.3 International specifications for octave band and fractional octave band filters are provided in IEC 61260-1. This standard is often adopted as a national standard. In the United States this is ASA/ANSI S1.11/Part 1/IEC 61260-1.

7. Adjustments to Sound Levels to Account for Conditions Influencing Human Response

7.1 *Introduction*—Many acoustical and non-acoustical factors influence human response to environmental noise. Special measurements and criteria apply adjustments to the sound level for these factors.

7.2 *Time-of-Day Penalties*—Many people expect and need lower sound levels at night, primarily for sleep and relaxation. In most outdoor locations, ambient noise levels are lower at night. It is preferable to have lower limits for sound during normal sleeping hours, most commonly from 10:00 pm until 7:00 am. The difference between daytime and nighttime limits in local ordinances for residential areas is usually 5 or 10 dB. For those criteria based on average levels over a period containing both day and night, a 10 dB penalty is commonly added to sound levels during the night period before computing the average level (see 8.5.2). In some cases an evening penalty of approximately 5 dB is also used (see 8.5.3).

7.3 *Penalties based on Sound Characteristics*—Sounds that are concentrated at a specific frequency, or a series of frequencies that are typically multiples of the lowest such frequency, are called tonal with the individual frequencies being discrete tones. Such sounds give the sensation of pitch. These can be particularly perceptible, intrusive, unpleasant, and annoying, especially if persistent. The same is true of sounds consisting of repeated pulses less than a second apart, which are called repetitive impulsive sounds. In such cases, local noise ordinances sometimes specify that the objective criterion be 5 dB more stringent than would be the case if the sound character were not tonal or impulsive.

7.4 *Normalization or Adjustments to Sound Levels*—Some criteria presume conditions that are not appropriate in all cases. When these conditions are not met, the measured level can be adjusted or normalized for the different conditions before comparing it to the normal criterion. This is done by adding or subtracting a number of decibels from the measured or calculated expected level for each factor different from the normal assumption. The U.S. Environmental Protection Agency (EPA) (**11**) provided a "normalization" procedure when it introduced the DNL because it found that such adjustments provided much better correlation with community reactions. Most of the EPA adjustments were taken from earlier procedures but with some changes. The EPA adjustments addressed seasonal differences, existing sound in the community without the noise, prior community experience with the noise or community attitudes, and tonal or impulsive characteristics. Similarly, ASA/ANSI S12.9 Part 4 provides ways to account for various residual or background sound conditions and sound characteristics. The measured or calculated DNL is "adjusted" upward by 5 dB for tonal or normal impulsive sound or sound occurring during daytime on weekends, 12 dB for highly impulsive sound such as small arms gunfire, hammering, riveting, and railyard shunting operations, up to 5