Designation: E1780 – 12

Standard Guide for Measuring Outdoor Sound Received from a Nearby Fixed Source[1]

This standard is issued under the fixed designation E1780; 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 and guidelines for measurement and evaluation of community noise. Techniques and precautions in this guide are not fixed or mandatory and cannot replace the judgment of acoustical professionals. Rather, this guide is a summary of processes found to be productive and useful in ensuring that meaningful information will be gathered in an efficient manner about fixed sources of noise in a community as they each may exist. Others in this series include Guide E1014, which covers manual A-Weighted measurements of outdoor noise using a simple meter, and Test Method E1503. ANSI 12.18 provides a method of obtaining repeatable sound pressure level measurements of the sound emitted by a source. This document differs in that atmospheric and ground effects are not controlled. Thus, the results may not repeat if atmospheric conditions or ground conditions between the source and the measurement position change. This guide provides only a method of accurately documenting the sound levels occurring at the measurement position at the time of measurement.

1. Scope

1.1 This guide covers the measurement of outdoor sound due to a fixed sound source such as a siren, stationary pump, power plant, or music amphitheater. Procedures characterize the location, sound level, spectral content, and temporal characteristics of that sound source at the time of measurement. Users should be aware that wind and temperature gradients can cause significant variations in sound levels beyond 300 m. With appropriate caution, the use of measurements resulting from this guide include but are not limited to:

1.1.1 Assessing compliance with applicable regulations,

1.1.2 Monitoring the effectiveness of a noise reduction plan,

1.1.3 Verifying the effectiveness of measures for mitigation of noise impact,

1.1.4 Validating sound prediction models, and

1.1.5 Obtaining source data for use in sound prediction models.

1.2 *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

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

2.2 *ANSI Standards:*[3]

S1.4 Specification for Sound Level Meters

S1.11 Octave-band and Fractional Octave-band Analog and Digital Filters, Specifications for

S1.13 Methods for the Measurement of Sound Pressure Levels in Air

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

[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.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

S1.17 Microphone Windscreens - Part 1: Measurements and Specification of Insertion Loss in Still or Slightly Moving Air
S12.1 Guidelines for the Preparation of Standard Procedures to Determine the Noise Emission from Sources
S1.40 Specification for Verification Procedures for Sound Calibrators
S1.43 Specifications for Integrating-Averaging Sound Level Meters
S12.18 Procedures for Outdoor Measurement of Sound Pressure Level

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

3. Terminology

3.1 For definitions of terms used in this guide including, but not limited to, barrier, dummy microphone, equivalent sound level, Leq, impulse sound, interference, measurement plan, measurement set, noise floor, self-noise, and time average sound level, see Terminology C634.

3.2 *fixed source*—any permanently installed equipment capable of emitting sound on a regular basis such as a pump, power station, warning siren or sound amplification system permanently installed or stationary for a concert.

4. Significance and Use

4.1 Situations for which outdoor sound level data are required include, but are not limited to, comparison of sound levels with criteria or regulatory limits.

4.2 This guide provides information to (*1*) measure outdoor sound level in the vicinity of outdoor fixed noise sources, and (*2*) document other observations necessary for the measurements. This guide provides a standard procedure for a trained acoustical professional that will produce results and documentation which are consistent with the purposes cited in 1.1.1 – 1.1.5.

4.3 These sound measurements should be performed by or under the direction of a person experienced in the measurement and analysis of outdoor sound, and who is familiar with the use of the required equipment and techniques.

4.4 This guide can be used by individuals, regulatory agencies, or others as a measurement guide to collect data on the sound level received from a fixed source within the constraints cited in Section 8 and Appendix X1 and Appendix X2.

4.5 This guide can be used to establish compliance or noncompliance at the time, distance, and conditions during which the data were obtained. However, this guide is only a measurement procedure and does not address the problem of projecting the acquired data outside those conditions, other times of day, other distances, or comparison with specific criteria. In particular, for a given sound source level, distant noise levels will often be found to be greater at night than during the day.

5. Apparatus

5.1 *Acoustical Measurements:*

5.1.1 *Sound Level Meter*—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 and capability and with a dynamic range of at least 60 dB.

5.1.1.1 The instrument should have a buffered AC signal output port to permit the use of headphones. If measurements are to be made in fractional octave-bands, the system should include filter sets that fulfill the objectives of the measurement plan. Filters should meet the requirements of ANSI S1.11.

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 network 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 *Outdoor Microphone System*—At a minimum the outdoor microphone system should consist of the following:

5.1.2.1 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 should also meet the measurement requirements for frequency response, directional response and internal background noise (self-noise).

5.1.2.2 The windscreen recommended by the manufacturer may not be adequate in quiet environments with mild wind conditions.

5.1.2.3 The microphone system should include the following features as appropriate for the time duration and weather conditions expected during the measurement set.

5.1.2.4 Microphone and preamplifier system that does not experience a sensitivity or frequency response change beyond ANSI Type 1 or Type 2 limits caused by moisture and temperature effects during the course of the measurement.

5.1.2.5 Microphone rain shield for use when applicable.

5.1.3 *Tripod*—A tripod of the type normally used for supporting photographic equipment, a mast, or other support sufficiently strong to support the weight of the microphone, possibly the sound level meter and attached protective equipment.

5.1.3.1 To prevent fouling of windscreens by roosting birds during long term and unattended measurement, it is recommended that a bird repellant device, known as a "bird spike" be installed on the windscreen.

5.1.4 *Acoustical calibrator (required),* with adapters necessary to fit the microphone.

5.1.5 *Headphones (recommended)*—Headphones for monitoring the AC output of the sound level meter portion of the analyzer should have the ability to exclude external sound and

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

prevent sound from the earphones from reaching the measurement microphone. The headphones, with an appropriate battery-powered driver, should have sufficient frequency response to permit detection of anomalies in the data caused by wind, humidity, and electrical interference. A frequency response of 50–20 000 Hz is adequate. The headphones or other load should be correctly matched to the source impedance of the sound level meter AC output port.

NOTE 2—**Caution:** Headphone impedance may not be compatible with the AC output port of some sound level meter instruments. An impedance matching amplifier (buffer) may be required. Failure to use such an amplifier, when needed, can cause the meter to produce inaccurate results. If the sound level meter circuit is modified to use headphones, a functional check and calibration of that sound level meter must be performed by a qualified technician before using that instrument.

5.1.6 When there is likelihood of rain, extreme heat or humidity, or of extreme cold conditions, an enclosure capable of protecting the critical components of the measurement instruments from causing measurement error should be provided. (See 5.1.4 regarding protection for the microphone.)

5.2 *Physical Measurements:*

5.2.1 *Distance*—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 (6 ft), 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*—A scale map of the measurement site environs should be available while preparing for measurements. The fixed source position and all measurement locations should be annotated on that map.

5.3 *Meteorological Observations:*

5.3.1 Observe and record wind speed, relative humidity, and temperature for potential effects on the sound level meter instruments, and these factors plus wind direction for potential effects on sound propagation from the fixed sound source to each measurement location. General accuracy meteorological instruments should be available to measure:

5.3.1.1 Wind speed (5-km/h increments),

5.3.1.2 Wind direction,

5.3.1.3 Relative humidity (in 10 % increments), and

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

NOTE 3—NOAA weather reports may be used for wind, temperature, and humidity data when meteorological instruments are not available on site.

5.3.2 Site absolute atmospheric pressure may be required for the proper use of the microphone calibrator. See Appendix X1.

5.4 *Photographs*—A camera should be carried by the measurement team for the purpose of documenting the equipment setup and surroundings at least once at each measurement location.

6. Calibration and Self-Noise

6.1 The measurement system should be calibrated and its self-noise, also known as “noise floor” determined according to Appendix X1.

7. Interference from Airborne Sound and Electromagnetic Fields

7.1 Sound level meter measurements are subject to interference from a number of sources, some of which are discussed in Appendix X2. See also ANSI S1.14.

8. Measurement Plan and Procedure

8.1 A measurement plan should be established to produce accurate data according to the stated objectives of the test. These objectives should be coordinated with the sponsoring person or agency, and if possible with representatives of any contending person or agency.

8.2 *Measurement Locations*—Establish a source envelope which just encloses the noise sources. This may be a rectangle A × B, or any other appropriate shape around the fixed source or source complex, for example, a pumping station or amphitheatre. Prescribe a measurement surface at 10 m or some other fixed distance from that inner surface and where there is confidence that the measurements so made will be meaningful in representing the sound level in that azimuthal direction of that or other identical fixed noise sources in the foreseeable future. See Fig. 1. Sound level measurements should be made on this source emission surface for reference in evaluating sound level data obtained at greater distances.

8.2.1 Use USGS or other satellite imagery topographic maps or appropriate site plans as a graph layout medium. Circumscribe circles outside and centered on the centroid of the source envelope. The radius ranges selected should be divided into nominal logarithmic increments that result in equal decibel level reductions with a minimum of two radii. For example, the set of 30 m, 100 m, 300 m, and 1000 m will produce level reductions of about 10 dB each over hard ground, but any convenient values may be used. Over soft ground, the decay of the first 30 m could be greater. It is emphasized that at distances beyond 30 m and especially beyond 300 m, the sound diminishment with distance will be strongly influenced by wind, temperature gradients, and ground conditions. In addition, the received level is modified by interference between the direct wave and the wave reflected from the ground. The maximum radius where measurements will be significant is determined by a distance where background sounds from other sources dominate over the sound source of interest. Noise measurements may be conducted beyond this range in community areas where noise annoyance has been shown to exist due to the source.

8.2.2 Choose a minimum of four points about the azimuth, for example, north, east, south, and west. These may be adjusted for local conditions such as access, acoustical barriers,

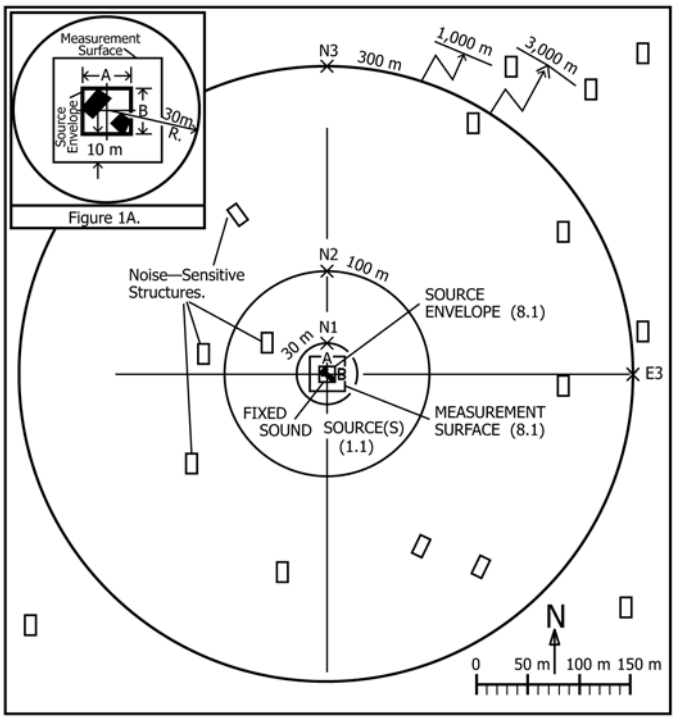

FIG. 1 Arrangement of Measurement Locations About a Fixed Source

reflectors, and interference and community concern for noise from the source (see X2.5 and X2.6). Thus, at least eight measurement locations are selected, four on the source measurement surface and four at the maximum radius.

8.2.3 Locations, times, and sound level meter settings (time weighting and frequency weighting filter) for sound level measurements (see X2.4) should be consistent with the reason for making the measurements, as stated in the measurement plan, and the manner in which the data results will be used. Establish limits of wind speed and interference according to the measurement plan (see X1.2, X1.5 and X1.6).

8.2.4 The sound level meter microphone should be mounted on a tripod or pole 1.5 to 2 m above the ground surface, unless otherwise specified in the measurement plan. Higher locations should be chosen where human occupancy is likely, for example, the future top story of a high-rise building.

8.2.5 *Measurement Location Descriptions*—A measurement location description should be prepared as part of this measurement plan. 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 visible or apparent from the measurement sites.

8.3 *Measurement of Tonal and Impulsive Sounds*—Since annoyance by sound is a strong function of spectral content, at least one observation of a spectral nature shall be made at each distance.

8.3.1 If tonal sound is emitted by the fixed source under test, the frequency of those tones should be measured, or a tape recording of that sound should be made for subsequent analysis.

8.3.2 If impulsive sound is emitted by the fixed source under test, the appropriate sound level meter settings should be specified. See X2.4 and refer to ANSI S1.13.

8.4 *Measurement Location and Time*—For repeatable measurements, sound levels should be measured at short distances according to ANSI 12.18. Alternatively the sound level can be measured over a long time period, which includes various atmospheric conditions, and according to Test Method E1503 to obtain the maximum expected sound level.

8.4.1 For distances less than 300 m from the source centroid, the sound may be measured any time that the fixed sound source is known to be operating in the conditions set forth in the measurement plan. Variation of the source sound level should be considered. For any source distance, measurements should be made at least over the time period when annoyance by noise from the source can occur. Interference, atmosphere, and ground anomalies noted in 8.2.1 may reduce the measured sound level by 20 dB or more under less than ideal propagation conditions.

8.4.2 The measurement duration should be sufficient to characterize the noise source of interest at each measurement location. If round-the-clock monitoring and acquisition of variable source level statistics is required, these data should be obtained and calculated according to Test Method E1503.

8.4.3 Sound associated with vehicle passbys, even if short in duration, can have a considerable effect on the time average sound level, also known as the equivalent level. Care should be taken to locate the sound level meter or recorder as far from roads, rail, or other sources as possible or the meter should be paused during passbys.

8.5 The sound measurement equipment may be prepared according to Annex A1.

8.6 Conduct the measurement.

8.6.1 Measure the sound level from the fixed source according to 8.4. The response rate, filter settings, data sampling time, averaging time, whether impulsive noise is to be measured separately, and the like, shall be determined by the measurement plan, or specified uniquely for this test.

8.6.2 Measure the background sound level when the fixed source is not operating. If this is not possible due to continuous source operation, then measure the background sound level in a nearby or cognate location where the environmental noise is believed to be similar to that at the measurement location.

8.6.3 If the background level is more than 10 dB below the fixed source level, then no correction is needed. If the background level is 3 to 10 dB below that of the fixed source, then correct by subtraction the background noise energy from the measurement signal energy as shown in Eq 1. If the background is less than 3 dB below that of the fixed noise source, then it can only be stated that the fixed noise level is less than that measured.

$$Lp,\ s \approx 10\ Log\left[10^{(Lp,\ m/10)} - 10^{(Lp,\ b/10)}\right] \quad (1)$$

where:

Lp,s = Sound Pressure Level in dB, fixed source
Lp,m = Sound Pressure Level in dB, measurement signal
Lp,b = Sound Pressure Level in dB, background noise

NOTE 4—If it is necessary to evaluate the fixed noise source level even

when less than 3 dB above the background, it is recommended that a band filter be used to isolate the prominent source noise components from other environmental sounds. Alternatively, the broadband output audio may be recorded over several minutes for subsequent spectral analysis.

8.7 Annex A2 provides guidance for keeping the measurement log.

8.8 Annex A3 provides guidance for preparing the measurement agent.

9. Precision and Bias

9.1 The instrument precision of the data obtained using this guide is a function of the acoustical instruments used. See ANSI S1.4. For steady noise, the precision for the measurement result of the set or subset will be ±1 dB for a Type 1 meter and ±2 dB for a Type 2 meter.

9.2 This guide has no bias because the sound levels are defined only in terms of this guide.

9.3 *Variability of Measurement Results:*

9.3.1 Atmospheric changes at or near the surface cause significant variations in the propagation of sound to locations 100 m or more from the source. Critical variables are wind direction and vertical gradients of wind speed and of air temperature. The subsequent changes to the sound level will increase with distance. At positions considerably greater than 300 m from the source, the sound level received from the source could change by as much as 20 dB or more from day to night or from upwind versus downwind. Distant sound levels are greater downwind and in the presence of a temperature inversion (warmer air aloft).

10. Keywords

10.1 community noise; fixed sound source; outdoor sound; sound measurement; sound survey

ANNEXES

(Mandatory Information)

A1. PREPARATION OF EQUIPMENT

A1.1 The following procedure has often been found to be helpful for producing reliable data in an expeditious fashion.

A1.1.1 Check the battery. The useful charge should be sufficient to complete the planned measurement.

A1.1.2 Calibrate the sound level meter in accordance with manufacturer's instructions. See 5.3.2, X1.1, and X2.2. The calibration record for all measurements positions should be used to standardize the data during subsequent data reduction and analysis. If manipulation of the calibration control is performed at any time during this measurement program, a record should be maintained of calibration adjustments over the course of the measurement campaign. The record should show the time(s) at which calibration manipulations were performed and the instrument calibration indication before and after each such manipulation.

A1.1.3 Replace the microphone wind screen(s) and other protective devices removed during acoustical calibration.

A1.1.4 Place the microphone according to 8.2.4. Mark this position on the layout plan called for in 8.1 and to the accuracy specified in 5.2.1.

A1.1.5 Select the weighting and filter bandwidths called for in 8.2. If the analyzer has multiple output channels and if the outputs are being recorded electronically, it is recommended that at least one analysis channel be used for A-weighted sound level.

A1.1.6 Set the averaging time and sample rate called for in the measurement plan. If applicable standards or regulations require the use of slow response in collecting data, this requirement should be followed.

A1.1.7 If a vehicle is used to shelter the operator or the test equipment, the microphone should be located as far away from the vehicle as a microphone cable will allow. At a minimum the distance should be at least 2 + times the largest dimension of the shelter vehicle.

A1.1.8 Unless specified differently in the measurement plan, support the microphone on a sturdy tripod or mast. 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 should be described on the data sheet and in the report.

A1.1.9 Following the guidance of the measurement plan or the microphone manufacturer's recommendation, orient the microphone properly with respect to the direction from which sound from the fixed source under test is arriving.

A2. FIELD LOG

A2.1 Maintain a log during the measurement as a written record, preferably on a pre-printed data entry form. See Fig. A2.1. Include information which is not expected to be printed by the measurement system including the following:

A2.1.1 Describe the locations clearly to associate each measurement position with the description in 8.1. If a sampling plan is being followed, use the name or code assigned to the location by the plan. Note the height of any significant objects that may act as an acoustical barrier or a sound reflector.

A2.1.2 Record the date, start time, and end time of the measurement. If the measurement is not within the time period called for in 8.3, state the reason for the deviation.

A2.1.3 State the operating conditions of the fixed source under test.

A2.2 Identify the manufacturer, model, serial number, and the last traceable laboratory calibration, for the following acoustical instrumentation system components, when used:

A2.2.1 Sound analyzer or sound level meter, and instrument settings used (for example, weighting network, time-average, impulse, octave band, etc.),

A2.2.2 Microphone,

A2.2.3 Outdoor microphone system, and

A2.2.4 Calibrator.

A2.3 *Environmental Conditions*—Record environmental conditions representative of the measurement set. The information recorded should include the following:

A2.3.1 Temperature,

A2.3.2 Relative humidity,

A2.3.3 Site altitude above sea level (if local pressure is needed for microphone calibration),

A2.3.4 Wind speed and speed range if appropriate,

A2.3.5 Wind direction (direction blowing from) in octants (N, ENE, ... WNW, or multiples of 45 degrees 0°, 45°, ... 315°), and

A2.3.6 Ground surface condition, for example, dry, dew, wet, frozen, snow covered (and snow depth).

A2.3.7 If the measurement period is prolonged, wind direction and speed should be reported frequently, that is, at intervals of no more than 15 min. If the wind speed is close to the threshold at which measurements should be suspended, wind speed should be monitored continuously.

A2.4 *Other Major Sound Sources*—Identify major sound sources other than the fixed source under test and record the distance and direction from each source to the measuring location (see 5.2.1).

A2.5 *Comments* —Provide comments, as necessary, including:

A2.5.1 Unusual sound sources which could not be averted and which should be considered in evaluation of the data. Examples in various situations could be aircraft overflights, railroad operations, barking dogs, birds, crickets, locusts, and frogs,

A2.5.2 Unusual weather conditions, especially thunder,

A2.5.3 When applicable under 8.1, 8.2, or 8.3, note changing acoustical propagation conditions, correlation between wind direction and direction of unexpectedly loud or quiet sounds, and subjective estimates of the relative loudness of other sound sources as compared that coming from the fixed sound source under test.

(Ref.) DATE_____
JOB _____
SITE_____

FIXED NOISE SOURCE MEASUREMENT SUMMARY FORM
(Annex A2.)

Sound Source Under Test: (A3.1) _____
TestCode (A2.1) _____

Band Sound Pressure Level —·—·—·—>> dB re 20 µPa.

Local Time	Loc.	Sound Type	A	C	L	31	63	125	250	500	1k	2k	4k	8k
(A2.1.2)	(A3.1.3)	(A3.1.5)												
	N0													
	N1													
	N2													
	N3													
	E0													
	E1													
	E2													
	E3													
	S0													
	S1													
	S2													
	S3													
	W0													
	W1													
	W2													
	W3													

(A3.1.3, X2.4,X2.9) Site Comments:

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.
_____

(A3.1.4) Source Conditions

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_____

(X2.8) Weather:

.
.
.
_____

(A3.2.3) Calibration _____

(A3.2.5) (Operator/Observer _____/_____

FIGURE 2: Sample Data Sheet for a Fixed Noise Source.

FIG. A2.1 Sample Data Sheet for a Fixed Noise Source

A3. FIELD MEASUREMENT REPORT FOR A FIXED SOURCE OF COMMUNITY NOISE

A3.1 It is recommended that a written report as appropriate or as called for by the measurement plan include the following items:

A3.1.1 A description of the fixed noise source may be provided on a plot plan with elevations in sufficient detail to evaluate the effects of acoustical barriers, multiple sources, and effects of ground surface on propagation of sound.

A3.1.2 Data prescribed by the measurement plan in 8.1 – 8.3 and collected during the measurements cited in 8.5. Tabulate each measurement set to a precision consistent with requirements of the study and the capability of the measurement system. Identify the location, date, time, and duration of each measurement set. See 8.1 – 8.3. Time-averaged sound level as well as various statistical levels and repeated periodic values may be graphically depicted, for example, Fig. A3.1 for hourly levels and Fig. A3.2 for octave band levels.

A3.1.3 A written description of the overall site and measurement area may be provided, including a sketch showing measurement microphone locations. The measurement microphone height and the estimated heights of structures and vegetation along the line of sight from the fixed sound source under test to the measurement microphone may be included. The meteorological conditions for each measurement set in the data results table may be provided.

A3.1.4 A brief description may be included about 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.

A3.1.5 Describe the sounds that were measured as steady, tonal, impulsive sound, repetition rate if impulsive, and the identity of sound sources measured or recorded.

A3.1.6 Describe the circumstances about lost data, if any, for example, positions not measured. Estimate the effect of these losses on measurement plan integrity.

A3.2 The following instrumentation information should be provided if known:

A3.2.1 Detector response time or averaging time (X1.6).

A3.2.2 Analysis system self-noise at the range used (X1.4).

A3.2.3 *Calibration*—List the calibration method, results and any unusual readjustments (X1.2).

A3.2.4 Manufacturer, model and, where appropriate, serial number and date of last laboratory calibration that may have been acquired according to Appendix X1.

A3.2.5 Names, business addresses, and phone numbers of the persons making the measurements.

A3.2.6 A statement, to the extent true, that this guide was followed. Any exceptions should be noted and reasons given.

A3.2.7 It is suggested that all field notes or log sheets, whether or not included with the report, be retained for future reference.

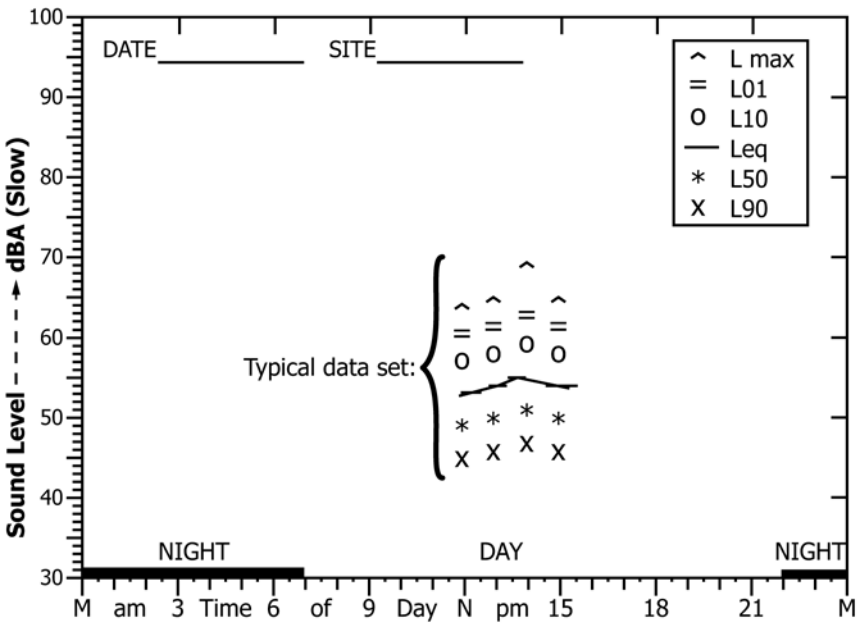

FIG. A3.1 Typical Long-Term Noise Monitoring Data Graph (dBA)

APPENDIXES

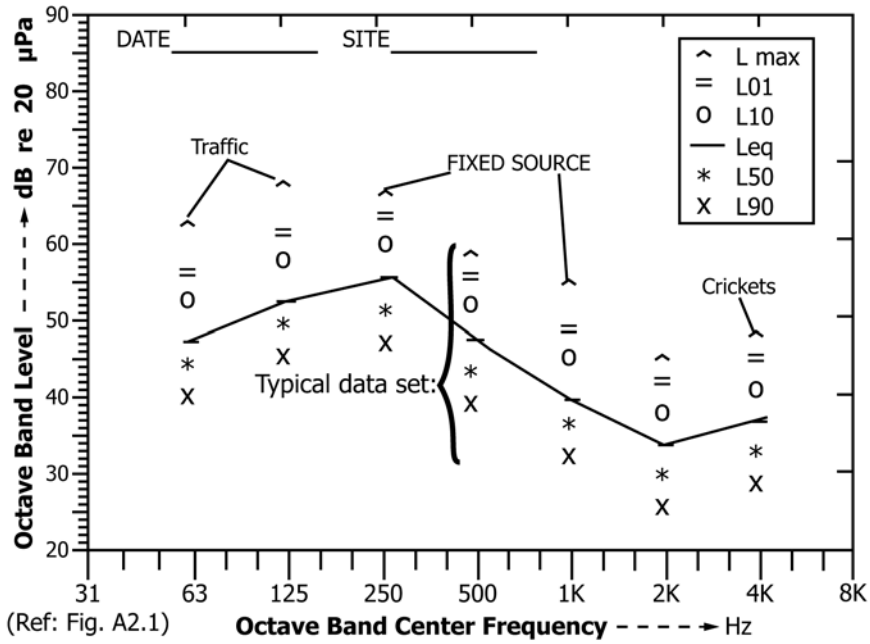

FIG. A3.2 Typical Octave Band Spectrum Graph

(Nonmandatory Information)

X1. CALIBRATION AND SELF-NOISE

X1.1 The calibration of the sound level meter portion of the sound measurement and recording system should be verified using a portable acoustical calibrator that meets ANSI S1.40 immediately before and after each sound level measurement set in a manner prescribed by the manufacturer. This calibration data should be entered in the official handwritten field log at the time of calibration. If measurement data stored by the analysis system are to be transferred to magnetic media, at least one of the periodic calibration data sets should be stored in a calibration file on that medium.

NOTE X1.1—For certain types of calibrators site atmospheric pressure must be known at the time of calibration and measurement. This pressure can be measured on-site with a barometer, or estimated at any time with acceptable accuracy from the site altitude above sea level as:

$$P = 760^{*}\exp(-E/7\,925)\ \text{mm Hg} \qquad (X1.1)$$

where:

E = the measurement site elevation above sea level in metres.

This elevation is found as the elevation contour line through the site as recorded on the USGS 7.5 min quadrangle containing the site. Thus, for Columbus, OH at an elevation of 243 m, P = 736 mm Hg, and the Bruel and Kjaer UZ0001 barometer scale indicates a pistonphone correction of – 0.3 dB (less indicated SPL). Note that the absolute pressure is required, and not the equivalent sea level pressure as reported by the U.S. Weather Service.

X1.2 After initial calibration and during a series of related measurements, no further adjustments should be made to the instrument to make the calibration indication agree with the expected value unless specifically required in the measurement plan.

X1.2.1 If the change in the indication exceeds ½ dB, the data should be marked in a way that will call attention to the change. If the change is 1 dB or greater, the cause of the change should be investigated and suspect components of the system replaced to the extent possible in an attempt to isolate the problem in a manner consistent with the measurement schedule.

X1.2.2 Any change of 1 dB or greater shall be discussed in the measurement report.

X1.2.3 Calibration should be verified if the sound level meter or microphone is abused (for example, dropped, wetted).

X1.3 Within one year or a period specified by the measurement plan, all equipment specifications claimed by the manufacturer should have been verified prior to starting the measurements using methods traceable to a recognized standards organization and following recommendations of the instrument manufacturer. These checks should include the calibrator, microphone, preamplifier, attenuator, filters (if used), and display.

X1.4 The self-noise of the measurement system, including the microphone and microphone preamplifier system, should be measured with all connecting cables in the system. This should be done before starting measurements and at least daily

thereafter until the measurements are complete.

X1.4.1 Measurement system self-noise may be measured by covering the microphone with a suitable acoustic isolator and recording the indicated sound level. This may be a calibrator consisting of an O-ring lined cavity opening that seals the microphone from most exterior noise. Microphone noise may be distinguished from system electronics noise by replacing the microphone cartridge with a dummy microphone. A microphone with erratic noise or with noise above the lowest site noise to be measured may be replaced.

X1.4.2 When fractional-band measurements are being performed, the self-noise in each band should be determined for each measurement set.

X1.4.3 It may not be possible to show that the self-noise is below the lowest fixed source sound level expected in the measurement set because the isolation device does not provide sufficient noise isolation for X1.4.1. If so, then data recorded should be marked to reflect the fact that actual sound levels may, at times, be lower than recorded levels.

X2. INTERFERENCE FROM AIRBORNE SOUNDS AND ELECTROMAGNETIC FIELDS

X2.1 *Responsibilities of the Operator/Observer*—The observer should be aware of potential interferences, such as wind, precipitation, and site visitors. He or she should interrupt or terminate the measurements when the interference is judged to be significant, or when guideline limits 8.2.3 are exceeded.

X2.1.1 The operator/observer, visitors and support staff should not engage in activities which create extraneous sounds during data accumulation periods. Examples of activities to be avoided at that time are; talking, use of radiotelephones (voice and electromagnetic interference), operating vehicle engines, and in the case of a relatively quiet site, walking on gravel, leaves, or twigs. The distance at which interfering activities may resume varies with the sound sources and the environment of the test in question. If necessary, move the interfering activity sufficiently far away from the measurement microphone so that no perceptible sound level meter data perturbation occurs.

X2.2 *Effects of Wind*—Air movement (wind) at the microphone will produce interfering sounds in the measurement system especially at low frequencies, even with a microphone windscreen in place.

X2.2.1 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.

X2.2.2 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.

X2.2.3 If wind interference with measurement of low sound levels is suspected, the output signal of the measuring instrument should be monitored with headphones (see 5.1.5). The operator may switch the sound level meter to "off" or "pause" during interfering wind gusts.

X2.3 *Effects of Moisture, Snow and High Humidity:*

X2.3.1 Measurable and even only trace precipitation can influence outdoor sound level measurements. For example, tires rolling on a paved surface produce higher sound levels when the pavement is wet. Snow accumulated on the ground will affect the propagation of sound across that ground. Traffic noise will be reduced due to abnormally light traffic and slowed speed. Data obtained under such conditions should be retained but marked for special consideration in subsequent analysis. Individual raindrops on a canopy can emit airborne sound interference.

X2.3.2 Relative humidity over 90 % causes reduced sensitivity and excess noise in air condenser microphones and preamplifiers. This is due to corona discharge through water vapor that has infiltrated into the microphone cartridge, or across the polarization voltage resistor in the preamplifier. The "popping and crackling" can be heard through the headphone and observed as displayed sound levels obviously not related to airborne sound. Humidity is highest in the early morning hours or when there is rain, fog, or condensing dew. Manufacturer's instructions should be followed under all high humidity conditions.

X2.3.2.1 Some air condenser microphones are back-vented to a desiccant canister mounted between the microphone and preamplifier. Some preamplifiers contain a heating element,

which reduces moisture condensation in both the microphone and on the polarization resistor.

X2.3.2.2 Use of sealed preamplifier desiccator units or the application of external radiant heat to the microphone may be necessary under extreme or persistent humidity conditions.

X2.3.2.3 Electret microphones are less, and ceramic microphones are least, sensitive to moisture.

X2.4 For fixed sources that emit impulsive sound, accepted measurement methods for impulsive sound according to ANSI S1.13, such as SEL to quantify individual impulse and time-everage 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 fixed 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 (see 8.2) for the sampling rate, system response, and other pertinent guidelines including reference to appropriate measurement standards.

X2.5 Locate the microphone away from sound reflective surfaces that are not normally present at the measurement site. This includes any vehicle or enclosure used in the measurement program. Generally, the microphone should be located away from any such reflective surfaces by at least 2½ times the major dimension of that surface.

X2.6 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.

X2.6.1 Avoid placing the sound level meter, microphone, or microphone cable directly under power lines, in the ground plane area of radio and television transmitters, or close to electrical power transformers. RFI or EMI capable of causing measurement error can usually be heard through earphones connected to the acoustical analyzer AC output.

X2.6.2 If EMI is suspected, check system self-noise according to X1.4.1. Alternatively, move the entire acoustical system to another location along a line of constant sound level, but where the distance to the interfering equipment is more than doubled. If the sound heard in the earphones or the measurement indications are perceptibly reduced, then data taken at the first measurement location should not be used since it was probably affected by RFI or EMI. Perform test measurements at that second location if practical.

X2.6.3 Noise from power lines can increase dramatically with high humidity, especially during light rain.

X2.7 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 rural environment such sounds often exceed the ambient sound level.

X2.7.1 Determine if these wire sounds are part of the environmental sound to be measured. See 8.1. If the sound can be defined as a interference, that is, one which masks an area wide ambient baseline, the measurement location should be moved to a point where the contribution of the wire sound source is at a level representative of its area wide level. The only way to avoid wire sound interference is to avoid measurement locations close to power poles or lines when the measurement plan does not require a measurement.

X2.8 Measurements aimed at quantifying source emission should be made at distances ideally at 30 m or less. Refer to ANSI S12.18 for guidance. Measurements at greater distances from fixed sources are allowed in this guide. However, temperature gradients and wind influence the propagation of sound over greater distances and especially beyond 300 m. If such are required, consult someone experienced in meteorological influences on sound propagation.

NOTE X2.1—Atmospheric influence at a particular location can be evaluated by measuring the sound at that location under differing meteorological conditions but when the sound output from the source is the same. These measurements may be done at different times on the same day, different days, different weeks, or different seasons. Data on air temperature gradients are often not readily available. A measurement downwind of the source after sunset and especially just before sunrise will usually yield the highest level. The fixed source sound output should be verified by a simultaneous measurement at a distance of 30 m or less in the same direction.

X2.9 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 the 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 occuring 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.

X2.10 Measurements should not be made within a horizontal distance equal to the height of existing buildings unless specifically allowed in the measurement plan.