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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. It includes the following:

1.1.1 The use of weightings, penalties, and 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 selected available criteria; and

1.1.6 Suggested applications of sound level measurements and criteria.

1.2 *Criteria Selection*—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; or

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

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. The listing of specific criteria includes national government regulatory requirements. 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. Ease of enforcement and cost impact on government are considerations for these criteria. They may not be the most appropriate criteria in some circumstances. This guide will discuss the limitations of these criteria.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C634 Terminology Relating to Building and Environmental Acoustics

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 Digital Statistical Sound Analysis System

2.2 *ANSI Standards:*[3]

ANSI S1.1 Acoustical Terminology

ANSI S1.4 Part 1, Electroacoustics – Sound Level Meters – Part 1: Specifications

ANSI S1.11 Part 1, Electroacoustics – Octave-Band and Fractional-Octave-Band Filters – Part 1: Specifications

ANSI S1.13 Measurement of Sound Pressure Levels in Air

ANSI S3.4 Procedure for the Computation of Loudness of Noise

ANSI S3.14 Rating Noise with Respect to Speech Interference

ANSI S12.4 Method for Assessment of High-Energy Impulsive Sounds with Respect to Residential Communities

ANSI S12.7 Methods for Measurement of Impulse Noise

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

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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.

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

and Prediction of Long-Term Community Response; Part 5: Sound Level Descriptors for Determination of Compatible Land Use; Part 6: Methods for Estimation of Awakenings Associated with Outdoor Noise Events Heard in Homes

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 Acoustics—Method for Calculating Loudness Level

ISO 1996 Assessment of Noise with Respect to Community Response

ISO 2204 Guide to the Measurement of Airborne Acoustical Noise and Evaluation of Its Effects on Man

2.4 *IEC Standard:*[4]

IEC Standard 61672 Electroacoustics-Sound Level Meters

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 defined in other documents. Most acoustical terms used in both this and other ASTM standards are defined in Terminology C634 along with their abbreviations and symbols for use in equations.

3.2 *Definitions of Terms Specific to This Standard:* The following terms are not used in other ASTM standards:

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

3.2.2 *day-evening-night average sound level (DENL), 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 a calendar day period with the addition of 4.77 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.

3.2.3 *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 a calendar day period with the addition of 10 dB to all levels 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 auditory sensation in terms of which sounds may be ordered on a scale extending from soft to loud. **ANSI S1.1**

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.

3.2.6 *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 also includes the self-noise of measurement systems, and 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, 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 where * is a letter that denotes the frequency weighting (understood to be A if deleted), L_{*E} where * is a letter that denotes the frequency weighting (understood to be A if deleted), (dB), n—ten times the logarithm to the base ten of the ratio of a given time integral of squared instantaneous frequency-weighted sound pressure, over a stated time interval or event, to the product of the squared reference sound pressure of 20 micropascals and reference duration of one second.

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 *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. 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, the 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. **ANSI S12.9, Part 1**

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

[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.

community noise equivalent level	8.5.3
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	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.

4.2 *Selection of Criteria*—This guide assists in selecting the appropriate criteria and measurement method to evaluate noise. In making the selection, the user should consider the following: purpose of the evaluation (compatibility, activity interference, aesthetics, comfort, annoyance, health effects, hearing damage, etc.); type 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.); available budget for instrumentation and manpower to obtain that data; and regulatory or legal requirements for the use of a specific criterion. After selecting a measurement method, the user should consult appropriate references for more detailed guidance.

4.3 *Objective versus Subjective Evaluations*—The overall sound environment as perceived outdoors is often called a soundscape. Soundscapes have both objective (quantitative) and subjective (qualitative) attributes. This guide is limited to the objective measurement and evaluation of sound found outdoors though the criteria used may be influenced by qualitative factors. Current soundscape research involves evaluation 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 heard by people. **(1)**[7]

5. Bases of Criteria

5.1 Most criteria for environmental noise are based on the prevention of problems for people. However, there are criteria for evaluating effects on animals, physical damage to structures, or reduced utility of property. When selecting criteria to evaluate a situation, it is very important to recognize the many different problems that may be caused by the noise. Sound-scape methods address aesthetic components of sounds and provide for comfortable or satisfying sounds in addition to preventing noise problems.

5.1.1 *Health Impacts*—Damage to human hearing is the best documented effect of noise on health, with the best established criteria. Damage depends on sound levels and exposure time. Most noise-induced hearing loss is due to exposure over several years. People are often annoyed by noise at a much lower level than that required to damage hearing. This annoyance causes stress that can aggravate some physical conditions. Criteria for preventing these problems are usually based on annoyance. Research has shown some physical reactions of the human body to sound including 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. **(2, 3, 4)**

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

5.1.3 *Sleep Interference*—High levels of sound and changes in sound level affect the quality of sleep or awaken sleepers. See ANSI S12.9 Part 6.

5.1.4 *Task Interference*—High sound levels can either hinder or improve the performance of a task. The effect depends on the nature of the task as well as the sound.

5.1.5 *Annoyance and Community Reaction*—Annoyance and community reaction are different effects. Annoyance is a personal reaction to noise. Community reaction is evidenced by complaints to authorities. 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 reaction are related to speech or sleep interference, reduced environmental aesthetics, or the effect of these factors on the utility and value of property. Many 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.

5.1.6 *Noise Characteristics*—Certain quantitative criteria can be used to further restrict sounds that have been found to be particularity 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 are used to specify or evaluate the aesthetic quality of the sound present. Some 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 overall A-weighted sound levels in ordinances and regulations. C-weighted limits or octave-band

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