Designation: E1014 – 12

Standard Guide for Measurement of Outdoor A-Weighted Sound Levels[1]

This standard is issued under the fixed designation E1014; 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 Test Method E1503 for conducting outdoor sound measurements using a digital statistical analysis system, and Guide E1780 which covers measurement of sound received from a nearby fixed source

1. Scope

1.1 This guide covers the measurement of A-weighted sound levels outdoors at specified locations or along particular site boundaries, using a general purpose sound-level meter.

1.2 Three distinct types of measurement surveys are described:

1.2.1 Survey around a site boundary,

1.2.2 Survey at a specified location,

1.2.3 Survey to find the maximum sound level at a specified distance from a source.

1.3 The data obtained using this guide are presented in the form of either time-average sound levels (abbreviation TAV and symbol L_{AT}, also known as equivalent sound level or equivalent continuous sound level abbreviated LEQ and with symbol L_{AeqT}) or A-weighted percentile levels (symbol L_X).

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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

E1503 Test Method for Conducting Outdoor Sound Measurements Using a Digital Statistical Sound Analysis System

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

2.2 *ANSI Standard:*[3]

S1.4 Specification for Sound Level Meters

S1.4A Specification for Sound Level Meters

S1.14 Recommendations For Specifying And Testing The Susceptibility Of Acoustical Instruments To Radiated Radiofrequency Electromagnetic Fields, 25 Mhz To 1 Ghz

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

S1.40 Specifications and Verification Procedures for Sound Calibrators

S1.43 Specifications for Integrating-Averaging Sound Level Meters

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

Current edition approved May 1, 2012. Published June 2012. Originally approved in 1984. Last previous edition approved in 2008 as E1014–08. DOI: 10.1520/E1014-12.

[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.

2.3 *IEC standard:*[4]
61672–1 Electroacoustics - Sound Level Meters - Part 1: Specifications

3. Terminology

3.1 *Definitions*—For definitions of acoustical barrier, impulsive sound, measurement set and percentile levels, see Terminology C634[5].

4. Significance and Use

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

4.1.1 Documentation of sound levels before the introduction of a new sound source (for example, assessment of the impact due to a proposed use).

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

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

4.2 This guide provides a means for selecting measurement locations, operating a sound level meter, documenting the conditions under which the measurements were performed, and recording the results.

4.3 This guide provides the user with information to (*1*) make and document the sound level measurements necessary to quantify relatively steady or slowly varying outdoor sound levels over a specific time period and at specific places and (*2*) make and document the physical observations necessary to qualify the measurements.

4.4 The user is cautioned that there are many nonacoustical factors that can strongly influence the measurement of outdoor sound levels and that this guide is not intended to supplant the experience and judgment of experts in the field of acoustics. The guide is not applicable when more sophisticated measurement methods or equipment are specified. This guide, depending as it does on simplified manual data acquisition, is necessarily more appropriate for the simpler types of environmental noise situations. As the number of sources and the range of sound levels increase, the more likely experienced specialists with sophisticated instruments are needed.

4.5 This guide can be used by individuals, regulatory agencies, or others as a measurement method to collect acoustical data for many common situations. Criteria for evaluating or analyzing the data obtained are beyond the scope of this guide.

4.6 Note that this guide is only a measurement procedure and, as such, does not address the methods of comparison of the acquired data with the specific criteria. No procedures are provided for estimating or separating the influences of two or more simultaneously measured sounds. This guide can be useful in establishing compliance when the measured data are below a specified limit.

4.7 Section 8.2.1 outlines a procedure that can be used for a survey of the site boundary; paragraph 8.2.2 for a survey of specified monitoring points; and paragraph 8.2.3 for determining the location and magnitude of maximum sound level.

5. Apparatus

5.1 *Acoustical Measurements:*

5.1.1 *Sound Level Meter* (required) Type 2, or better, integrating averaging, as defined by ANSI S1.43, and ANSI S1.4, ANSI S1.4A with statistical analysis capability, and, with at least a 60-dB dynamic range.

5.1.1.1 The instrument should have an a-c output port to permit use of headphones.

5.1.1.2 The instrument shall be equipped with an A-Weighting network. It is recommended that the instrument also be equipped with a C-weighting or a Z-weighting, or both.

NOTE 1—Z-weighing is an unweighted (flat) network, that is sometimes called "Linear" by manufacturers.

5.1.1.3 If "fast" or "slow" response is used, it should be so stated in the report.

5.1.2 *Microphone Windscreen* (required), The windscreen recommended by the manufacturer may not be adequate in quiet environments with mild wind conditions. See 7.1.1.

5.1.3 *Acoustical Calibrator* (required), with adaptors necessary to fit the microphone.

5.1.4 *Set of Headphones* (desirable), compatible with and electrically connected to the a-c output of the sound level meter. Monitoring the output of the sound level meter with headphones may enable the operator to detect equipment malfunctions or anomalies in the data caused by wind, humidity, and electrical interference.

5.1.5 *Tripod* (desirable), to ensure a steady and repeatable microphone position.

5.2 *Physical Measurements:*

5.2.1 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.

5.2.2 *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.

5.2.3 *Site Map* (optional).

5.3 *Meteorological Measurements*—Any of the many available general-accuracy meteorological instruments may be used in order to enable the measurement of:

5.3.1 Wind speed (5-km/h or increments),

5.3.2 Wind direction (in octants),

5.3.3 Relative humidity (in 10 % increments),

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

[5] Terminology C634–81a was used in the development of this guide.

5.3.4 Dry bulb temperature (in 2°C increments).

6. Calibration

6.1 The calibration of the sound level meter shall be checked using an acoustical calibrator immediately before and after each measurement set, in a manner prescribed by the manufacturer. Adjustments, if required, shall be made at this time. If the change in the calibration reading, as shown on the sound level meter, is 1 dB or greater, the data gathered since the preceding calibration are considered invalid and should be discarded. It is strongly recommended that an instrument that shows an unexplained calibration drift greater than 1.5 dB over a 24 h or less be taken out of service until the cause of the drift can be identified and remedied.

6.2 The sound level meter and the acoustical calibrator shall have been thoroughly calibrated with equipment traceable to a recognized standards organization, and following recommendations of the instrument manufacturer with 1 year, or a period specified the measurement plan, prior to starting the measurements. Included in this calibration shall be checks of frequency response, amplifier sensitivity, internal noise, and verification of correct operation of meter circuits and microphone.

7. Interference

7.1 Sound level meter measurements are subject to interference from a number of sources, such as wind, rain and snow, impulsive sound, tonal sound and electromagnetic interference.. Interfering noise must be identified and accounted for. A sound can be interference if it is concentrated in a small area and not representative of the sound that is to be documented. A measurement plan should address how such sounds are to be treated. It may be advisable for many types of sound sources to avoid interferences by testing at night. If it is determined that a given sound is an interference, the measurement location might be moved to a position where the contribution of the interfering sound is acceptably minimized or, if possible, the conduct of the survey may be modified so as to avoid the influence of the interference. Some of the more common sources of interference are discussed in the following:

7.1.1 *Wind*—A microphone windscreen should be used for all outdoor measurements. 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 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. 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.

7.1.2 *Rain and Snow*—Measurable precipitation almost always influences outdoor sound levels. For example, tires rolling on a paved surface result in higher sound levels when the pavement is wet. Also, fallen snow may affect the propagation of sound so that sound levels may be different with and without fallen snow. For these reasons, making measurements during precipitation or when pavement is wet or snow covered is discouraged. If it is necessary to obtain data when ground surfaces are wet or snow covered, the conditions shall be carefully described in the report. High humidity can influence certain microphones; manufacturers' instructions should be closely followed under these conditions.

7.1.3 *Impulsive Sound*—This guide is not intended to evaluate impulsive sound because Type 2 sound level meters operating in "fast" or "slow" modes do not accurately or precisely measure impulse sound. If occasional impulses occur during the survey, estimation of their magnitude may be attempted using the fastest available meter response, either "fast," "peak," or "impulse." The maximum meter reading, the meter response setting, and the repetition rate within the measurement set shall be reported. Whenever most of the sound level meter readings in any measurement set are influenced by impulsive sound, this guide shall not be used.

7.1.4 *Tonal Sound*—Occasionally it is necessary to measure sources of pure tonal sound perceived as a "buzz," "hum," or "whistle." Since both the operator's body and reflections can significantly influence the sound level meter indication when tones are present, the report must include observations of tonal sound when present.

7.1.5 *Power Lines*—Power lines can create both electromagnetic radiation interference and acoustical interference in the form of audible noise.

7.1.5.1 Electromagnetic radiation from high voltage transmission lines or strong television or radio signals may affect the sound level meter indication. See ANSI S1.14. 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.

7.1.5.2 Noise from power lines can increase dramatically with high humidity, especially during light rain. In a quiet rural environment such sounds can easily exceed the ambient level.

7.1.5.3 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.

7.1.6 *Meteorological Effects*—Temperature inversions and other meteorological conditions may strongly influence the propagation of sound over long distances. Therefore, when sound from sources at horizontal distances of about 300–500 m or more need to be quanitified, measurements should taken at different times of the year in different weather conditions to fully identify the acoustical character of the environment.

7.1.7 *Nature Sounds*—During certain times of the year, naturally occurring sounds such as from birds or insects (crickets, locusts) may interfere or dominate A-weighted sound levels particularly during evening and nighttime periods. Such noises 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.

8. Procedure

8.1 *Preparation of Equipment*—Prepare the sound level meter for use as follows:

8.1.1 Check the battery condition indicator (recheck every 15 to 30 min during the measurement set).

8.1.2 Verify calibration of the sound level meter in accordance with the manufacturer's instructions.

8.1.3 Place the windscreen over the microphone.

8.1.4 Set the weighting to "A."

8.1.5 Set the response to "slow" or "fast" as required in 7.1.3 (unless otherwise specified).

8.1.6 Select a range so that the sound level meter reading is on scale.

8.1.7 Support the instrument and orient the microphone in accordance with the manufacturer's instructions. In the absence of a specified height, position the microphone between 1.2 m and 1.5 m above the ground.

8.2 *Selecting Measurement Locations and Times:*

8.2.1 *Survey Around a Site Boundary*—Follow procedures in 8.2.1.1 – 8.2.1.5 when it is necessary to measure A-weighted sound levels at the boundary of a site.

8.2.1.1 Select the time periods of the survey. In general, the time of day that each measurement set is obtained should be such that the sound levels are representative of a specific condition. The period of operation of a time-varying or time-restricted source may also dictate the time to measure. In the absence of specified time periods the following shall apply: (*1*) day (7 am to 10 pm), and (*2*) night (10 pm to 7 am). If appropriate, it may be useful to additionally define an evening period from 7pm to 10pm and define daytime from 7am to 7pm. When source or background sound levels are supspected to change overtime, community sound levels should be measured a number of times on different days to determine variability. It may also be necessary to measure community noise levels separately for weekend periods. For sites that are influenced by traffic noise, it may be necessary to seperately measure levels during peak and non-peak traffic periods.

8.2.1.2 The sound level meter may be used in selecting the locations on the basis of sound level. For each time period, walk the site boundary, measure and note the trend of sound levels. Select a minimum of two locations to meet one or more of the following:

(1) Local maximum, the location where the highest A-weighted sound level is observed.

(2) Local minimum, the location where the lowest A-weighted sound level is observed.

8.2.1.3 Alternatively, locations may be selected for other reasons:

(1) Sensitive Locations, considering sound sources and receivers either inside or outside the site, including upper floors of nearby structures.

(2) Locations Nearest to a Community, considering sound sources within the site.

(3) Intermediate Locations, locations selected so that the indicated sound level at adjacent locations might not differ by more than 5 dB.

(4) Other Locations: (*1*) so that locations are separated by no more than one-half the site perimeter; (*2*) so that such conditions as variable terrain, acoustical barriers adjacent to site activities, and presence of adjoining structures are considered.

NOTE 2—The location of the microphone, relative to barriers and large reflecting surfaces influences the indicated sound level. It is extremely important to record the location of the microphone relative to other objects.

8.2.1.4 Measure the sound levels at each location in accordance with 8.3.1.

8.2.1.5 Measure the meteorological conditions in accordance with 8.3.2.

8.2.2 *Survey at a Specified Location*—Follow procedures in 8.2.2.1 – 8.2.2.3 for those surveys where a particular sound source is being evaluated. These steps can be used to determine compliance with a criterion given in terms of A-weighted sound level at a specified location relative to the source. When a local ordinance or other requirement states the exact location of the microphone (that is, "1 m from the center of the building facade and 1 m off the ground"), the steps of 8.2.2.1 – 8.2.2.3 are applicable.

8.2.2.1 Select the time period(s) for the survey. Note the period and the day of week the survey is conducted. An additional measurement set is recommended during the same time period with the source not operating. When a specific noise source is being evaluated, specify its mode of operation clearly for each measurement. For example, if the equipment cycles on and off, the sound levels and duration should be reported for each cycle.

8.2.2.2 Measure the sound levels at each location with and without the source operating in accordance with paragraph 8.3.1.

8.2.2.3 Measure the meteorological conditions in accordance with 8.3.2.

8.2.3 *Survey to Find the Maximum Sound Level at a Specified Distance from a Source*—Follow procedures in 8.2.3.1 – 8.2.3.3 when a particular noise source is being evaluated and the applicable criterion specifies the maximum

sound level at a given distance from the source. When an ordinance or regulation states that the microphone must be located at a fixed distance from the source (that is "3 m from the cooling tower in any direction, etc."), this measurement procedure should be used.

8.2.3.1 Select the time period of the survey from those given in accordance with 8.2.1.1. Note the period and the day of week the survey is conducted and the operating mode of the source, including "off."

8.2.3.2 Walk slowly and quietly along points at the specified distance from the source while measuring the sound level. Obtain a measurement set in accordance with 8.3.1 at the position where the A-weighted sound level from the test source appears highest. Repeat the measurements for each principal operating mode of the source.

8.2.3.3 Measure the meteorological conditions in accordance with 8.3.2.

8.3 *Measuring and Recording the Data:*

8.3.1 Obtain a measurement set using the sound level meter set to run for a selected time period either by presetting the time of the instrument permits, or by observing the time and stopping the data acquisition at the end time.

8.3.2 Measure the wind speed, wind direction, relative humidity, and dry bulb temperature, and note the general sky condition. This information shall be obtained for each day of the survey and is recommended for each measurement set or on an hourly basis, whichever is less.

NOTE 3—In place of direct measurement, data from National Oceanographic and Atmospheric Administration (NOAA) Weather is acceptable for all weather data except wind velocity values.

8.3.3 Record or store, or both, the duration of the measurement and the minimum, maximum and LEQ values indicated by the sound level meter. If available on the sound level meter used also record the L90, L50 and L10 values.

8.3.3.1 Record the measurement locations on a map, plan, or chart, and, when not obvious, indicate the reason for each selection, together with a brief description of the area, including ground cover.

8.3.3.2 Note the characteristics of the dominant noise sources and expected changes. Note any acoustical events such as intermittent operation of machinery, aircraft, sound made by animals, and impulsive sound events including estimated rate of occurrence.

8.3.3.3 Record the sound levels measured in accordance with 8.3.1 in either tabular or graphical form.

8.3.3.4 Record the ambient temperature, relative humidity, barometric pressure, wind speed, wind direction, and sky condition measured in accordance with 8.3.2. If NOAA weather radio is used, record the station location, the call letters, and the station frequency, or the source from which the data were taken.

8.3.3.5 Record the start time, stop time, and date of the measurements and the serial number, type, and manufacturer of the sound level meter, microphone, and calibrator.

8.3.3.6 Using the acoustical calibrator, record the sound level meter indication before and after the measurement set.

9. Report

9.1 The report shall include the following:

9.1.1 A tabulation of sound levels for each measurement set with identification of the location and time the data were obtained.

9.1.2 Information on the weighting network and meter response setting ("fast" or "slow," etc.) used for the measurements.

9.1.3 Calibration data including time of calibrations. If applicable, battery checks should also be noted.

9.1.4 Meteorological data including notations of wet pavement or fallen snow.

9.1.5 A schematic map of the area showing:

9.1.5.1 Measurement locations,

9.1.5.2 Nearby sensitive noise receivers,

9.1.5.3 Location of potential future noise receivers within the area,

9.1.5.4 Identifiable noise sources,

9.1.5.5 Explanatory legend relating measurement locations and observation periods, if necessary,

9.1.5.6 Relevant topography and foliage,

9.1.5.7 Acoustical barrier locations including their height and other dimensions.

9.1.6 Instrument data, including manufacturer, model, serial number, and dates of the last factory (or laboratory) calibration of the sound level meter and acoustical calibrator.

9.1.7 Times, dates, and durations of measurements, and the names and telephone numbers of persons making the measurements.

9.1.8 A description of the measured sounds (steady, tonal, impulse), the identified or suspected sound sources, relevant interferences and the rate of repetition of any periodic components.

9.1.9 A statement, to the extent true, that this guide was followed. Any exceptions should be noted.

9.2 It is recommended that all raw data sheets, whether or not they are included in the report, be permanently retained.

10. Precision and Bias

10.1 *Precision*—The precision of this guide is estimated to be ±3 dB for the arithmetic mean sound level of a given measurement set. This estimated precision is based upon the use of a Type 2 sound level meter or better. It is expected to hold true for most typical outdoor environmental data.

10.2 *Bias*—Bias is limited to the accuracy of the acoustical instruments.

11. Keywords

11.1 A-weighted sound levels; community noise; outdoor noise; noise sampling