



Designation: E 1503 – 97

Standard Test Method for Conducting Outdoor Sound Measurements Using a Digital Statistical Analysis System¹

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:

C 634 Terminology Relating to Environmental Acoustics²
E 1014 Guide for Measurement of Outdoor A-Weighted Sound Levels²

E 1779 Guide for Preparing a Measurement Plan for Conducting Outdoor Sound Measurement²

E 1780 Guide for Measuring Outdoor Sound Received from a Nearby Fixed Source²

2.2 ANSI Standards:

¹ This test method is under the jurisdiction of ASTM Committee E-33 on Environmental Acoustics and is the direct responsibility of Subcommittee E33.09 on Community Noise.

Current edition approved Sept. 10, 1997. Published June 1998. Originally published as E 1503-92. Last previous edition E 1503-92.

² Annual Book of ASTM Standards, Vol 04.06.

S1.4 Specification for Sound Level Meters³

S1.11 Octave-Band and Fractional Octave-Band Analog and Digital Filters, Specifications for³

S1.13 Methods for the Measurement of Sound Pressure Levels³

S1.40 Specification for Acoustical (Microphone) Calibrators³

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 *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.

3.2.6.1 *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.

3.2.7 *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.)

3.2.8 *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

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

³ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

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 wind-screen.

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 be adequate. The headphones shall be correctly matched to the source impedance of the output terminals.

NOTE 1—Caution: 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 should be done by, or under guidance from, the instrument manufacturer. A thorough functional check and calibration should 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 measurements must be within 5%. Any instrument or technique that provides this degree of accuracy is satisfactory.

6.2.2 *Pocket Compass (desirable)*, 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 is preferable to use available general accuracy meteorological instruments to enable the measurement of:

6.3.2.1 Wind speed (5-km/h (2.5-mph) increments),

6.3.2.2 Wind direction to the nearest of the eight common compass directions,

6.3.2.3 Relative humidity (in 10% increments),

6.3.2.4 Dry bulb temperature (in 2°C (5°F) increments), and

6.3.2.5 Barometric pressure as specified by the (acoustic) calibrator manufacturer if required for the proper use of the calibrator. The absolute pressure is needed, not the pressure corrected to sea level as reported by the weather bureau.

6.4 *Photographs*—A camera, preferably with 35-mm film format, and a wide-angle lens should be carried by the measurement team for the purpose of documenting the equipment setup and surroundings at least once at each measurement location.

7. Calibration

7.1 Verify the calibration of the sound level meter portion of the system using a portable acoustical calibrator immediately before and after each continuous run of the analyzer in a manner prescribed by the manufacturer. If measurement data stored by the analysis system are to be transferred to magnetic media, store and transfer at least one of the periodic calibration data sets to a calibration file on media separate from data files.

In all cases, enter the calibration data in the official handwritten field log at the time of calibration. (See 8.5.)

7.2 During a series of related measurements, after initial calibration adjustment, make no further adjustments to the instrument to make the calibration indication agree with the expected value, unless required by the measurement plan. Instead, use the calibration record to standardize the data during subsequent data reduction and analysis. If the measurement plan requires manipulation of the calibration control during the measurement program, maintain a record of calibration adjustments over the course of the measurement campaign. Record the time(s) at which calibrations were performed and the instrument calibration indication before and after each adjustment. If the change in the indication exceeds ½ dB, mark the data in a way that will call attention to the change. If the change is 1 dB or greater, investigate the cause of the change and replace suspect components of the system to the extent possible, in an attempt to isolate the problem in a manner consistent with the measurement schedule. Discuss any change of 1 dB or greater in the measurement report. It is strongly recommended that an instrument that shows an unexplained calibration drift greater than 1.5 dB over 24 h or less be taken out of service until the cause of the drift can be identified and remedied. Also, verify calibration if the sound level meter or microphone is abused (dropped, wet, etc).

7.3 Within one year, or a period specified by the measurement plan, prior to starting the measurements, verify all equipment specifications claimed by the manufacturer using standards traceable to a recognized standards organization, and following recommendations of the instrument manufacturer. These checks shall include the instrument, microphone and preamplifier, and filters (if used).

7.3.1 Thoroughly calibrate the acoustical calibrator following recommendations of the instrument manufacturer, as specified in the preceding paragraph.

7.4 Measure the self-noise of the measurement system, including the microphone and microphone preamplifier system, with all connecting cables in the system, before starting measurements and at least daily, thereafter, until the measurements are complete, to verify that the self-noise is less than the lowest level to be measured.

7.4.1 Measure the self-noise by covering the microphone with a suitable acoustic isolator and recording the indicated sound level.⁴

7.4.1.1 If a suitable acoustic isolator is not available, perform the measurement by temporarily replacing the microphone cartridge with a dummy microphone recommended and approved by the microphone manufacturer, recording the indicated sound level(s). To the indicated sound level(s), add the typical microphone self-noise values provided by the manufacturer of the microphone.

⁴ To be effective the isolation device used should provide isolation at all frequencies of interest. The level reduction in each fractional band of interest should be sufficient to assure that the instrument noise is at least 10 dB below the lowest level of interest.

7.4.2 When fractional-band measurements are being performed, check the self-noise in each band at least weekly, or at intervals called for in the measurement plan.⁵

7.4.3 If it is not possible to demonstrate ability to measure to the necessary lowest level, either because of an actual instrument self-noise, or because of an isolation device having sufficient sound level reduction is not available, clearly mark any subsequent data recorded to reflect the fact that actual sound levels may, at times, be lower than those recorded. The cautionary statement shall, if practical, include an estimate of the self-noise, and a statement concerning the effect it would have, in terms of the difference between the indicated lower levels and the actual lower levels.

8. Procedure

8.1 *Selecting Measurement Locations and Times*—When acquiring sound-level data, select locations and times for measurements consistent with the reason for making the measurements and the manner in which the results will be used.

8.2 *Location Descriptions*—A location description prepared as part of a measurement plan can be used for this purpose, otherwise prepare a detailed written description of the location. Describe the location in terms of its relation to permanent landmarks. List and give distance and bearing to structures, roads, and other identifiable noise sources that are within 1000 m (3000 ft) of, and visible from, the site. Photographs are recommended, as are USGS 7½ minute topographic maps, site plans, etc.

8.3 *Preparation of Equipment*—Prepare the measurement and analysis system according to manufacturer's instructions. Preparation should include the following steps:

8.3.1 Check the battery condition before and after a continuous measurement and record the condition on the data sheet.

NOTE 2—**Caution:** Make certain that the useful charge is sufficient to complete the planned measurement. Consult the manufacturer of the equipment for information on battery life and the use of auxiliary battery packs.

8.3.2 Verify calibration of the sound measuring equipment in accordance with manufacturer's instructions.

8.3.3 Replace the wind screen(s) and any other items removed for calibration.

8.3.4 At least once each day, more often in wet weather and when measurements are continued over more than an 8-h period, verify that any system which is intended to keep the microphone and preamplifier dry is functioning properly.

8.3.5 Select the weighting and filter bandwidths as outlined in the measurement plan. If no guidance is available, it is recommended that at least one analysis channel be used for A-weighted sound level.

8.3.6 Set the averaging time and sample rate as called for in the measurement plan. To mimic an older analog sound level meter, default settings should use slow response time. To fully utilize the capability of digital systems the fast response time should be used.

8.3.7 Set the measurement duration, dynamic range, and maximum range at values appropriate for the measurement situation. Consider the possible occurrence of intrusive sounds such as vehicles, aircraft, trains, etc, as well as the relative levels of the equipment self-noise and the lowest sound level anticipated during the measurement session. The dynamic range of the system may be smaller than the range of sound levels encountered. If this is the case it will be necessary to choose to forgo measurements at one extreme of the range. Include the choice and the rationale in the measurement plan, and document in the field log. Include with this information the manner in which the instrument documents an out-of-range measurement.

8.3.8 *Protection of Equipment:*

8.3.8.1 Provide protection for the analyzer against rain and solar heating as necessary, especially if measurements will involve a substantial time period. Consult the manufacturer's specifications for acceptable ranges of temperature and humidity, and take steps to maintain the equipment environment within these ranges, recognizing that solar heating could increase equipment temperature above ambient air temperature.

8.3.8.2 Obtain any microphone cable needed to allow proper placement or sheltering of equipment from the manufacturer of the equipment, or meet the manufacturer's specifications. Tests shall be performed to determine that the cable meets manufacturer's specifications, and that the microphone system and cable perform satisfactorily over the range of sound level and frequency to be measured.

8.3.8.3 If it is necessary to use a vehicle as a shelter for both the operator and equipment, take extreme care to avoid acoustical or electromagnetic interference as well as wind turbulence effects. In this case locate the microphone as far away from the vehicle as a 30-m (100-ft) microphone cable will allow. At a minimum, the distance shall be at least 2½ times the largest dimension of the shelter vehicle.

8.3.9 Unless specified differently by the measurement plan, support the microphone on a sturdy tripod or mast at a height between 1.2 m (4 ft) and 1.5 m (5 ft) above the ground. In general, avoid placing the microphone tripod on a surface that is not typical of the locale, or in tall grass (in excess of 0.25 m (10 in.)). The microphone location and height as well as the surface condition in the area of the microphone shall be described on the data sheet and in the report.

8.3.10 Following the guidance of the measurement plan or the microphone manufacturer's recommendation, orient the microphone properly with respect to the source of the sound to be measured.

8.4 *Conducting the Measurement*—Having completed the preparations called for in 8.1-8.3, if the analyzer controls permit, start the measurement remotely, or set the analyzer to start the analysis after a 1 or 2-min delay. This will allow time for the operator to move away from the microphone and complete any noisy operations before the measurement starts. If the delay feature is not available, avoid making extraneous sound in the vicinity of the microphone after starting the measurement.

⁵ It is recognized that obtaining an effective isolation device may be difficult.

8.5 *Maintaining a Log*—During the measurement make a written record, preferably using a pre-printed data entry form, of any necessary data relevant to the specific measurement which is not printed by the measurement system or previously recorded. Include the following information.

8.5.1 *Location Information*—A brief description (one or two hand-written lines will suffice) of the location which will positively associate the location with the description prepared in accordance with the instructions in 8.2. If a formal sampling plan is being followed, use the name or code assigned to the location by the plan.

8.5.2 The date, start and end time of the measurement. If the measurement is not within the time period called for by a predetermined plan, state the reason for the deviation.

8.5.3 Information sufficient to identify the manufacturer, model, serial number (where applicable), and the last laboratory calibration (where applicable), for the following acoustical instrumentation system components, when used:

- 8.5.3.1 Analyzer or sound level meter,
- 8.5.3.2 Microphone,
- 8.5.3.3 Outdoor microphone system,
- 8.5.3.4 Microphone cable, and
- 8.5.3.5 Calibrator.

8.5.4 *Environmental Conditions*—Record environmental conditions representative of the measurement set. The information recorded should include the following:

- 8.5.4.1 Temperature,
- 8.5.4.2 Relative humidity,
- 8.5.4.3 Barometric pressure (and altitude, if required for microphone calibration),
- 8.5.4.4 Wind speed (range if appropriate),
- 8.5.4.5 Wind direction (direction blowing from) in octants (N, ENE, ... WNW) or multiples of 45° (0, 45, ... 315),
- 8.5.4.6 Sky condition, for example, clear, scattered clouds, partly cloudy, mostly cloudy, overcast, and
- 8.5.4.7 Ground condition, for example, dry, dew, wet, snow.
- 8.5.4.8 Record the conditions at the beginning and end of the sound measurement set, and at least hourly, if the set is more than one hour in duration. Note the time and type of any unusual weather conditions or change. If significant for the purpose of the measurement, measure wind direction and speed and record more frequently, for example, at intervals of no more than 15 min.

NOTE 3—If the wind speed is close to the threshold at which measurements should be suspended, wind speed should be monitored continuously.

8.5.5 *Traffic Count*—Some measurement plans require making a record of traffic count, especially if traffic is the dominant source of interest or a significant interference with another source of interest. Keep a record according to the instructions of the measurement plan.

8.5.6 *Major Sound Sources*—Identify major contributing sound sources and record the distance from each source to the measuring location (see 6.2.1).

8.5.7 *Comments*—Provide brief narrative comments, as necessary, including:

8.5.7.1 Any unexpected or unusual sound sources which need to be considered in evaluation of the data. Examples in various situations could be aircraft overflights, railroad operations, barking dogs, or other animal sounds.

8.5.7.2 Unusual weather conditions, especially thunder.

8.5.7.3 Any pertinent observations such as that acoustical propagation conditions are different from those expected, correlation between wind direction and direction of unexpectedly loud or quiet distant sounds, and subjective estimates of the relative loudness of distance sources compared to nearby sources. This information can facilitate the evaluation of the effect of meteorological conditions on sound propagation.

9. Report

9.1 Report the following information:

9.1.1 All pertinent data prescribed by the measurement plan and collected during the measurement, including:

9.1.1.1 A tabulation showing the results of each measurement set (to the number of decimal places consistent with requirements of the study and the capability of the measurement system), with identification of locations, date, time, and duration of each measurement set.

9.1.1.2 A description of measured sounds (steady, tonal, impulse), repetition rate of impulse sounds, and the identified or suspected sound sources.

9.1.1.3 A description of circumstances concerning lost data, that is, interrupted samples, loss of power, etc, with an estimate of the effect on data integrity.

9.1.2 *Information on analyzer settings:*

9.1.2.1 Range,

9.1.2.2 Analysis bandwidths and weightings,

9.1.2.3 Sampling rate,

9.1.2.4 Detector response time or averaging time, and

9.1.2.5 Analysis system self-noise at the range used.

9.1.3 *Calibration*—In addition to a description of the calibration method, describe any problems with calibration, that is, unusual requirements to readjust system calibration.

9.1.4 *Meteorological Conditions*—Report meteorological conditions for each measurement set. It is recommended that this data be included in the tables showing the results of the measurement sets. If field notes show conditions were stable throughout several measurement sets, a single statement of the conditions will suffice.

9.1.5 *Site Descriptions*—This may be done by referencing and including the measurement plan. If there is no measurement plan, a written description shall be prepared, including a map showing the microphone location, as well as distance, direction, and estimated height of structures and vegetation within 300 ft of the microphone.

9.1.6 *Instrumentation Information*—Manufacturer, model, and, where appropriate, serial number and date of last laboratory calibration for the following:

9.1.6.1 Analyzer,

9.1.6.2 Microphone,

9.1.6.3 Outdoor microphone system, and

9.1.6.4 Calibrator.

9.1.7 Names, business addresses, and phone numbers of the persons making the measurements.

9.1.8 A statement, to the extent true, that this test method was followed. Any exceptions shall be noted and reasons given.

9.1.9 It is recommended that all field notes or log sheets, whether or not included with the report, be retained for future reference.

9.1.10 A brief description of conditions existing at the time of the measurement, relative to past or future long-term conditions, that is, is this a measurement of the baseline ambient condition, a perturbed condition, or a random sample.

10. Precision and Bias

10.1 The precision of the data obtained using this test method is a function of the instrument used, analysis parameters selected, and the range of sound levels measured. In general, if the number of samples in a set or subset of data is at least 10 times the range of the measured data in the set or subset, the precision for the result of the set or subset will be better than plus or minus 2 dB.

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NOTE 4—As an illustration, assume an analyzer with a sampling rate of 20 samples per second per band. A set of averages stored every 15 s would contain 300 samples per average in each band. If the range of the samples is not more than 30 dB, each stored average would have a precision of at least plus or minus 2 dB because the number of samples is ten times the range of the samples.

NOTE 5—This precision applies only to the specific measurement period and not to any degree to which that period might be representative of a longer period of time.

10.2 Bias is limited to the accuracy of the acoustical instruments (see ANSI S1.4).

11. Keywords

11.1 acoustical environment; analysis; calibration; community noise; data storage; digital; equipment; interferences; loudness; measurement; measurement plan; meteorological effects; microphone system; outdoor; precautions; procedures; sound level; statistics; supporting data