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Standard Guide for Preparing a Measurement Plan for Conducting Outdoor Sound Measurements[1]

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INTRODUCTION

This is one of a series of standards on the measurement and evaluation of community noise. Others in the series include Guide E 1014 for Measurement of Outdoor A-Weighted Sound Levels, which covers manual measurement, using a simple meter, and analysis of the resulting data, and Test Method E 1503 for Conducting Outdoor Sound Measurements Using a Digital Statistical Analysis System. Also under consideration or in preparation are: a standard guide for the selection of environmental noise metrics and criteria, a standard guide for determining the validity and significance of data, and a standard guide for measuring sound received from a nearby discrete fixed sound source.

1. Scope

1.1 This guide covers the preparation of a formal plan for measurement of outdoor sound levels. A documented, detailed plan is highly desirable and useful for major environmental noise studies requiring measurements at several locations over a long period. This guide is intended primarily for use in such cases. Many simple measurements can be made without extensive prior planning or documentation. It is recommended that persons or organizations routinely performing such measurements draft and use a brief generic plan based on, but not referencing, this guide.

NOTE 1—The extent of planning and plan documentation should be consistent with the budget and needs of the project. In a large measurement program it is possible that use of a formal measurement plan could result in cost savings greater than the cost of preparing the plan. A formal documented plan can be prepared for even the simplest measurement. However, on a small project, the cost of preparation of a formal plan may not be cost effective. In such cases, plan documentation could be limited to inclusion in the final report.

1.1.1 This guide addresses the following aspects of outdoor sound level measurements:

Reporting Requirements	4.8
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Defining the Scope of the Measurement	5.1
Selecting the Appropriate Survey Class	5.1.1
Requirements for Unattended Measurements	5.2, Annex A2
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Identification of Interferences	5.4.1.2, Annex A1
Measurement Procedures	5.8
Procedures for Dealing with Impulsive Sounds, Tonal Sounds, and Infra-Sound	5.8.1.3, 5.8.3
Analysis and Post-analysis Requirements	5.9
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Specification of the following:	
Precision and Accuracy Requirements	5.1.2.4, 5.6.4
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Measurement Schedule	5.5
Measurement Durations	5.5
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1.1.2 Test Method E 1503 for Conducting Outdoor Sound Measurements Using a Digital Statistical Analysis System addresses listed aspects of outdoor sound level measurements for situations that are normally encountered. Many other formal and informal practices also address most of these issues. However, there is sometimes a need to depart from the normal methods in order to accommodate a special situation or a regulatory requirement. This guide provides options that are technically correct for specific situations, and provides the information needed for selecting appropriate options.

1.1.3 This guide may be used when planning a program for obtaining either a single measurement set of sound level data or multiple sets of data, as well as related supporting data.

1.2 Measurements that may be planned using this guide include, but are not limited, to the following:

1.2.1 Characterization of the acoustical environment of a site.

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1.2.2 Characterization of the sound emissions of a specific sound source that exhibits a temporal variation in sound output.

1.2.3 Measurement of low-frequency sound (infra-sound) is included because it is sometimes implicated in driving structural vibration that translates to audible interior sound.

1.2.4 Measurement of impulsive sound and sound with significant tonal content.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 634 Terminology Relating to Environmental Acoustics[2]

E 1014 Guide for Measurement of Outdoor A-Weighted Sound Levels[2]

E 1503 Test Method for Conducting Outdoor Sound Measurements Using a Digital Statistical Analysis System[2]

E 1686 Guide for Selection of Environmental Noise Measurements and Criteria[2]

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

S1.40 Specification for Acoustical (Microphone) Calibrators

S12.1 American National Standard Guidelines for the Preparation of Standard Procedures for the Determination of Noise Emission from Sources

S12.7 American National Standard Methods for Measurements of Impulse Noise

S12.9 American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Parts 1, 2, and 3

S12.40 American National Standard Sound Level Descriptors for Determination of Compatible Land Use

3. Terminology

3.1 For definitions of terms used in this guide, see Terminology C 634.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *barrier*—any obstacle, in (or near) the lines of sight between the microphone and potential sound sources, that could block, or interfere with, the direct passage of sound from potential sound sources to a receiver or a measurement location.

3.2.2 *dummy microphone*—a microphone cartridge substitute that has electrical characteristics identical to a functional microphone but that has extremely low sensitivity to incident acoustic energy. (Used instead of a functional microphone when evaluating the internal noise of an acoustic measuring system.)

3.2.3 *exceedance level*—See *percentile level*.

3.2.4 *impulse sound*—a brief, intrusive sound, such as that associated with a tire blowout, operation of a power press, or the discharge of a firearm. One definition of an impulse is an event having a rise time not more than 35 ms to peak, and a duration of not more than 500 ms to 20 dB below peak. Impulse sound also includes repetitive events occurring at rates of 20 or less per second. When the repetition rate falls between 10 and 20 per second, the perception could be that of a steady tone, and it would be measured by a sound level meter as such. (See ANSI S1.13.)

3.2.5 *interference, n*—any activity, situation or event, near the measurement location, that could produce anomalous measurement results, or that could produce data that are not representative in the context of the measurement objectives. Interferences fall into two categories: those that produce sound and those that affect the propagation of sound or the measurement process, or both. Examples of the former include air turbulence generated by the wind at, or near the microphone, and people, animals, atmospheric phenomena, or machinery making sounds in the vicinity of the microphone. Examples of path interferences are temporary surfaces, objects, or atmospheric conditions that alter the normal sound propagation path. An example of interference that affects the measurement process is an internal self noise (in the measurement system) that corresponds to a sound level that will affect the measurement results. See Annex A1 for additional details and precautions.

3.2.6 *maximum level*—the highest meter reading using the frequency weighting and time weighting required by the measurement procedure or plan.

3.2.7 *measurement plan*—a document prepared by or for the organization or individual responsible for performing the measurement, giving the purpose and objectives of the measurements and stating requirements unique and specific to the objectives. These requirements address, for example, methods of selecting measurement times and locations, number and length of measurement sets, and directions on actions to be taken in case of major changes in environment during a measurement session.

3.2.8 *measurement set*—the set of acoustical and related data obtained at a single measurement location during a specific uninterrupted time period. The time period for a measurement set is flexible but should be based on the purpose of the measurement and specified in the measurement plan. If the purpose of the measurements is to document the sound for a specific source operating condition or propagation condition, a measurement set should not extend beyond the time period in which conditions affecting sound generation or propagation remain reasonably constant. If data analysis is performed by the measuring instrument during the measurement period, the

[2] *Annual Book of ASTM Standards*, Vol 04.06.

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

analysis results are considered part of the measurement set. The aggregate of measurement sets comprises the data set for the overall study.

3.2.8.1 *Discussion*—If more than one combination of conditions exists, the investigator may want to perform separate measurement sets, one at each set of conditions.

3.2.9 *statistical sound level*—a result of statistical analysis of data in a measurement set. Three representative types of statistical sound level that may be derived from either weighted or unweighted sound levels, or from fractional octave bands of sound are the following:

3.2.10 *time-average sound level*—the average sound level measured over a length of time, also known as equivalent sound level (symbol L_T or L_{eq}). The length of time must be specified when presenting the results. For unweighted sound pressure levels and fractional octave bands,“ time average sound pressure level” is the correct term, and ″equivalent sound pressure level” is also used. See the note under “average sound pressure level” in Terminology C 634.

3.2.11 *percentile level*—the sound level exceeded a specific (x) percent of the time in a measurement set (symbol L_x). (Sometimes called “*exceedance level*.”)

3.2.12 *tonal sound*—the presence in broad-band sound of one or more simple tones (single frequencies) or complex tones (multiple frequencies or harmonics) that create a sensation of pitch in the perceived sound, and thus can be easily detected by a listener.

4. Significance and Use

4.1 This guide deals with methods and techniques that are well defined and that are understood by a trained acoustical professional. The guide has been prepared to provide both an outline for a measurement plan and guidance in selecting procedures that are appropriate for the type and purpose of the measurements to be performed. Use of the guidelines provided will produce measurement results that are reproducible and can be documented, that are consistent with requirements of government and industry, and that can be validated using information gathered and documented in the course of the measurement program.

4.2 This guide is intended to be used in preparing a measurement plan to be agreed on by the parties having a contractual interest, and, if appropriate, the regulatory or enforcement body having jurisdiction. The plan shall reference this guide. The plan may deviate from this guide providing any changes or additions, and the rationale therefore, are clearly stated in the report of any measurement referencing this guide. This guide shall not be referenced if it is not used in preparing the plan, if the detailed measurement plan is not prepared in advance of performing the measurements, or if the plan has any major inconsistencies with the guide or minor inconsistencies are not explained.

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

4.3.1 *Documentation of Sound Levels Before the Introduction of a New Sound Source*. (For example, assessment of the noise impact caused by a proposed facility and associated activities.)

4.3.2 *Comparison of Sound Levels With and Without a Specific Source Operating*, that is, assessment of the impact potential of an existing source.

4.3.3 *Comparison of Sound Levels with Criteria or Regulatory Limits*. (For example, indication of compliance with criteria for speech interference, community annoyance, building vibration, or compliance with mandated limits.) Measurements for evaluating hearing damage potential are excluded from the scope of this guide.

NOTE 2—Measurement results obtained using a plan developed according to this guide can be used in establishing compliance when the measured data are below a specified limit, or conversely, establishing noncompliance when any of the data are above a specified limit.

4.3.4 *Noise Impact Assessment and Mitigation*. A common application of data from acoustical characterization of a location or area is in modeling the effect of a projected activity on the acoustic environment and modeling the effect of noise impact mitigation plans. Because of the costs associated with noise control, especially in the case of retrofit controls, it is important that the effect of the baseline sound level be accurately assessed. Inaccurate baseline sound data can lead to over (or under) specification of mitigation measures, or to the need to add additional noise control after the fact.

4.3.5 *Monitoring the Effectiveness of a Noise Impact Mitigation Plan*.

4.3.6 *Comparison of Statistical Sound Level Data with Appropriate Criteria*.

4.3.7 *Derivation of Loudness Levels*, provided the necessary requirements regarding sample duration and signal bandwidth are observed in collecting the data. It is recommended that a specialist in the area of loudness evaluation be consulted in preparing a plan for measurements intended to produce data that will be used for this purpose.

4.4 This guide provides procedures that will work well for alternative measurement systems, ranging from a basic standard sound level meter to a sophisticated sound analysis system that incorporates digital circuits for instrument control, sampling, processing, and storing sound level data.

4.5 This guide provides (*1*) standard formats for documenting conditions under which the measurements are performed, and for reporting the results, and (*2*) procedures for making and documenting the physical observations necessary to qualify the measurements.

4.6 This guide can be used by individuals, regulatory agencies, or others in planning a program to collect acoustical data for many situations. The guide provides for ensuring data are collected according to procedures that are consistent with specified data requirements. The guide also identifies requisite capabilities of the equipment and equipment operational options.

4.7 The user is cautioned that there are many factors that can strongly influence the results obtained during measurement of outdoor sound levels and that this guide is not intended to be a substitute for the experience and judgment of experts in the field of acoustics. The guide is intended for use by people who are familiar with data requirements, who are experienced in the

measurement and analysis of outdoor sound, and who are thoroughly familiar with the use of the equipment and techniques involved.

4.8 This guide is intended only to provide an appropriate measurement procedure and, as such, does not address the methods of comparison of the acquired data with specific criteria. No procedures are provided within this guide for separating the influences of two or more simultaneously measured sounds.

4.9 The final report of work performed using a measurement plan developed using this guide shall reference the following:

4.9.1 The measurement plan and

4.9.2 This guide, with a statement of any exceptions to its use.

5. Required Sections

5.1 From this point on, the guide is presented as the outline for, and in the format of, a typical noise measurement plan. Included in the outline are mandatory sections, with guidance for preparation of appropriate text. Also included are optional sections and guidance for their use. Each section or subsection with conditional requirements shall be considered mandatory if the conditions of the requirement apply.

NOTE 3—The following section numbering for this guide continues as subsections of Section 5. The recommended numbering format for a plan uses corresponding Guide section numbers with the "5." redacted. As an option, when Guide subsections that are not mandatory are not included in the plan, the appropriate section number may be included in the plan followed by the parenthetical statement, "This section (subsection) not applicable." Use of keywords in a measurement plan is not mandatory but is recommended. Keywords would follow 10.6, and thus would be Section 11.

5.1.1 *Scope of Measurement (Mandatory)*—A clear statement of the scope of the measurement shall be prepared and agreed upon by the following parties prior to planning outdoor noise measurements: (*1*) All parties having a contractual interest in the measurements, and (*2*) State, local, or federal government officials having regulatory authority relative to sound levels (if applicable). The statement of the scope shall be formatted to provide an appropriate opening statement for the measurement plan. The following basic information shall be contained in the scope:

5.1.1.1 *Identification of Client*—The name and address of the organization or person for whom the measurements are to be made.

5.1.1.2 *Reason for Measurements*—The reason for performing the measurements, carefully described in a way that provides guidance in defining the measurement process.

5.1.1.3 *Type of Analysis Required*—The type of analysis planned for the data obtained.

5.1.1.4 *General Location*—Describe the geographic location of the measurements, for example, the area or political subdivision that encompasses all of the measurement locations. Examples of the location would be a specific named subdivision or platted area, a city, township, county, or state.

5.1.1.5 *Oversight Responsibility*—Give the names and addresses of organizations or persons, if any, having responsibility for oversight or monitoring of the measurement program.

5.1.1.6 *Property Owners*—Give the names and addresses of persons or organizations controlling access to property on which measurements are to be made. Procedures for communicating with property owners shall be summarized here. Details may be communicated separately from the plan if appropriate.

NOTE 4—In cases involving need to perform measurements on private property the plan should indicate the type of arrangement that has been made with property owners for access.

5.1.1.7 *Regulatory Information*—If the measurement is required by, or results of the measurements will be reviewed by, a regulatory agency, see Appendix X6 for recommendations relative to inclusion of regulatory information.

5.1.1.8 *Time Period Covered*—Describe the time period over which the measurements are to be made. Include any specific requirements to perform measurements while specific activities are in progress, or when certain atmospheric conditions prevail.

NOTE 5—Measurement time period requirements are discussed in detail in ANSI S12.9.

5.1.2 *Survey Class*—Select one of the following survey classes for the measurements:

5.1.2.1 Class A, defined in ANSI S12.9 as a sound-level survey designed to achieve a spatial accuracy of ±3 dB with a confidence interval of 95 %.

5.1.2.2 Class B, defined in the referenced ANSI document as designed to achieve a spatial accuracy of ±5 dB with a confidence interval of 95 %.

5.1.2.3 Class C, defined in the referenced ANSI document as designed to define the upper limit, highest level, or worst case for environmental sounds.

5.1.2.4 *Precision and Accuracy*—State the precision and accuracy objectives of the measurements.

5.2 *Attended/Unattended Measurements*—It is strongly recommended that there be agreement between the performing organization, the client, and representatives of cognizant regulatory bodies, regarding the necessity of having a qualified person in attendance during all sound level measurements. The plan shall state the rationale for the decision. See Annex A2 for guidance.

NOTE 6—An exception would be a measurement involving only the determination of the sound level exceeded 90 percent of the time (L_{90}), in this case monitoring is less critical because the analysis process strips away most of the interference related to spurious sound sources.

5.2.1 *Manually Recorded Data*—Measurements that involve manually recorded data shall have an observer present. In this case, 5.2 shall state that an appropriately trained observer, as defined in 5.3, shall be present to read and record data.

5.2.2 *Automatically Recorded Data*—For measurements for which sound level data are automatically recorded at regular intervals, 5.2 shall contain the following information:

5.2.2.1 A statement that the measurements will be attended or unattended, as the case may be. Annex A2 shall be followed in making this determination.

5.2.2.2 A list of the names of the people, and their organizations, involved in determining whether the measurements are to be attended or unattended.

5.2.3 In the case of unattended measurements, 5.2 shall state that a qualified observer, as defined in 5.3, shall be present at least part of the time during some of the measurements.

5.3 *Statement of Operator Qualifications*—Mandatory if measurement results will be used in connection with a permit application or formal environmental assessment. The plan shall include a statement regarding the requirements for qualifying an operator to set up and operate the measurement system and to measure and record supporting data. This requirement shall apply whether the measurements are attended or unattended.

5.3.1 *Qualifications and Training*—The measurement plan shall either incorporate the text of Annex A3 or shall state the extent to which the responsible person and the equipment operator(s) meet the requirements of Annex A3.

5.4 *Selection of Measurement Locations*—This paragraph, together with Annex A4 and Appendix X1 provides a guide for selecting measurement locations for use in characterizing the acoustic environment of a point, zone, district, or enclave in a manner that ensures a degree of spatial resolution necessary to adequately, and appropriately, characterize the acoustic environment of an area. (See also ANSI S12.9, Parts 2 and 3.)

5.4.1 The sound level at any point outdoors is a combination of sounds from nearby and distant sound sources. As each source varies in sound emission or distance, or as sound propagation characteristics of the area change, the combined sound level at any point changes. The amount of change in the level will depend on the relative contribution of the source involved in the change. Selection of measurement locations shall take these factors into consideration. The locations shall be selected to:

5.4.1.1 Be representative of the area or location to be studied,

5.4.1.2 Not be influenced by the interferences described in Annex A1, and

5.4.1.3 Allow effective use of the measurement resources available, particularly time and trained personnel.

5.4.2 *Documentation of Study Area*—The measurement plan shall include a map of the study area. The map shall show potential noise sources and receptors, and identify areas where the human population density exceeds 240 per km^2 (600 per square mile). The map should be drawn to a standard scale, such as 1:10 000 in which 1 cm represents 100 m (1:7200 in which 1 in. = 600 ft) for large areas, or 1:1000 in which 1 cm represents 10 m (1:720 in which 1 in. represents 60 ft) for smaller areas. As potential measurement locations are selected they shall be identified on the map by appropriate code numbers or letters. The map should be chosen, or designed, to aid in the selection of measurement locations as well as guide the measurement crew during the measurement program.

NOTE 7—See Appendix X2 for information on USGS topographic maps.

5.4.3 Select measurement locations using the following three-step process:

5.4.3.1 Using Annex A4, establish the extent of the study area and identify points within the study area at which measurements are needed.

5.4.3.2 Eliminate redundant points as outlined in X1.4.

5.4.3.3 Using Annex A1, evaluate the potential for interferences at each location. If necessary, adjust the location to avoid, or minimize, the interference.

5.5 *Schedule and Duration of Measurements*—This section provides guidelines for establishing a sampling sequence for use in preparing a plan for outdoor sound level measurements that will provide the degree of temporal resolution necessary to adequately characterize the acoustical environment of a point or area. For situations that do not require a long-term assessment it may not be necessary to make more than a single measurement, however, if the measurement is being made for any reason other than to determine the sound level at a specific time, it is recommended that the user consider the potential for time-dependent variations in level as discussed below.

NOTE 8—ANSI S12.9, Parts 2 and 3 provide guidance in setting up a measurement schedule.

5.5.1 *Temporal Changes* in sound level are often cyclic. Hourly cycles are normally based on activity patterns of the inhabitants of a community. The same is true of daily cycles. Over a period of a week it is not unusual to see two daily cycles superposed, that is, a weekday cycle and a weekend cycle. There are also annual cycles that are associated with land use. In agricultural regions there may be periods of tilling, planting, cultivation and harvesting alternating with periods of low activity. Cyclic changes due to seasonal climatic changes play an important role in cycles of environmental noise, due to some extent to changes in foliation and changes in activity of human and animal populations. The following subsections provide guidance in setting up a measurement schedule that will adequately sample these cycles.

5.5.1.1 *Short-term Cycles*—Hour-to-hour sound levels should be estimated so the measurement schedule may be constructed to obtain data representative of the level changes that occur over the course of a day.

5.5.1.2 *Weekdays and Weekend Days*—In order that systematic differences between weekday and weekend sound levels can be evaluated, separate sequences should be established for weekday and weekend periods. (Tuesday through Thursday and Friday through Monday are frequently used, however the periods chosen should be specific to the community.)

5.5.1.3 *Seasonal Cycles*—The potential for systematic seasonal cycles should be evaluated and, if appropriate to the purposes of the measurements, the measurement schedule should provide for measurements at various times of the year to include the extremes of sound level. See 5.5.1.4.

5.5.1.4 *Documenting Temporal Changes in the Natural Ambient Level*—It is important that the investigator be aware of the potential for changes in ambient sound production (such as bird, insect and wind noise) because of changes in meteorological conditions. The plan shall require documentation of the occurrence of such a change. The plan shall also recommend that if the distinction between the two sound modes is important the time period in question be separated into two

distinct measurement sets. Otherwise the time period containing the interferences should be excluded from the measurements since the affected sound levels detract from the reproducibility of the data.

5.5.2 *Procedure For Setting Up a Measurement Schedule*—The following tools and procedures are recommended for expediting the preparation of a measurement schedule.

5.5.2.1 *Labeling Locations*—Assign unique numbers or letters to each measurement location. (If this was done during the location selection process do not renumber the locations.)

NOTE 9—A map showing the measurement locations and the local road network can be very helpful. The map prepared in the documentation of measurement locations is recommended (see 5.4.2).

5.5.2.2 *Establishing Sequence, by Location, of Measurement Sets*—The objective is to randomize the sequence of visits to the set of measurement locations while insuring that all locations are sampled equally during the measurement campaign. A true randomization, by location, of measurement sets could eliminate some locations from the measurement schedule or cause some locations to be oversampled. It is the intention of this procedure to not allow this. For this reason a separate, but not necessarily unique, non-repeating random sequence, by location, should be assigned to each cycle of measurement sets.

NOTE 10—It is left to the user to decide how the random sequences are selected.

5.5.2.3 As the random sequences for measurement sets are developed, prepare a table that lists the sequences in the order selected. Initially assign dates and times for each visit, taking into account the time required for each visit and travel time to the next location.

5.5.3 *Evaluation of Significance*—The following statement shall be made a part of the schedule section of the plan: "The significance of aggregate data from each location shall be evaluated on a daily basis. (See Annex A5 for evaluation of significance.) When it becomes obvious that additional visits to a location are not likely to produce an improvement in the data set, that location can be skipped when it appears in a sequence. Note that weekday and weekend sequences should be treated separately in this respect."

NOTE 11—When field analysis of the data shows that data significance has been achieved for a location over a period of seven to ten days, reduce the number of measurement sets scheduled for that site in favor of additional measurement sets for sites for which data significance has not been achieved.

NOTE 12—**Caution:** Care should be taken, however, to be certain that seasonal activities do not produce a short-term correlation effect that is not representative of long-term situation. An example is the daily periodic cycle of the level of highway noise. If measurements were unintentionally scheduled to coincide with peak traffic periods, one could not tell from the measurement results alone that the data were not representative of the entire day. To avoid such a possibility, the investigator should plan to visit measurement locations at times outside the schedule and make a personal assessment of current conditions, including random sound level meter readings.

5.5.4 *Reporting Method and Rationale For Measurement Schedule*—The schedule based on this guide shall be a part of the measurement plan and shall accompany the report for the measurement program. The location sequences, as well as the method used to obtain them, shall be included in the measurement plan. The measurement report shall include explanatory notations for measurement sets that have to be dropped or rescheduled.

5.6 *Equipment Requirements and Specification*—This section provides guidance in using the measurement scope (5.1) to determine minimum requirements for sound measurement equipment for performing the noise measurements and for physical measurements associated with the noise measurements. Any equipment that meets the minimum requirements may be used provided the features required to satisfy the requirements of the scope are considered in setting up the measurement plan. The following subsections deal with microphones, time weighting, band-pass filters, statistical data analysis, and microphone windscreens.

5.6.1 *Microphones*—Microphone characteristics of concern in optimizing a measurement system for a particular situation are the following: (*1*) frequency response, (*2*) directional response, and (*3*) self noise.

5.6.1.1 *Frequency Response*—The microphone selected for the measurements shall have a nominal frequency response range that includes the range of frequencies called for in the scope of measurements.

NOTE 13—Because microphones having greater frequency range generally have lower sensitivity, it may be necessary to consider a trade-off between self noise and frequency range. (See 5.6.1.3 and 5.6.4.3.)

5.6.1.2 *Directional Response*—The directional characteristics of microphones should be considered in their selection and use. This is especially important if there are nearby high-frequency sources of interest. High-frequency sound from distant sources (more than 90 m (300 ft)) will usually not be significant due to atmospheric attenuation. Microphones should be selected and oriented to provide the most accurate measurement of expected high-frequency sounds. See Appendix X3 for further information.

5.6.1.3 *Microphone Self Noise*—Microphone self-noise may constitute an interference in the measurement of sound levels. A copy of the self noise data for the microphone, generally supplied by the microphone manufacturer, should be consulted in determining if the microphone selected has an adequately low self noise. The plan should include the information or state that it is not available. See 5.6.4.3 for discussion of the system self noise.

5.6.2 *Characteristics of Sound Measurement Equipment*—The plan shall specify the characteristics of all equipment used to process the microphone signal, including but not limited to sound level meters, pre-amplifiers, filters, analyzers, and recording devices. This specification may be made either by limiting the equipment to specific makes and models that are known to provide the appropriate characteristics, or by specification of the characteristics without regard to specific instruments that may have these characteristics. (It is recommended that in the latter case, that the specified characteristics be associated with currently available equipment.)

5.6.2.1 *Band Pass Filters*—If measurements are to be made in octave bands or in fractional octave-bands, the plan shall specify filter sets that fulfill the objectives of the measurement, or of the measurement plan. Filters shall meet the requirements of ANSI S1.11.1985.