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

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INTRODUCTION

This is one of a series of standards on the measurement and evaluation of community noise. Others in the series include Guide E1014 which covers manual measurement, using a simple meter, and analysis of the resulting data, and Guide E1780, which covers measurement of sound received from a nearby fixed source.

1. Scope

1.1 This test method covers the measurement of outdoor sound levels at specific locations using a digital statistical sound analysis system 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 shall 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 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 standard. No other units of measurement are included in this standard.

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]

C634 Terminology Relating to Building and Environmental Acoustics

E1014 Guide for Measurement of Outdoor A-Weighted Sound Levels

E1780 Guide for Measuring Outdoor Sound Received from a Nearby Fixed Source

[1] This test method 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.

2.2 *ANSI Standards:*[3]

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

S1.13 Measurement of Sound Pressure Levels in Air

S1.17 Microphone Windscreens - Part 1: Measurements and Specification of Insertion Loss in Still or Slightly Moving Air

S1.40 Specification for Verification Procedures for Sound Calibrators[3]

S1.43 Specifications of Integrating-Averaging Sound Level Meters

2.3 *IEC Standards*

61672–1 Electroacoustics - Sound Level Meters - Part 1: Specifications

3. Terminology

3.1 For definitions of terms, including the following used in this test method, see Terminology C634: dummy microphone, interference, impulsive sound, measurement plan, measurement set, percentile level, self noise and time-average sound level.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *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.

3.2.1.1 *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 S1.11, and ANSI S1.43 is assumed.

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

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 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.

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 shall 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 5.1-5.8.

5.2 *Effects of Wind:*

5.2.1 Wind may influence sound level measurements, even with a windscreen in place. The windscreen recommended by the manufacturer may not be adequate in quiet environments with mild wind conditions, especially in environments where low frequency, ambient sound must be evaluated. With wind speeds of 20 km/h and a typical windscreen the resulting A-weighted sound level due to the wind alone is 40-45 dB. Wind speeds of 40 km/h result in measured A-weighted sound levels due to wind alone of 60-65 dB. Manufacturers' instructions shall be followed with respect to meter limitations under windy conditions. When wind speeds approach or exceed 20 km/h, headphones shall be used to monitor the sound level meter output or the sound level meter indicator shall be

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

carefully observed to determine if fluctuations correspond to wind speed or actual sound sources. Data obtained during intervals when wind generated sound is influencing the measurements shall not be used. No measurements shall be made when steady wind speeds exceed 20 km/h. Propagation of sound from a source will be influenced by the direction of wind relative to the source and measurement positions. Measurements may need to be taken at different times of the year in different wind conditions to fully identify the acoustical character of the environment.

5.2.2 In special circumstances requiring measurements with wind speeds higher than 20 km/h, such as a background sound level survey involving a wind turbine project, a large (not less than 175 mm) windscreen shall be used. A larger windscreen will produce less low frequency windscreen noise near the microphone. However, it is cautioned, that large, foam type windscreens can cause additional attenuation of high frequency sound. A calibration adjustment may be required. See ANSI S1.17.

5.2.3 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.

5.2.4 Propagation of sound from a source will be influenced by the direction of the wind relative to the source and measurement positions. In some situations it may be desirable to make such measurements at different times of the year in different wind conditions to fully identify the acoustical character of the environment.

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 shall be retained but carefully marked so that these data may be used with caution in subsequent analysis.

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

5.4 For sources that emit impulsive sound, the accepted measurement methods for impulsive sound according to ANSI S1.13, such as SEL to quantify individual impulse and time-average sound level to measure periods of time that include impulses, should be used to obtain accurate results. The presence of impulsive sounds emitted by the source under test should be noted in the report. Any measurements in which data (other than a narrative description of the impulses) are obtained should require a prescription for the sampling rate, system response, and other pertinent guidelines including reference to appropriate measurement standards.

5.5 Care shall 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 shall 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 or strong television or radio signals may affect the sound level meter indication. The operator should use caution when these are nearby. Such electrical interference problems, when they occur, might result in wild and unexpected swings of the sound level meter indicator or upward indications even when the instrument is turned off. The most effective way to detect these conditions and other anomalies is through monitoring headphones.

5.6.1 Noise from power lines can increase significantly with high humidity, especially during light rain.

5.7 A non-electrical 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 often influence or even dominate the background 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 shall be measured. If the sound can be defined as an interference, one which masks an area-wide baseline, the measurement location shall 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 *Effects of Meteorological Conditions:*

5.8.1 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 or more need to be measured, it may be desirable to make measurements at different times of the year in different weather conditions to fully identify the acoustical character of the environment.

5.9 *Effects of Wildlife and Insects:*

5.9.1 At various times of the year, naturally occurring sounds from birds, frogs, or insects, including crickets and locusts, may interfere or even dominate the ambient A-Weighted and some fractional octave band sound levels, especially during evening and night hours. Such sounds should be noted in the report. Where possible, an effort may be made to quantify or account for such influence by making measurements at different times or different locations to document conditions with and without such naturally occurring interfering sounds. Octave-band (or ⅓ octave-band) data should be gathered when this is a problem. These data can be used during post-processing to mathematically remove the effect of the insect noise from the results.

6. Apparatus

6.1 *Acoustical Measurements:*

6.1.1 *Digital Statistical Sound Analysis System,* Use a Type 1 or Type 2 integrating, or averaging sound level meter as defined by ANSI S1.43 and IEC 61672–1, with statistical analysis capability and with a dynamic range of at least 60 dB.. The system shall 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 sound level descriptors, or permanent storage of data for later processing,

6.1.1.5 Weighting filters, that is, A, C,

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 sound level, that is, the percentile level, (L_X) or the time–average sound level (L_{AT}) also called equivalent sound level (L_{EQ}) 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 The windscreen recommended by the manufacturer may not be adequate in quiet environments with mild wind conditions. See 5.2.1 and 5.2.2.

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, meeting ANSI S1.40.

6.1.5 *Headphones*—Headphones for monitoring the a-c output of the sound level meter portion of the analyzer shall 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 be adequate. The headphones shall be correctly matched to the source impedance of the output terminals.

Warning—Exercise care when using headphones with sound level meters since some meters and headphones are not compatible without the use of an impedance matching amplifier. Failure to use such an amplifier, when needed, may damage the meter, or cause the meter to produce inaccurate results. If it is necessary to modify the circuits of an instrument in order to use headphones, it shall be done by, or under guidance from, the instrument manufacturer. A thorough functional check and calibration shall be performed by qualified technicians before using the instrument.

6.1.6 When there is a likelihood of adverse conditions, an environmental enclosure capable of protecting the critical components of the measurement instruments (other than the microphone) from physical damage, keeping them dry and at a temperature within the manufacturer-recommended operating range. (See 6.1.3.2 regarding protection for the microphone.)

6.2 *Physical Measurements:*

6.2.1 To ensure an accuracy of 1 dB in values obtained from calculations that include the results of distance measurements, the accuracy of the distance measurements to be used in calculations must be within 5 %. A Global Positioning System (GPS) or any technique that provides this degree of accuracy is satisfactory. If the data are to be used for modeling, and if the study area is undulating in nature, and the variation in elevation exceeds 2 m it is recommended that a topographical map be consulted for estimating elevation of sound sources, potential receptors, and potential acoustical barriers.

6.2.2 *Direction*—A pocket compass should be used for site layout work and a wind vane capable of measuring wind direction in octants should be used for determination of wind direction used for site layout work and determination of wind direction.

6.2.3 *Site Map*—If it is not included in the measurement plan, it is recommended that a site map be acquired or prepared prior to starting measurements.

6.3 *Meteorological Measurements:*

6.3.1 It is important to observe and record wind speed, relative humidity, and temperature for potential effects on the instruments, and these factors plus wind direction for potential effects on sound propagation.

6.3.2 For certain types of calibrators barometric pressure must be observed at the time of calibration. In some cases radio reports of meteorological conditions can be useful; however, it