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Standard Test Method for Conducting Outdoor Sound Measurements Using a Digital Statistical Analysis System[1]

This standard is issued under the fixed designation E 1503; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

This is one of a series of standards on the measurement and evaluation of community noise. Others in the series include Guide E 1014 which covers manual measurement, using a simple meter, and analysis of the resulting data, Guide E 1779, which covers preparation of a measurement plan for conducting outdoor sound measurements, and Guide E 1780, which covers measurement of sound received from a nearby fixed source. Also, under consideration or in preparation as supporting document, is a draft standard guide for determining the validity and significance of data obtained using this test method.

1. Scope

1.1 This test method covers the measurement of outdoor sound levels at specific locations using a digital statistical analyzer and a formal measurement plan.

1.1.1 This test method provides basic requirements for obtaining either a single set of data or multiple sets of related data. However, because there are numerous circumstances and varied objectives requiring multiple sets of data, the test method does not address planning of the measurement program.

1.2 The use of results of measurements performed using this test method include, but are not limited to, the following:

1.2.1 To characterize the acoustical environment of a site,

1.2.2 To characterize the sound emissions of a specific sound source which exhibits a temporal variation in sound output, and

1.2.3 To monitor the effectiveness of a noise impact mitigation plan.

1.3 This test method is intended to be used in conjunction with a measurement plan that references this test method. Changes or additions to the provisions of this test method should be clearly stated in the plan.

1.3.1 In the event it is necessary, for example, because of time constraints, to conduct measurements without first formalizing a plan, this test method can be used if an operator/observer whose qualifications are satisfactory to both the performing organization and the client is present at all times during the measurements and who complies, to the extent possible, with all the applicable requirements of this test method, including record keeping.

1.4 The data obtained using this test method enable comparison of statistical sound level data with appropriate criteria.

1.4.1 The data obtained with this test method can be used in the derivation of loudness levels provided the necessary requirements regarding sample duration and signal bandwidth are observed in collecting the data. It is recommended that a specialist in the area of loudness evaluation be consulted in preparing a plan for measurements intended to produce data which will be used for this purpose.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are provided for information only.

1.6 *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]

C 634 Terminology Relating to Environmental Acoustics

E 1014 Guide for Measurement of Outdoor A-Weighted Sound Levels

E 1779 Guide for Preparing a Measurement Plan for Conducting Outdoor Sound Measurement

[1] This test method is under the jurisdiction of ASTM Committee E33 on 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.

E 1780 Guide for Measuring Outdoor Sound Received from a Nearby Fixed Source

2.2 *ANSI Standards:*

S1.4 Specification for Sound Level Meters[3]

S1.11 Octave-Band and Fractional Octave-Band Analog and Digital Filters, Specifications for[3]

S1.13 Methods for the Measurement of Sound Pressure Levels[3]

S1.40 Specification for Acoustical (Microphone) Calibrators[3]

3. Terminology

3.1 For definitions of terms used in this test method see Terminology C 634.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *barrier*—any obstacle, in the lines of sight between the microphone and potential sound sources, that could block, or interfere with, the direct passage of sound from potential sound sources to a receiver or a measurement location.

3.2.2 *digital statistical sound analysis system*— combination of a sound level meter, either analog or digital, interfaced with a digital data storage device, and a digital statistical analyzer, for sampling environmental sound levels over a specified timed interval.

3.2.2.1 *Discussion*—For the purposes of this test method, a generic analyzer having the necessary features for the intended measurement and meeting the requirements of ANSI S1.4 (1983), and ANSI S1.11 (1985), is assumed.

3.2.3 *dummy microphone*— microphone cartridge substitute which has electrical characteristics identical to a functional microphone, but which has essentially no sensitivity to incident acoustic energy.

3.2.3.1 *Discussion*—Used instead of a functional microphone when evaluating the internal noise of an acoustic measuring system.

3.2.4 *equivalent sound level,* L_{eq}—obtained by integrating A-weighted sound level measured over a specific period of time, or in the case of un-weighted (flat) sound pressure and fractional octave bands, equivalent sound pressure level. See the definition of **average sound pressure level** in Terminology C 634.

3.2.5 *exceedance level*—See 3.2.11.

3.2.6 *impulse sound*—brief, intrusive sound, such as that associated with a tire blowout, operation of a power press, the discharge of a firearm, or a shout. (See ANSI S1.13.)

3.2.7 *interference*—any activity or event, occurring near the measurement location, that could produce anomalous measurement results, or data which are not representative in the context of the measurement objectives.

3.2.7.1 *Discussion*—Examples of interference are air turbulence generated by the wind at, or near the microphone, people or animals making sounds in the vicinity of the microphone, or the presence of surfaces which alter the normal sound propagation path. See Section 7 for additional details and precautions.

3.2.8 *measurement plan*—external document covering requirements unique and specific to the objectives of the measurement.

3.2.8.1 *Discussion*—These requirements address, for example, methods of selecting measurement times and locations, number and length of measurement sets, and directions on actions to be taken in case of major changes in environment during a measurement session. Such a plan is highly recommended for use in conjunction with this test method.

3.2.9 *measurement set*— set of acoustical and related data, and analysis results, obtained at a single measurement location during a specific time period.

3.2.9.1 *Discussion*—The time period for a measurement set is flexible but should be based on the purpose of the measurement and specified in the measurement plan. If the purpose of the measurements is to document the sound for a specific source operating condition or propagation condition, a measurement set should not extend beyond the time period in which conditions affecting sound generation or propagation remain reasonably constant.

3.2.10 *noise floor*—See *self-noise*.

3.2.11 *percentile exceedance levels*— measured level exceeded a specific percent of the time in a measurement set.

3.2.12 *self-noise*—extraneous signal components, not part of the sound field to be measured, generated, or induced in a measurement system.

3.2.12.1 *Discussion*—The magnitude of the extraneous component sets a lower limit, or floor, below which accurate measurements cannot be made. See the definition of background noise in Terminology C 634.

3.2.13 *statistics of sound level*—results of statistical analysis, performed simultaneously with the measurement or immediately following measurement of sound level, on the data in a measurement set. Three representative types of sound-level statistics that may be derived from either frequency weighted or un-weighted (flat) sound levels, or from fractional octave bands of sound are the equivalent sound level (see 3.2.4) percentile exceedance levels (see 3.2.11) and maximum and minimum sound levels occurring during a measurement set.

4. Significance and Use

4.1 This test method deals with methods and techniques which are well defined and which are understood by a trained acoustical professional. This test method has been prepared to provide a standard methodology which, when followed, will produce results which are consistent with requirements of government and industry, and which can be validated using information gathered and documented in the course of the measurement program.

4.2 There are numerous situations for which outdoor sound level data are required. These include, but are not limited to the following:

4.2.1 Documentation of sound levels before the introduction of a new sound source as a reference for assessment of the noise impact caused by a proposed facility and associated activities,

4.2.2 Comparison of sound levels with and without a specific source (for example, assessment of the impact of an existing source), and

[3] Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

4.2.3 Comparison of sound levels with criteria or regulatory limits (for example, indication of exceedance of criteria or non-compliance with laws).

4.3 This test method provides a means for operating a sound analysis system which incorporates digital circuits for processing and storing sound level data, documenting conditions under which the measurements were performed, and reporting the results.

4.4 This test method provides the user with information to (*1*) perform and document statistical analysis performed during measurement of outdoor sound level over specific time periods at specified places, and (*2*) make and document the physical observations necessary to qualify the measurements.

4.5 This test method can be used by individuals, regulatory agencies, or others as a measurement method to collect acoustical data for many common situations. The data are collected in a format determined by the capabilities of the equipment, equipment operational options selected, and by post-processing options available. An example would be tables of statistical sound levels.

4.6 The user is cautioned that there are many factors that can strongly influence the results obtained during measurement of outdoor sound levels and that this test method is not intended to supplant the experience and judgment of experts in the field of acoustics. This test method is intended to facilitate communication between sound measurement professionals and individuals who are responsible for administering regulations, or are otherwise involved in decisions involving sound measurements. Measurements should be performed only under the direction of people who are experienced in the measurement and analysis of outdoor sound, and who are thoroughly familiar with the use of the equipment and techniques involved.

4.7 This test method is only a measurement procedure and, as such, does not address the methods of comparison of the acquired data with specific criteria. No procedures are provided within this test method for estimating the influences of two or more simultaneously measured sounds. This test method can be used, with an appropriate plan, in establishing compliance when the measured data are below a specified limit, or conversely, establishing noncompliance when any of the data are above a specified limit.

5. Interferences

5.1 Measurements intended to provide detailed spectral and temporal sound level data are subject to interferences from a number of sources. The most significant of these are mentioned briefly in paragraphs 5.1-5.9. The user of this test method is referred to Guide E 1779 for the full details of interferences and recommended practices for avoiding or minimizing the effects of the interferences mentioned here. Normally the measurement plan will include a requirement to have an operator/observer present at all times during the performance of outdoor sound measurements. The observer, in addition to monitoring potential interferences, such as wind, precipitation, and site visitors, should interrupt or terminate the measurements when the pending or existing interference is judged to be significant, or when guideline limits in the measurement plan are exceeded. The operator/observer, as well as any visitors or support staff should be made aware of the importance of not engaging in activities which create extraneous sounds. Examples of activities to be avoided while measurements are in progress are talking, walking on gravel, leaves, or twigs, use of radio-telephones (electromagnetic interference), or operating vehicle engines.

5.2 *Effects of Wind*:

5.2.1 Interaction of the wind with the microphone may influence the results of sound level measurements even with a windscreen in place. Even for wind speeds below 20 km/h (12 mph) special care must be used if sound levels are very low or if measuring fractional band, C-weighted, or flat frequency-weighted levels. Higher wind speeds can be tolerated for high-sound levels or if a windscreen designed for high-wind speeds is used. Manufacturer's instructions for operation in wind should be followed. Appropriate guidelines for measurements in wind are included in Guide E 1779.

5.2.2 If maximum wind speeds are not addressed in the measurement plan, manufacturer's instructions shall be followed with respect to analyzer limitations under windy conditions.

5.3 *Effects of Moisture and High Humidity*:

5.3.1 Measurable precipitation almost always influences outdoor sound levels. For example, tires rolling on a paved surface produce higher sound levels when the pavement is wet. Fallen snow may affect the propagation of sound. Data obtained under such conditions should be retained but carefully marked so that its use in subsequent analysis is used advisedly.

5.3.2 High relative humidity, generally over 90 %, can influence certain preamplifiers and microphones, especially air-condenser microphones. Microphone manufacturer's instructions should be followed under high-humidity conditions.

5.4 In situations involving impulse sound events, the user should be aware that the fast and slow exponential time weighting typically used to measure continuous sound do not appropriately quantify impulsive sound. To obtain accurate measurement of impulsive sounds, other methods (for example, see ANSI S1.13) shall be used in conjunction with this test method. The presence of impulsive sounds shall be noted in the report. Any measurements in which data other than a narrative description of the impulse(s) are obtained shall require a measurement plan which prescribes the sampling rate, system response, and other pertinent guidelines. The plan should also include reference to standards that provide guidance.

5.5 Care should always be taken to position the microphone away from acoustically reflective surfaces which are not normally present at the location specified by the measurement plan. This includes any vehicle used in connection with the measurement program. In the absence of guidance from a measurement plan, the microphone should be placed away from any such acoustically reflective surface by at least 2½ times the major dimension of that surface.

5.6 Electromagnetic radiation from high-voltage transmission lines, either overhead or underground, or strong television or radio signals may affect the measurement system, causing a high, erroneous indication. The operator should use caution when this type of equipment is nearby, being especially careful to avoid being directly under power lines, in the ground-plane

array of transmitters, or close to transformers. Anomalies caused by such interference can usually be detected by using the earphones with the analyzer a-c output.

5.7 A nonelectrical problem related to power lines is the generation of sound by aeolian strumming, or buzzing or rattling by wires which are not tightly secured to insulators near a power line. In a quiet rural environment such sounds can easily exceed the ambient level. This is an example of a noise source which requires careful consideration when choosing a measurement location. For guidance in determining if such sounds are part of the ambient or constitute interference, determine if the sound is part of the ambient at a point for which the ambient is to be characterized. If it is, it should be measured. If the sound can be defined as an interference, one which masks an area-wide baseline, the measurement location should be moved to a point at which the contribution of the source is at a level more representative of its area-wide level. The only way to avoid such interference is to avoid measurement locations close to power poles or lines when the measurement plan does not require a specific location.

5.8 Temperature inversions, wind and other meteorological conditions may strongly influence the propagation of sound over long distances. Therefore, when sound from sources at horizontal distances of about 300 m (1000 ft) or more need to be measured, someone experienced in meteorological influence on sound propagation should be consulted.

5.9 During certain times of the year, naturally occurring sounds, as from birds or insects (crickets, locusts) may dominate A-weighted sound levels and some fractional octave band levels, particularly during evening and nighttime periods. Such sounds shall be noted in the report. Where possible an effort may be made to document their influence by making measurements at different times or places to document conditions with and without such naturally occurring sounds. Octave-band (or 1/3 octave-band) data should be gathered when this is a problem: such data can frequently be used (during post-processing) to remove the effect of the insect noise.

6. Apparatus

6.1 *Acoustical Measurements*:

6.1.1 *Digital Sound Level Meter*, with statistical analysis capability (required) and capability for storing analysis results, with at least a 60-dB dynamic range, Type 1 or Type 2 as defined by ANSI S1.4. The instrument should have an a-c output port to permit the use of headphones. If measurements are to be made in fractional octave-bands, the system shall include filter sets which fulfill the objectives of the measurement, or of the measurement plan. Filters shall meet the requirements of ANSI S1.1.1. The system should have one or more of the following capabilities as needed for a specific measurement plan:

6.1.1.1 Selectable exponential time averaging (fast, slow),

6.1.1.2 Ability to be interfaced with a portable computer or programmable calculator which can function as the controller, data storage, or analysis device,

6.1.1.3 Ability to be programmed to perform specific types of measurements and store the data within the analyzer,

6.1.1.4 Computation of values of statistical descriptors, or permanent storage of data for later processing,

6.1.1.5 Weighting filters, that is, A, B, C, D, E,

6.1.1.6 Frequency-domain filters, for example, fractional octave-bands such as 1/1, 1/3 ... 1/n octave, etc.,

6.1.1.7 Ability to compute one or more of various types of average, that is, the 50th percentile, (L_{50}), or the equivalent (L_{eq}) sound level for the measurement period, and

6.1.1.8 Ability to identify the occurrence of sound-level events which exceed some level threshold and provide data on the time and duration of occurrence, and sound level during the event, including generation of histograms of the number of occurrences, or durations, that sound levels exceed selected thresholds.

6.1.2 *Outdoor Microphone System (required)*—At a minimum, the outdoor microphone system shall consist of the following:

6.1.2.1 Microphone and preamplifier recommended by the manufacturer of the measurement instrument, and compatible with and supporting the ANSI Type 1 or Type 2 requirement of the sound level meter portion of the system. The microphone shall also meet the measurement plan requirements for frequency response, directional response, and internal background noise (self noise).

6.1.2.2 Microphone windscreen compatible with the microphone system and meeting the requirements of the measurement plan and the conditions under which measurements are made.

6.1.3 The microphone system shall include the following features as appropriate for the time duration and conditions expected during the measurement;

6.1.3.1 Microphone and preamplifier system that (*a*) does not experience a significant sensitivity- or frequency-response change caused by humidity effects, or (*b*) can be used with an appropriate desiccant system prescribed by the manufacturer,

6.1.3.2 *Microphone Rain Shield*.

6.1.3.3 *Tripod*, of the type normally used for supporting photographic equipment, a mast integral with the instrument shelter, or other support sufficiently strong to support the weight of the microphone and protective equipment mounted on it, and which by virtue of its weight or attachment to the ground is resistant to being upset by the wind or other disturbances,

6.1.3.4 *Bird Deterrent Accessory*, known as a *bird spike*, used to prevent fouling of windscreens by roosting birds. It is recommended that a bird-deterrent accessory, available from some microphone manufacturers, be installed on the windscreen.

6.1.4 *Acoustical Calibrator (required)*, with adapters necessary to fit the microphone.

6.1.5 *Headphones (recommended)*—Headphones for monitoring the a-c output of the sound level meter portion of the analyzer should have the ability to exclude external sound. The headphones, with an appropriate battery-powered driver, shall have sufficient frequency response to permit detection of anomalies in the data caused by wind, humidity, and electrical interference. A frequency response of 50 to 20 000 Hz should