



Designation: E1780 – 12 (Reapproved 2021)

Standard Guide for Measuring Outdoor Sound Received from a Nearby Fixed Source¹

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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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appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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](#)

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>.

- S1.11 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
- 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 Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland, <http://www.iec.ch>.

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-weighting 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 repellent 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 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 $A \times B$, 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

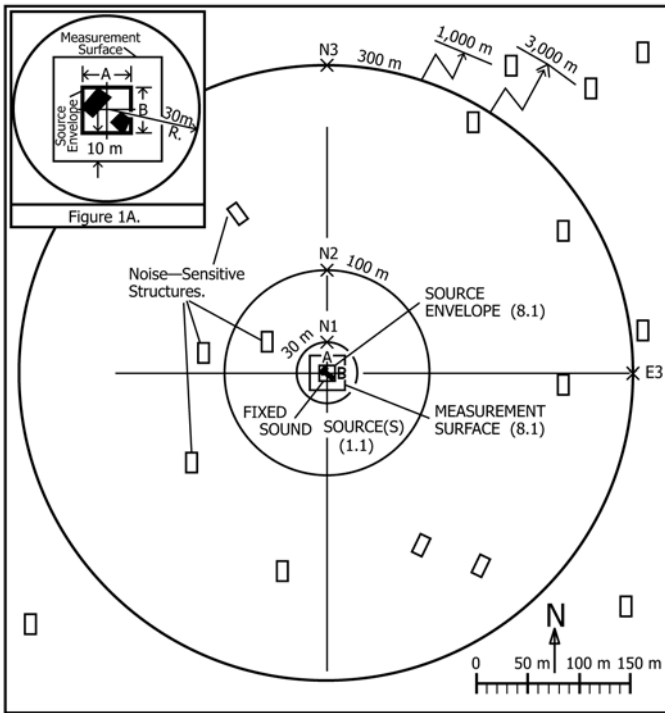


FIG. 1 Arrangement of Measurement Locations About a Fixed Source

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, 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.

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

where:

- $L_{p,s}$ = Sound Pressure Level in dB, fixed source
 $L_{p,m}$ = Sound Pressure Level in dB, measurement signal
 $L_{p,b}$ = 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 _____
 Sound Source Under Test: (A3.1) _____
 TestCode (A2.1) _____

**FIXED NOISE SOURCE
 MEASUREMENT SUMMARY FORM**
 (Annex A2.)

Local Time	Loc.	Sound Type	Band Sound Pressure Level ----->>								dB re 20 µPa.			
			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 _____

(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