ASME PTC 36-2018

[Revision of ASME PTC 36-2004 (R2013)]

# Measurement of Industrial Noise

## Performance Test Codes

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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Two Park Avenue • New York, NY • 10016 USA

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This Code will be revised when the Society approves the issuance of a new edition.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this Code. Interpretations are published on the Committee web page and under http://go.asme.org/InterpsDatabase. Periodically certain actions of the ASME PTC Committee may be published as Cases. Cases are published on the ASME website under the PTC Committee Page at http://go.asme.org/PTCcommittee as they are issued.

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The American Society of Mechanical Engineers
Two Park Avenue, New York, NY 10016-5990

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# NOTICE

All Performance Test Codes must adhere to the requirements of ASME PTC 1, General Instructions. The following information is based on that document and is included here for emphasis and for the convenience of the user of the Code. It is expected that the Code user is fully cognizant of Sections 1 and 3 of ASME PTC 1 and has read them prior to applying this Code.

ASME Performance Test Codes provide test procedures that yield results of the highest level of accuracy consistent with the best engineering knowledge and practice currently available. They were developed by balanced committees representing all concerned interests and specify procedures, instrumentation, equipment-operating requirements, calculation methods, and uncertainty analysis.

When tests are run in accordance with a code, the test results themselves, without adjustment for uncertainty, yield the best available indication of the actual performance of the tested equipment. ASME Performance Test Codes do not specify means to compare those results with contractual guarantees. Therefore, it is recommended that the parties to a commercial test agree before starting the test and preferably before signing the contract on the method to be used for comparing the test results with the contractual guarantees. It is beyond the scope of any code to determine or interpret how such comparisons shall be made.

# FOREWORD

In October 1967, the Board on Performance Test Codes recognized the need for procedures and measuring techniques to provide reliable and accurate sound-measurement analysis. This action was taken in view of the growing environmental concern that lengthy, unprotected exposure to high industrial noise levels is detrimental to human health. This concern has also resulted in government-sponsored noise-level criteria. Accordingly, the Board on Performance Test Codes authorized the organization of Performance Test Codes Committee No. 36 on Measurement of Industrial Sound. The new PTC 36 was published as an American National Standard in 1985.

In May 1992, at the request of the Board on Performance Test Codes, a committee was convened to consider revisions to PTC 36-1985. There were three principal reasons for undertaking the revision. First, the technology of digital-sound data acquisition and processing had evolved dramatically since the development of the first edition of the Code, resulting in more widespread use of sound-intensity methods. Second, extending the scope of the Code to encompass far-field measurements was considered likely to make the Code more useful to a broader range of potential users. Third, a considerable enlargement of uncertainty considerations, included as an integral part of the procedure, was believed to enhance its applicability. Keeping these industry needs in mind, changes were made to the 1985 edition and published as PTC 36-2004.

The latest revisions are as follows:

*(a)* deleted reference to B133.8-2011 because it is to be withdrawn and absorbed, in parts, into this Code
*(b)* deleted references to sound intensity because it has become less popular than anticipated in 1992
*(c)* removed reference to two-surface method due to its relatively infrequent use by professionals
*(d)* introduced a more general formula for the K2 environmental absorption correction
*(e)* introduced a new method of uncertainty analysis, shown in Nonmandatory Appendix A

ASME PTC 36-2018 was approved by the PTC Standards Committee on January 16, 2018, and was approved as an American National Standard by the ANSI Board of Standards Review on May 15, 2018.

**ACKNOWLEDGMENT:** The preparation of this Code required several years, and a previous member of the Committee was not active at the time of its publication. The Committee chair would therefore like to recognize and thank Stephen Hambric for his significant contributions to the development of this Code.

# ASME PTC COMMITTEE
# Performance Test Codes

(The following is the roster of the Committee at the time of approval of this Code.)

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# CORRESPONDENCE WITH THE PTC COMMITTEE

**General.** ASME Codes are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Code may interact with the Committee by requesting interpretations, proposing revisions or a case, and attending Committee meetings. Correspondence should be addressed to:

Secretary, PTC Standards Committee
The American Society of Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990
http://go.asme.org/Inquiry

**Proposing Revisions.** Revisions are made periodically to the Code to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Code. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Code. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

**Proposing a Case.** Cases may be issued to provide alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee web page.

Requests for Cases shall provide a Statement of Need and Background Information. The request should identify the Code and the paragraph, figure, or table number(s), and be written as a Question and Reply in the same format as existing Cases. Requests for Cases should also indicate the applicable edition(s) of the Code to which the proposed Case applies.

**Interpretations.** Upon request, the PTC Standards Committee will render an interpretation of any requirement of the Code. Interpretations can only be rendered in response to a written request sent to the Secretary of the PTC Standards Committee.

Requests for interpretation should preferably be submitted through the online Interpretation Submittal Form. The form is accessible at http://go.asme.org/InterpretationRequest. Upon submittal of the form, the Inquirer will receive an automatic e-mail confirming receipt.

If the Inquirer is unable to use the online form, he/she may mail the request to the Secretary of the PTC Standards Committee at the above address. The request for an interpretation should be clear and unambiguous. It is further recommended that the Inquirer submit his/her request in the following format:

| | |
|---|---|
| Subject: | Cite the applicable paragraph number(s) and the topic of the inquiry in one or two words. |
| Edition: | Cite the applicable edition of the Code for which the interpretation is being requested. |
| Question: | Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. Please provide a condensed and precise question, composed in such a way that a "yes" or "no" reply is acceptable. |
| Proposed Reply(ies): | Provide a proposed reply(ies) in the form of "Yes" or "No," with explanation as needed. If entering replies to more than one question, please number the questions and replies. |
| Background Information: | Provide the Committee with any background information that will assist the Committee in understanding the inquiry. The Inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information. |

Requests that are not in the format described above may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

Moreover, ASME does not act as a consultant for specific engineering problems or for the general application or understanding of the Code requirements. If, based on the inquiry information submitted, it is the opinion of the Committee that the Inquirer should seek assistance, the inquiry will be returned with the recommendation that such assistance be obtained.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

**Attending Committee Meetings.** The PTC Standards Committee regularly holds meetings and/or telephone conferences that are open to the public. Persons wishing to attend any meeting and/or telephone conference should contact the Secretary of the PTC Standards Committee. Future Committee meeting dates and locations can be found on the Committee Page at http://go.asme.org/PTCcommittee.

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# Section 1
# Object and Scope

## 1-1 OBJECT

The object of this Code is to describe procedures for measuring and reporting airborne sound emission from stationary sound sources and equipment, or from facilities composed of multiple stationary sound sources.

## 1-2 PURPOSE

The purpose of this Code is to recommend measurement procedures in a variety of acoustical environments, including settings influenced by background or extraneous noise. Generally, an A-weighted sound-pressure level (see Section 2) is used to quantify the sound emission of industrial equipment and facilities.

## 1-3 SCOPE

This Code provides guidelines for the following two methods of measuring near- and far-field sound levels:

*(a) Survey Method (Survey Grade).* This method is used to expeditiously perform cursory measurements to assess acoustical performance of systems and equipment. This may consist of preliminary or limited measurements for further study and review, or for more in-depth follow-up work. Refer to ANSI/ASA S12.56/ISO 3746.

*(b) Engineering Method (Engineering Grade).* This method is used to perform precise field measurements for assessing acoustical performance and compliance with acoustical requirements. These types of measurements usually include an assessment of variability in the data and of uncertainty. Refer to ANSI/ASA S12.54/ISO 3744.

General guidance for sound-level measurements is found in Nonmandatory Appendix B.

## 1-4 UNCERTAINTY

There are two levels of uncertainty accuracy, engineering and survey, that are dependent on the test conditions during the measurement. These are discussed in subsection 3-3.

# Section 2
# Definitions and Descriptions of Terms

## 2-1 DEFINITIONS

For definitions or descriptions of any other terms, please refer to ANSI/ASA S1.1.

*absorption:* see *sound absorption*.

*acoustic, acoustical:* qualifying adjectives meaning containing, producing, arising from, actuated by, related to, or associated with sound. *Acoustic* is used when the term being qualified designates something that has the properties, dimensions, or physical characteristics associated with sound waves. *Acoustical is* used when the term being qualified does not explicitly designate something that has such properties, dimensions, or physical characteristics.

*airborne sound:* sound that arrives at the point of interest by propagation through air.

*ambient noise:* all-encompassing sound at a given place, usually a composite of sounds from many sources. When the intent is to measure or record a specific source or signal, the ambient noise does not include sounds of interest.

*A-weighted sound level:* a sound level to which an A-weighting electrical filter, or its equivalent, has been applied that conforms with ANSI/ASA S1.4/Part 1/IEC 61672-1. This filter attenuates low- and high-frequency sound.

*background noise:* total of all sources of interference in a system used for the production, detection, measurement, or recording of a signal, independent of the presence of the signal. Ambient sound detected, measured, or recorded with the signal is part of the background noise. Included in the definition of background noise is the interference resulting from primary electric power supplies that are commonly described as hum.

*decibel (dB):* unit of the level, $L$, of a power or power-like quantity when the base of the logarithm is 10.

$$L = 10\log_{10}(Q/Q_0),\ \mathrm{dB}$$

where

$Q$ = is the power-like quantity concerned
$Q_0$ = is the corresponding reference value

*discrete frequency:* a sound wave, the instantaneous sound pressure of which is a simple sinusoidal function of time.

*far field:* the region not included in the near field.

*filter:* a device for separating sound signal on the basis of frequency.

*free field:* the region where the sound-pressure level decreases 6 dB from a given point source for each doubling of distance from the source. This region will exist if the sound source is in the free field or when in an enclosure, the enclosure is large enough so that the reverberant field had not been reached first. The acoustic field should be sufficiently distant from a distributed sound source so that the sound pressure decreases linearly with increasing distance (neglecting reflections, refraction, and absorption). Figure 2-1-1 depicts in a general way the application of this terminology.

$$p(r) \sim 1/r$$

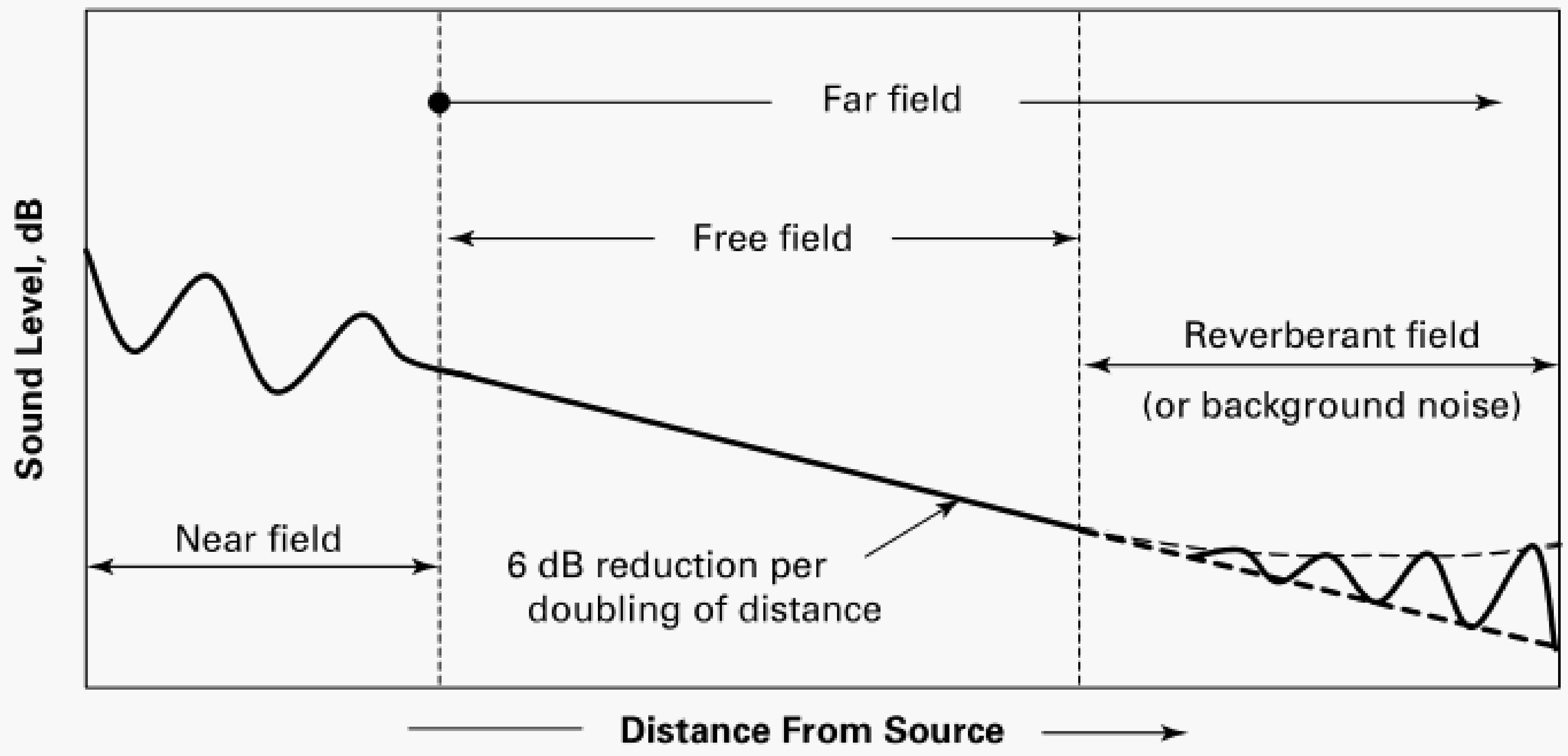
where

$p$ = pressure
$r$ = distance from source

Practically, the sound-pressure level decreases 6 dB with each doubling of distance from the acoustic source.

When making measurements inside buildings, the near field and reverberant field frequently overlap, eliminating the free field. See Figure 2-1-1.

**Figure 2-1-1 Generalized Depiction of Principal Near-Field and Far-Field Terminology**




*frequency:* The rate of change with time of the instantaneous phase of a sine function divided by 2π, with the dimensions of cycles per second or hertz (Hz).

*hertz (Hz):* see *frequency*.

*level:* in acoustics, logarithm of the ratio of a variable quantity to a corresponding reference value of the same units. The base of the logarithm, is assumed to be 10. Unless otherwise specified, the reference value and the kind of level are to be specified. See also ANSI/ASA S1.8.

*microphone:* electroacoustic transducer that produces electric signals when excited by acoustic signals.

*near field:* the part of the sound source field that lies between the source and the far field. In this region, the sound pressure does not decrease 6 dB for each doubling of distance from the source.

*octave band:* sound contained within a restricted frequency band where the highest frequency is twice the lowest frequency. Octave and one-third octave (octave band divided into three parts) band measurements are found on acoustical instruments. See also ANSI/ASA S1.6.

*reflecting surface:* an acoustically non-absorptive (acoustically hard) surface, as opposed to an acoustically absorptive (acoustically soft) surface.

*reverberant field:* the sound in an enclosed or partially enclosed space that has been reflected repeatedly or continuously from the boundaries.

*sound:* an oscillation in an elastic medium that can produce the sensation of hearing. Also, the sensation of hearing caused by a pressure oscillation.

*sound absorption:* reduction in sound energy as it reflects off a surface.

*sound level:* measured in decibels, a frequency-weighted sound-pressure level obtained using a sound-level meter whose weighting characteristics are specified in ANSI/ASA S1.4/Part 1/IEC 61672-1.

*sound-level meter:* a device that is used to measure sound-pressure level, functioning in accordance with the standard specifications for sound-level meters established by ANSI/ASA S1.4/Part 1/IEC 61672-1 and filters established by ANSI/ASA S1.11/Part 1/IEC 61260-1 (see Section 7).

*sound-power level ($L_w$):* ten times the logarithm to the base ten of the ratio of the sound power produced by the sound source to the reference power of $10^{-12}$ watts (W).

*sound-pressure level ($L_p$):* ten times the logarithm to the base ten of the ratio of the square of the sound pressure of the sound under consideration to the square of the standard reference pressure. The standard reference pressure is 20 micropascals (μPa) or its equivalent, $2 \times 10^{-5}$ N/m$^2$.

*tone:* a sound wave capable of exciting an auditory sensation of pitch (see also *discrete frequency*).

# Section 3
# Guiding Principle

## 3-1 CHOICE OF METHODS

Procedures described in ANSI/ASA S1.13 and ANSI/ASA S12.18 shall be used to measure airborne sound-pressure levels in a near field or far field under any conditions. ANSI/ASA S1.13 is primarily for indoor sound measurements, although it can be used outdoors, and ANSI/ASA S12.18 applies only to outdoor environments. If the sound-power level of outdoor sources must be characterized, the methods of other recognized standards may be used.

## 3-2 CONFIGURATIONS

*(a) Components to Be Tested.* Equipment being tested consist of a single component or an entire set of components that include all or part of an industrial facility. The equipment may be located indoors or outdoors and may include the enclosure building(s) as a source of noise. This Code utilizes, by reference, existing standards and provides additional informational guidance in the application of those methodologies (see Nonmandatory Appendix B).

*(b) Equipment Configuration.* A wide range of potential equipment configurations are allowed for indoor and outdoor noise sources. For those situations in which the receiver sound levels of indoor equipment is the objective, corrections shall be made for the reverberation effects of building surfaces (wall, floor, or ceiling).

## 3-3 TEST UNCERTAINTY

Tables 3-3-1 and 3-3-2 provide approximate limits for test data correction and the estimated amount of corresponding uncertainty for various grades of measurement accuracy. Table 3-3-1 defines the grade of accuracy available to the user of ASME PTC 36 based on the magnitude of the corrections. For example, a test for which the background noise correction exceeds 1.3 dB or the environmental correction exceeds 2 dB cannot be considered an engineering grade test. Therefore, the uncertainty of the test data degrades to survey grade (or special case), which results in a greater degree of uncertainty. Table 3-3-2 shows the estimated uncertainty associated with engineering grade and survey grade test results, expressed as the 95% confidence interval or 2 times the standard deviation. Both tables come from ISO 10494. Table 3-3-2 is slightly modified. If test result corrections exceed the allowable range for engineering grade or survey grade accuracy, the uncertainty will be greater than that shown in Table 3-3-2 and will require evaluation on a case-by-case basis.

In the absence of contractually negotiated test uncertainty, Table 3-3-2 can be used. If the test methodology has used one of the referenced standards in this Code, the uncertainty given in the referenced standard, if any, shall be stated. Nonmandatory Appendix B may be appropriate if the user of this Code is in a situation where he/she is required to test under conditions outside the allowable parameters in the referenced standards.

## 3-4 AGREEMENTS PRIOR TO TEST

The parties to a test conducted under this Code should reach agreement on the items listed in paras. 3-4.1 through 3-4.5 prior to the test. In many cases, the parties may need to agree on only one of the referenced standards.

**Table 3-3-1 Limits for Corrections**

| Grade of Accuracy | Background Noise Correction, dB | Environment Correction, dB |
|---|---|---|
| Grade 2 — Engineering | ≤1.3 | ≤2 |
| Grade 3 — Survey | ≤3 | ≤7 |
| Special Case [Note (1)] | >3 | >7 |

NOTE: (1) For higher values of background noise and/or environmental corrections, the real spatially averaged sound-pressure level cannot be determined with acceptable uncertainty, but the results can be useful to estimate an upper limit of the noise emission of the equipment to be tested.

**Table 3-3-2 Estimated Uncertainty Expressed as the 95% Confidence Interval**

| Grade of Accuracy | Octave Band Center Frequency | | | | | A-Weighted, dB |
|---|---|---|---|---|---|---|
| | 31.5 Hz to 63 Hz | 125 Hz | 250 Hz to 500 Hz | 1,000 Hz to 4,000 Hz | 8,000 Hz | |
| Engineering | 5 | 3 | 2 | 2 | 3 | 2 |
| Survey | … | … | … | … | … | 5 |

GENERAL NOTE: Survey uncertainty is related to stable conditions. Uncertainty for special cases will require evaluation on a case-by-case basis.

### 3-4.1 Test Objectives

The objective(s) of the test shall be defined as obtaining one or both of the following:
*(a)* near-field sound-pressure level
*(b)* far-field sound-pressure level

### 3-4.2 Sound Survey Report

The sound survey report shall be defined in terms of the following:
*(a)* acoustical instrumentation
*(b)* microphone locations and orientation
*(c)* data retrieval and archiving methods to be used, such as direct readout, data storage, and data recording
*(d)* data reduction required
*(e)* expected measurement uncertainty
*(f)* corrections

### 3-4.3 Acoustical Environment

The acoustical environment where the equipment components are to be tested shall be defined. The following variables shall be considered:
*(a)* free field or reverberant field
*(b)* reflecting surfaces
*(c)* contribution of auxiliary noise sources
*(d)* background noise
*(e)* atmospheric conditions

### 3-4.4 Operating Conditions

Equipment components to be tested shall be operated at conditions as stipulated. A record of the operating conditions shall be maintained. The following additional parameters shall be considered:
*(a)* location and mounting of equipment
*(b)* starting time of each acoustical test
*(c)* duration and number of tests
*(d)* number of times a measurement is made
*(e)* duration of operation at test conditions before measurements are made
*(f)* criteria for determining when test conditions are attained
*(g)* responsibility for control of operating conditions during test

### 3-4.5 Equipment Characteristics

Equipment to be tested shall be classified in terms of the following:
*(a)* size (physical dimensions); a controlled drawing, to be included in the report, may suffice
*(b)* mode of operation
*(c)* installation and mobility
*(d)* acoustical characteristics

## 3-5 SOUND MEASUREMENTS

Sound surveys shall be conducted by an engineer, technician, or acoustical consultant. The person making the test shall have sufficient experience in this area to have the skills and knowledge to collect and understand the measurement data. He or she shall provide a description of his/her skills and experience, as part of the report.

# Section 4
# Instruments and Methods of Measurement

## 4-1 INTRODUCTION

This Section describes acceptable procedures for measuring the sound-pressure levels of specific equipment components or of industrial installations comprising several separate components.

## 4-2 MEASUREMENT OF SOUND-PRESSURE LEVEL — GENERAL

The procedures presented herein shall be used to measure near-field or far-field sound-pressure levels of measurements of specific equipment components or a specific installation.

### 4-2.1 Instrumentation

The following instrumentation is required for the measurements outlined in this Code:

*(a)* sound-level meter and microphone system that comply with ANSI/ASA S1.4/Part 1/IEC 61672-1

*(b)* octave band and/or one-third octave band analyzer that comply with ANSI/ASA S1.11/Part 1/IEC 61260-1

*(c)* data recording equipment, if needed

*(d)* windscreen for microphone

*(e)* if the scope of the investigation involves the measurement of infrasound below 20 Hz, the following shall apply:

*(1)* Considerations shall be given to applicable measurement methodologies addressed in ANSI/ASA S12.9/Part 7, such as the use of special windscreens.

*(2)* Special instrumentation may be also needed. See ISO 7196.

*(f)* means of determining wind speed, wind direction, dry bulb temperature, and relative humidity

### 4-2.2 Laboratory Calibration

Instrument shall be calibrated in accordance with ANSI/ASA S1.4/Part 1/IEC 61672-1 and, if octave bands or one-third octave bands are measured with ANSI/ASA S1.11/Part 1/IEC 61260-1, the calibrations shall be made by an accredited laboratory, accredited by a body under the International Laboratory Accreditation Cooperation (ILAC). Calibrations shall be done per one of the following:

*(a)* in accordance with manufacturer's specifications

*(b)* at an interval justified per guidelines set forth in ILAC-G24-OIML D10

*(c)* at a time when laboratory calibration is reasonably suspected to be necessary based on condition or age of instrumentation, recent changes to instrumentation, or recent events that may have affected instrument calibration (e.g., potential damage to equipment)

### 4-2.3 Field Calibration/Sensitivity Check

Before and after each series of tests, and at least before and after each unattended series for continuous testing, the system shall be checked using an acoustical calibrator that complies with ANSI/ASA S1.40. The results of the pretest and posttest calibrations shall be documented. A variance of more than 1 dB may be cause to repeat measurements. It is recommended that the calibration be checked whenever batteries are changed and every few hours (if possible) when performing long-term measurements.

### 4-2.4 Operation of the Sound Source

The source shall be mounted and operated under conditions closely duplicating its actual configuration(s) and use(s). If the normal operating condition cannot be duplicated, the tests shall be made at some other agreed-upon condition and this condition shall be clearly described in the test report.

### 4-2.5 Test Environment

Near-field indoor and outdoor sound measurements shall be conducted in an environment that approximates, as nearly as possible, a free field situated above a reflecting plane and not influenced by specular reflections from walls and nearby projects. When this is not possible, an environmental correction shall be applied, as appropriate. The environmental correction for indoor sound measurements may be determined based on the acoustical absorption within the room; see the procedure in Nonmandatory Appendix B.

Regardless of whether strong discrete-frequency components are present, the test report for outdoor sound measurements shall note the presence of any reflective buildings, fences, walls, or other large structures that are located within a distance of 5λ of the microphone location, where λ is the wavelength determined as follows:

$$\lambda = c/f$$

where

$c$ = speed of sound
$f$ = center frequency of the lowest band of interest

For A-weighted levels, the presence of reflective buildings, fences, walls, or other large structures within 50 ft (15 m) of the microphone location shall be noted in the report.

Corrections for specular reflections shall be as defined in ISO 9613-2.

### 4-2.6 Background Sound-Pressure Level

While the test machine or facility is not operating, the background-sound level or sound-pressure level shall be measured at all the test microphone locations for all octave bands or one-third octave bands of interest. The background-sound measurements shall include the operation of any ancillary equipment necessary for the operation of the equipment being tested. See para. 4-2.8.

While the test machine is running, the sound-pressure level at each location should ideally exceed the background-sound level or sound-pressure level by at least 10 dB for each octave band. Sound-level differences less than 10 dB may be adjusted or corrected as provided in Mandatory Appendix I.

### 4-2.7 Microphone Positions

For measurements of near-field sound-pressure level, it is usually sufficient to select locations 3.3 ft (1 m) from the major vertical surfaces of the machine at a height of 5 ft ± 1 ft (1.5 m ± 0.3 m) above the floor or walk level. Measurement locations shall be established relative to an imaginary parallelepiped, which will just enclose the source, omitting minor projections.

### 4-2.8 Measurement Technique

The measurement techniques prescribed in the respective standards shall govern. If unique test conditions require departures from prescribed techniques, an explanation of the reasons for the departures shall be given in the final report.

In any measurement, the observer's body shall remain at least 1.6 ft (0.5 m) from the microphone. The observer shall in no event be between the microphone and the sound source. The microphone should be oriented as recommended by the manufacturer.

NOTE: If strong discrete-frequency components are present, large fluctuations in sound-pressure levels may occur because of the interference between direct sound waves and those from reflective surfaces such as the floor, the ground, or nearby walls or buildings. Atmospheric in-homogeneities exhibit similar influences on far-field measurements.

### 4-2.9 Test Conditions

The machinery under test shall be operated as agreed to by the parties involved. During the measurement of background sound-pressure level, all normally operating equipment that is not a part of the tested equipment scope of supply shall be operating to the maximum practical extent. However, it is not always feasible to continue to operate all equipment components that are not part of the test equipment scope of supply when the test equipment is turned off. In this event, the test report shall describe the conditions.

Reasonable care should be taken to obtain background sound-pressure level measurements and operational test measurements under the same general atmospheric conditions.

## 4-3 SPECIFIC MEASUREMENTS

### 4-3.1 Pressure Measurement

**4-3.1.1** The data forms of the standards referenced in this Code may be used to prepare test reports for the measurements obtained using the procedures of this Code. The data obtained using the procedures of this Code may be used to define the near-field sound-pressure levels or to determine far-field sound-pressure levels at prescribed positions.

**4-3.1.2** Refer to Nonmandatory Appendix B of this Code for guidelines regarding the application of the referenced procedures to expected industrial sound measurement situations.

**4-3.1.3** Distinguishing elements of the ANSI/ASA S12.18 procedure are as follows:

*(a)* ANSI/ASA S12.18 defines two methods for measuring sound-pressure levels; however, these provisions are specifically intended for measurements outdoors. Therefore, caution is required if these procedures are applied to near-field measurements indoors.

*(1) Method 1.* The general method outlines conditions for routine measurements and is used if meteorological variables fall within broad but predetermined limits. No effort is made to control the acoustical environment, i.e., the environment is accepted "as is". A hand-held sound-level meter, which provides a frequency-weighted and time-averaged sound level, is usually used for this method, but instruments for frequency band analysis may also be used.

*(2) Method 2.* This method describes strict meteorological, ground, and other conditions that, if maintained, enable accurate, reproducible measurements of sound-pressure levels. The acoustical environment may be left "as is," or it may be modified or controlled, per the method guidelines, for better accuracy. Procedures are suggested to adjust the measured sound-pressure levels to reference conditions. This precision method is suited for frequency band analysis, but also provides more accurate frequency-weighted sound-pressure levels, if required.

*(b)* Standardized receiver locations are not prescribed in ANSI/ASA S12.18.

### 4-3.2 Sound Measurement in the Near Field From Machinery or Facilities

**4-3.2.1** The procedures of the latest edition ANSI/ASA S12.18 shall be used to measure near-field sound-pressure levels from a piece of machinery, a component, or a group of components outdoors. The objective of ANSI/ASA S12.18 is to enable users to obtain sound-pressure measurements that are individually reproducible from a specific source or sources outdoors. However, aspects of the procedures may be adapted for use in measuring the sound-pressure levels in the near field of equipment indoors.

The immediate environment of the sound source and the local atmospheric conditions must be considered when near-field measurements are made. Near-field measurements are not intended to be used to extrapolate sound levels to other distances or locations.

**4-3.2.2** The following factors shall be determined prior to the near-field sound-pressure test:

*(a)* the purpose of the measurements, e.g., whether the test data will be used for the verification of compliance with equipment specification requirements or for engineering design calculations. The purpose of the measurements determines whether the general or precision measurement method is used.

*(b)* the locations from which measurements will be taken (or locations of the component being tested and the equipment recording the measurements).

*(c)* the operating condition for which the component under test will be measured.

**4-3.2.3** Near-field receiver positions shall conform to the following restrictions (see Figure 4-3.2.3-1):

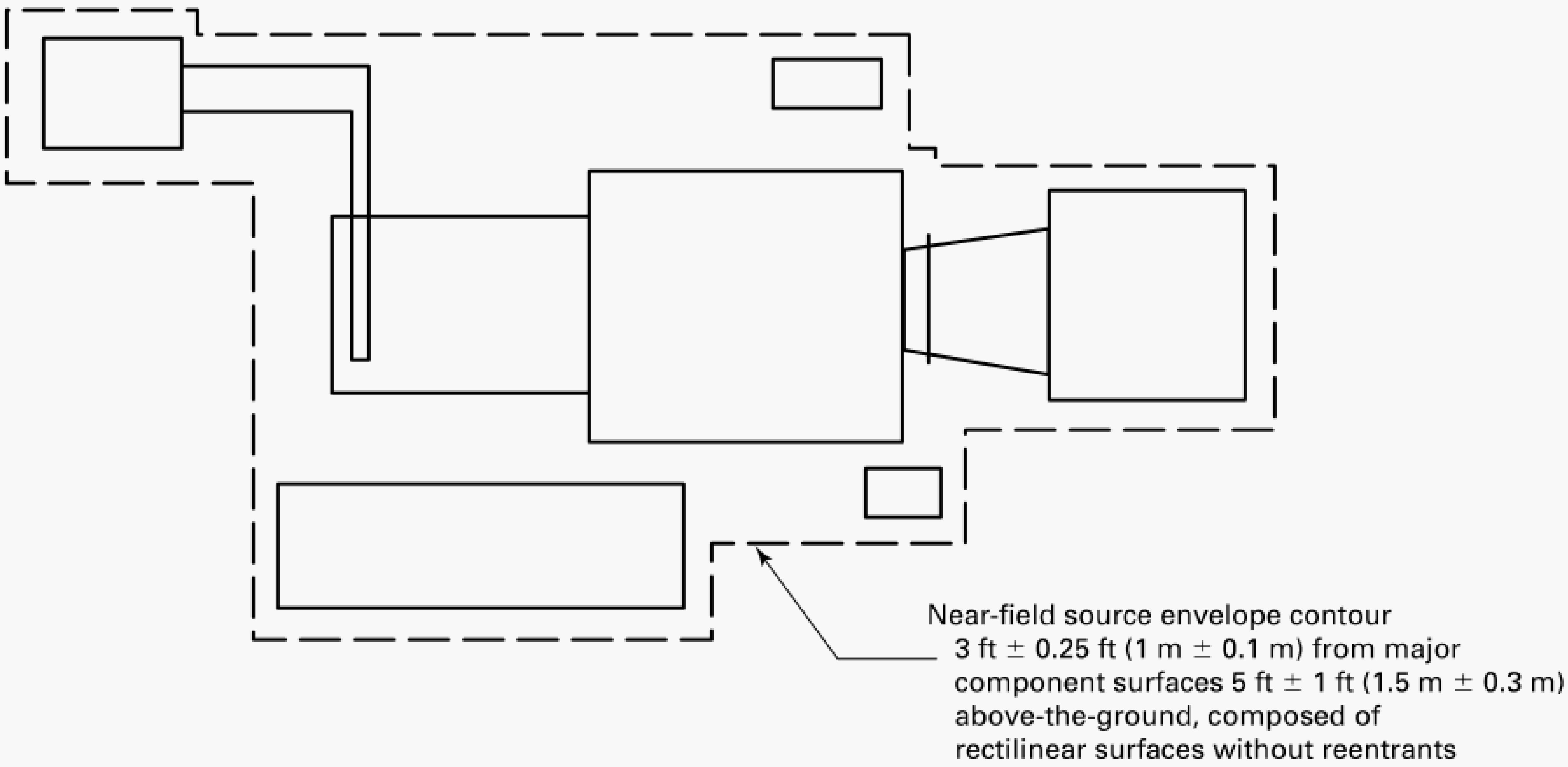
*(a)* The microphone height shall be 5 ft ± 1 ft (1.5 m ± 0.3 m) above the ground or personnel platform.

*(b)* The microphone positions shall be located on an imaginary measurement contour located 3 ft (1 m) from the major surfaces of the sound source, around the periphery of the sound source or its enclosure, including auxiliary equipment, at equally spaced intervals not exceeding 15 ft (5 m) and shall include the position of maximum sound emissions.

*(c)* The near-field measurement contour, as seen in plain view, shall be drawn to have no reentrants.

Figure 4-3.2.3-1 depicts acceptable near-field measurement locations relative to a single sound source. The equipment arrangement shown in Figure 4-3.2.3-1 is conceptual only; therefore the selection of near-field measurement positions in specific cases shall be modified, as necessary, through agreement among all parties in consideration of site-specific constraints.

**Figure 4-3.2.3-1 Near-Field Contours**




**4-3.2.4** Near-field measurements of the component under test shall be made for conditions in which the component is operated at its full, normal load or at other mutually agreed-upon operating conditions. The background noise shall be measured with the component not operating. These two measurements shall be made in a period during which the representative ambient conditions are reasonably similar. The representative ambient conditions may be determined using the guidance of Nonmandatory Appendix B.

### 4-3.3 Sound Measurement in the Far Field From Machinery or Facilities

**4-3.3.1** The procedures of the latest revision of ANSI/ASA S12.18 shall be used to measure the far-field sound-pressure levels from a piece of machinery, a component, or a group of components.

The objective of ANSI/ASA S12.18 is to enable users to obtain sound-pressure measurements that are individually reproducible from a specific source or sources outdoors. The source and receiver heights, type of ground, and local atmospheric conditions shall be considered when the measurements are taken. The measurements obtained using the recommended procedures can be used to calculate sound-pressure levels at other distances from the source or extrapolated to other environmental or ground conditions.

**4-3.3.2** The following factors shall be determined prior to the far-field sound-pressure test:

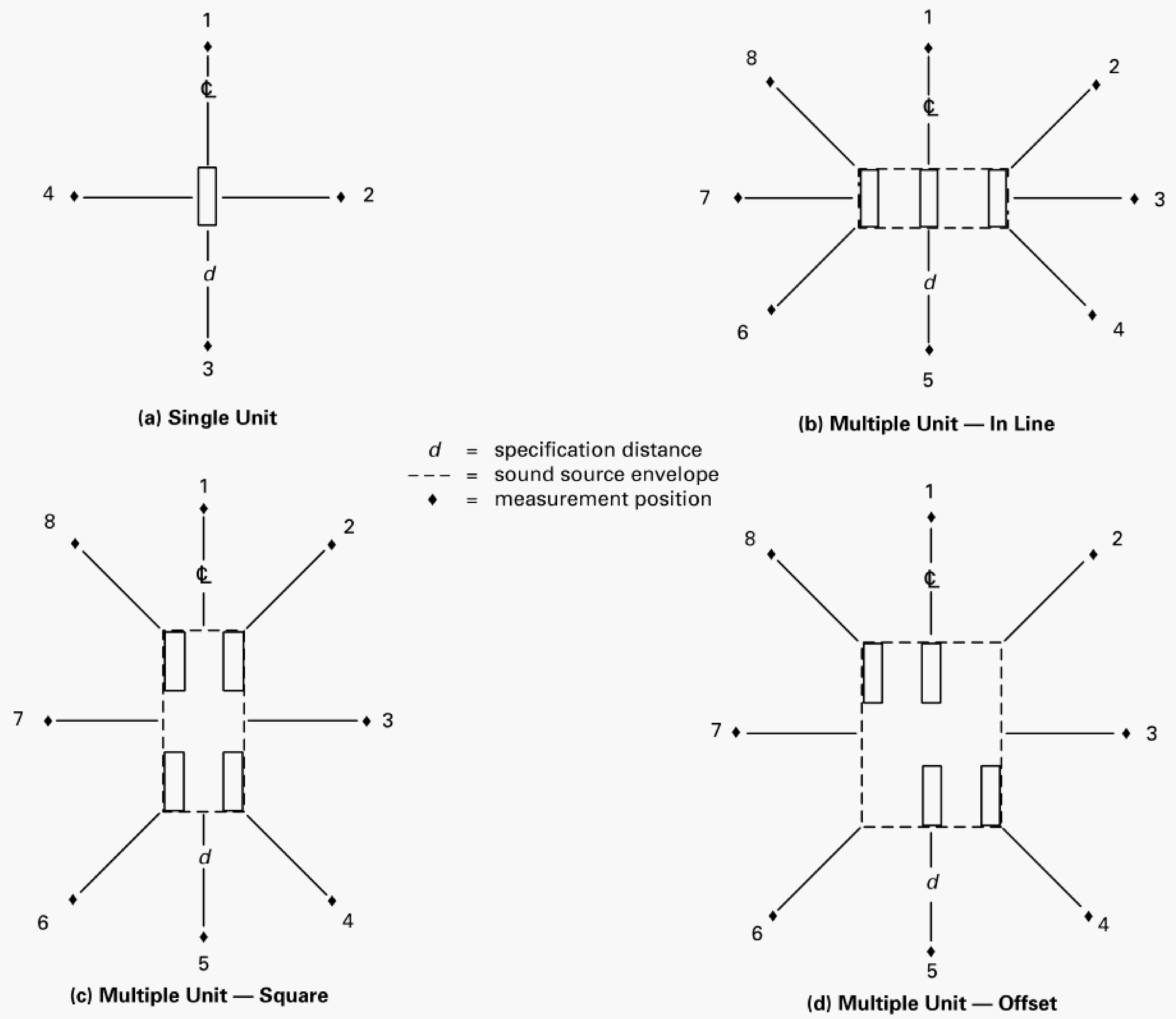
*(a)* the purpose of the measurements, e.g., whether the test data will be used for the verification of compliance with regulatory or equipment specification requirements or for engineering design calculations. The purpose of the measurements determines whether the general or precision measurement method is used.

*(b)* the locations of the receivers of interest. The receivers may be at a fixed distance and direction from the source equipment under test, or the receiver may be at another location of interest, such as the boundary line of a receiving property.

*(c)* the operating condition for which the component under test will be measured.

**4-3.3.3** Ideally, far-field receiver positions are selected such that they lie approximately in the acoustic far field, but not so far that the sound-pressure level is unduly influenced by ambient noise. A strict definition of the acoustical far field would mean the receiver location is at such a distance from the source that the source sound-pressure level is decreasing at the rate of 6 dB for each doubling of the distance between the receiver and the acoustic center of the source. Real situations, however, generally involve site specific conditions that constrain far-field receiver locations. Figure 4-3.3.3-1 depicts acceptable far-field measurement locations relative to a single sound source as well as a series of hypothetical alternate arrangements of multiple sound sources. Although the actual physical arrangement of the particular sound sources under test may not conform exactly to any of the arrangements depicted in Figure 4-3.3.3-1, these are intended to convey an approach to the selection of far-field measurement positions adaptable to specific cases, modified as

**Figure 4-3.3.3-1 Far-Field Measurements**




necessary through mutual agreement among all parties in consideration of site-specific constraints. The distance, *d*, in Figure 4-3.3.3-1 should be the same for all far-field positions at a given installation, so clearly some compromise is necessary in the selection of this measurement distance.

Industry practice for outdoor power plant installations have historically used a distance, *d*, of 400 ft (120 m). Other standard practices may exist in other industry categories.

In the absence of a specified and agreed-upon distance *d*, the distance, *d*, may be selected to be 400 ft (120 m). However, if a true far-field measurement location is necessary, *d* can be determined as the greater of the two distances shown below, provided the sound-pressure level is not unduly influenced by ambient noise.

*(a)* at least 2 times the greatest dimension of the sound source envelope

*(b)* at least 5 times the wavelength of the lowest acoustic frequency of interest

**4-3.3.4** Far-field measurements of the component under test shall be made for conditions in which the component is operated at its full, normal load or at other mutually agreed-upon operating conditions. The background noise shall be measured with the component not operating. These two measurements shall be made in a period during which the representative ambient conditions are reasonably similar. The representative ambient conditions may be determined using the guidance of Mandatory Appendix I.

# Section 5
# Computation of Results

## 5-1 GUIDELINES

In all cases, the computation of results shall conform to the requirements of the applicable method referenced in this Code.

Estimated uncertainty is as shown in Tables 3-3-1 and 3-3-2.

In the absence of prescribed methods for the determination of uncertainty in the applicable method referenced in this Code, or if site conditions exist such that the uncertainty values cited in Tables 3-3-1 and 3-3-2 are known to be inappropriate (i.e., weather or operating conditions are outside of the agreed range, excessive reflections or building reverberation exist, or sound cannot be measured at the prescribed locations), the computation in Nonmandatory Appendix A can be used. An uncertainty computation may be needed if conditions fall outside those prescribed in the referenced standards.

The uncertainty calculated from Nonmandatory Appendix A or as estimated from Table 3-3-2 may be used in the reporting of test results.

# Section 6
# Report of Results

## 6-1 TEST REPORT INFORMATION

When tests are made according to any of the methods referenced in this Code, the test report shall include the information listed in this Section.

## 6-2 GENERAL INFORMATION REQUIRED

*(a)* The test report shall include a summary of the test objective, the results, and conclusions.

*(b)* The test report shall include a statement of individual(s) authorizing the test, the objective, any contractual obligations, guarantees, or stipulated agreements between or among the parties to the test.

*(c)* The data reporting requirements of the respective referenced test procedures cited in this Code shall be met.

## 6-3 DESCRIPTION OF THE SOURCE OF SOUND

*(a)* The sound source or sources shall be described in appropriate detail including, as applicable, manufacturer, model, and description of the physical size of the equipment and relevant noise control measures to be noted.

*(b)* Auxiliary equipment shall be described, including relevant acoustical measurements.

*(c)* The operating conditions for the noise source(s), as well as the operating conditions of any equipment not included in the test objective, but which has potentially affected the measurements, shall be stated in appropriately specific terms.

*(d)* Appropriate notations shall be made of equipment mounting conditions, i.e., vibration isolators, if relevant.

*(e)* If vibration tolerances have been specified for the equipment under test and those tolerances constitute acceptable operating conditions, then such specifications shall be met during testing.

## 6-4 ACOUSTICAL ENVIRONMENT

*(a)* The test environment, especially if indoors, should be described as to size and location of surfaces and types of, or acoustical characteristics of, surface finishes, wherever relevant.

*(b)* The source location within the test environment shall be described, preferably graphically.

*(c)* If test is indoors, then the test room shall be described in terms of suitability for acoustical measurements.

*(d)* Any auxiliary equipment, extraneous structures, or other equipment not among the test objective equipment near the source(s) or potentially affecting the measurements shall be described, including relevant acoustical measurements.

*(e)* Atmospheric conditions shall be described. Required information for indoor measurements are temperature, relative humidity, and time of day. Required information for outdoor measurements are temperature, relative humidity, wind speed, wind direction, and time of day. If the test site is at an altitude of 1,000 ft (300 m) or more above sea level, or if the tested equipment is known to be intended for later installation at altitudes above 1,000 ft (300 m), the atmospheric pressure shall also be recorded. For outdoor measurements, the sky conditions or cloud cover should be recorded.

## 6-5 INSTRUMENTATION

*(a)* The instrumentation used shall be described by make, model, type, serial number, and date of last accredited laboratory calibration (see para. 4-2.3).

*(b)* A description of the relevant bandwidth limitations of the instrumentation shall be provided, if any.

*(c)* Relevant notations, appropriately comprehensive and consistent with the objectives of the test, i.e., the averaging time or dynamic meter response, as applicable, shall be provided.

*(d)* The method of field calibration of the measurement system shall be described.

## 6-6 ACOUSTICAL DATA TO BE RECORDED AND REPORTED

*(a)* The location of all measurement positions and microphone orientation shall be described.

*(b)* All measured source sound-pressure levels, weighted sound-pressure levels, or band sound-pressure levels shall be reported. All measured background ambient levels shall be reported in appropriate terms. All measured data required to be taken on other equipment not within the scope of the test, or to characterize the acoustical behavior of reflective surfaces or structures, shall be reported. The data shall be summarized or reported in the test report or as agreed to by the parties to the test.

*(c)* All adjustments and corrections for microphone and/or system shall be reported.

*(d)* Any derived average sound-pressure levels shall be averaged on an energy basis, unless otherwise agreed to by the parties to the test and such averaging shall be shown in the report.

*(e)* All correct calculations, e.g., for distance or background noise contributions, made to recorded data for distance, background noise contributions, or any other reason shall be reported.

# Section 7
# References

## 7-1 PAPERS

Johnson, Sr., Robert S. and Brittain, Frank H. "An Empirical Method To Improve Accuracy of In-Situ Power Measurements of Industrial Equipment," Proceedings, Noise-Con 2013, Denver, Colorado, August 26–28, 2013, pp. 510–519.

## 7-2 BOOKS

Kuttruff, Heinrich. "Room Acoustics," Taylor and Francis (Spon Press) 1999, ISBN13: 978-0-415-48021-5 (hbk); ISBN13: 978-0-203-87637-4 (ebk).

## 7-3 STANDARDS

ANSI/ASA S1.1-2013, Acoustical Terminology
ANSI/ASA S1.4-2014/Part 1/IEC 61672-1:2013, Electroacoustics — Sound Level Meters — Part 1: Specifications (a nationally adopted international standard)
ANSI/ASA S1.6-2016, Preferred Frequencies and Filter Band Center Frequencies for Acoustical Measurements
ANSI/ASA S1.8-2016, Reference Values for Levels Used in Acoustics and Vibrations
ANSI/ASA S1.11-2014/Part 1/IEC 61260-1:2014, Electroacoustics — Octave-band and Fractional-octave-band Filters — Part 1: Specifications (a nationally adopted international standard)
ANSI/ASA S1.13-2005 (R2010), Methods for the Measurement of Sound Pressure Levels in Air
ANSI/ASA S1.40-2006 (R2016), Specifications and Verification Procedures for Sound Calibrators
ANSI/ASA S12.9-2016/Part 7, Quantities and Procedures for Description and Measurement of Environmental Sound, Part 7: Measurement of Low-Frequency Noise and Infrasound Outdoors in the Presence of Wind and Indoors in Occupied Spaces
ANSI/ASA S12.18-1994 (R2009), Procedures for Outdoor Measurement of Sound Pressure Level
ANSI/ASA S12.54-2011/ISO 3744:2010 (R2016), Acoustics — Determination of Sound Power Levels of Noise Sources Using Sound Pressure — Engineering Methods in an Essentially Free Field Over a Reflecting Plane
ANSI/ASA S12.56-2011/ISO 3746:2010 (R2016), Acoustics — Determination of Sound Power Levels and Noise Sources Using Sound Pressure — Survey Method Using an Enveloping Measurement Surface Over a Reflecting Plane
Publishers: The Acoustical Society of America (ASA), Suite 300, 1305 Walt Whitman Road, Melville, NY 11747-4300 (www.acousticalsociety.org); International Organization for Standardization (ISO), Central Secretariat, Chemin de Blandonnet 8, Case Postale 401, 1214 Vernier, Geneva, Switzerland (www.iso.org)

ASME B133.8-2011, Gas Turbine Installation Sound Emissions
ASME PTC 19.1-2013, Test Uncertainty
Publisher: The American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990 (www.asme.org)

ILAC-G24-OIML D10, Edition 2007, Guidelines for the determination of calibration intervals of measuring instruments
Publisher: The ILAC Secretariat, P.O. Box 7507, Silverwater NSW 2128, Australia (www.ilac.org)

ISO 7196:1995, Acoustics — Frequency-weighting characteristic for infrasound measurements
ISO 9613-2:1996, Acoustics — Attenuation of sound during propagation outdoors — Part 2: General method of calculation
ISO 10494:1993, Gas turbines and gas turbine sets — Measurement of emitted airborne noise — Engineering/survey method
ISO/IEC Guide 98-3, Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)

Publisher: International Organization for Standardization (ISO), Central Secretariat, Chemin de Blandonnet 8, Case Postale 401, 1214 Vernier, Geneva, Switzerland (www.iso.org)

# MANDATORY APPENDIX I BACKGROUND NOISE AND DISTANCE CORRECTIONS FOR FAR-FIELD MEASUREMENTS

## I-1 INTRODUCTION

Whenever far-field measurements are to be performed, either for the purpose of characterizing a source or comparison to an agreed-upon criterion, it is often necessary to make corrections due to the influence of background noise or for necessity of measuring at a distance other than what is prescribed by the applicable standard.

## I-2 DISCUSSION

### I-2.1 Measurement

In determining the background noise to be subtracted from the total measured sound level, typically, one measures the total background noise at each position of interest when the source is not operating. The potential problem with such a procedure is the possibility of the background noise changing between the time of the background-only measurement and the total operational measurement. The unknown magnitudes of such background-noise changes are a source of error in far-field measurements. There are a number of ways to minimize this error; two of the methods are provided in this Appendix.

### I-2.2 Long-Term Monitoring at Each Measurement Position

In anticipation of the time of day during which the total operational measurement will be performed at each monitoring position (the "survey"), a series of short duration, average background-noise measurements would be obtained at each position (the "background"). The time window during which the background measurements are obtained should bracket the expected survey measurement time for each position. The number of individual background measurements obtained should be sufficient to enable a determination of the average trend of the background noise. It should be noted that variations from day to day will introduce an additional variable, so that the accuracy of the average background noise will be improved with additional surveys on successive days, remembering that background-noise trends during weekend days tend to be different from those during weekdays. The use of the L90 level, that level exceeded 90 percent of the time during the measurement period, is encouraged as a means of defining the background level.

### I-2.3 Control Position Monitoring

A "control" microphone position is used in those cases where it is reasonable to expect that the variations in background noise will be approximately the same at the entire set of far-field measurement positions as well as the control position, and the control position is distant enough that the source in question will be essentially inaudible. In such a case, the background readings are obtained at each measurement position as well as at the control position. Then the background noise is measured at discrete intervals continuously for the duration of the survey at the far-field measurement positions. All measurements should consist of the same average time. In this case, any differences between the background noise at the control positions without the source operating relative to the level with the source operating, may be applied to the background noise measured at each position of interest before the corrections are made.

## I-3 DISTANCE CORRECTION

A distance correction shall be applied to the measured data obtained with the sound source operating, in the event that site-specific constraints require a measurement position to be located at a distance from the source that is different from the distance that was prescribed by the standard method being used.

### I-3.1 Calculation

The distance correction shall be calculated as follows:

$$L_c = L_{ra} - 20\log_{10}(R_c/R_a) \tag{I-1}$$

where:

$L_c$ = distance corrected sound level
$L_{ra}$ = actual measured sound level at the measurement position
$R_a$ = distance from the estimated acoustical center of the source to the actual measurement position
$R_c$ = distance from the estimated acoustical center of the source to the prescribed measurement position

NOTE: This equation can be used only in the far field.

### I-3.2 Application

For the purposes of this Code, a distance correction may only be made from an actual measurement position that is closer to the source than what was prescribed.

## I-4 BACKGROUND NOISE CORRECTION

If the total measured operational sound-pressure level does not exceed the background sound-pressure level by 10 dB or more, the background sound-pressure level shall be used to correct the measured operational sound-level data obtained with the test machinery operating as described below.

For example, if the background sound-pressure level is 79 dB and the total sound-pressure level with the machine operating, is 84 dB, then the corrected sound-pressure level is 82.4 dB, in accordance with the following expression:

$$L_C = 10\log_{10}\left[10^{(0.1L_t)} - 10^{(0.1L_b)}\right] \tag{I-2}$$

where

$L_b$ = measured background sound-pressure level, dB
$L_C$ = background corrected sound-pressure level or sound level, dB
$L_t$ = total measured operational sound-pressure level, or sound level, dB

Corrections for background sound-pressure level do not eliminate extraneous sounds from associated system components that are not part of the test equipment, i.e., piping, intercoolers, accessories. Correcting for the influence of these sound sources requires supplementary measurement techniques, which should be determined beforehand.

If the total measured operational sound-pressure level exceeds the background sound-pressure level by 10 dB or more, no background sound-pressure level correction is necessary.

When the measured operational sound-pressure level is less than 3 dB above background sound-pressure level, the uncertainty in instrumentation and measurements suggest that the corrections are not valid. A corrected machine sound-pressure level may be reported, but must be qualified in the report as having been determined using a difference of less than 3 dB.

# NONMANDATORY APPENDIX A EVALUATION OF MEASUREMENT UNCERTAINTY

## A-1 INTRODUCTION

Measurements that result from the use of this Code may be compared with other similar measurement results, design goals, or criteria. For such a comparison to be valid, the uncertainty of the measurement results must be stated. It is the responsibility of the experienced acoustician making the measurements to determine this measure of uncertainty based upon measurement results, observations made during the measuring, and general knowledge. This Appendix presents the methodology for evaluating measurement uncertainty.

The source standards used in the development of this Code and the guidelines of the preceding discussion on uncertainty have been used to develop Table 3-3-2, which shows the estimated range of uncertainty when using this Code in the event that rigorous uncertainty analysis is not performed. These uncertainties may be used to evaluate the results of surveys conducted using this Code.

## A-2 UNCERTAINTY COMPONENTS OF TYPE A AND TYPE B

The measurement uncertainty of each of the reported acoustic quantities shall be derived and reported as the combined standard uncertainty in the manner defined in this Appendix.[1] Additional guidance on applying the methods is contained in the latest edition of ISO/IEC Guide 98-3. In this Appendix, a distinction is made between Type A uncertainty components that are evaluated by using statistical methods on a series of repeated determinations and Type B uncertainty components that are evaluated by judgment using different kinds of relevant information, including experience from similar situations. Uncertainty components of both Types A and B are expressed as standard deviations and are combined by the combination of variances method to form the combined standard uncertainty.

## A-3 SITE EFFECTS

When the uncertainty of the measurement results is evaluated, it is important to take into account the influence that the actual measurement site can have upon the acoustic conditions of the microphone mounting. The site effects are Type B uncertainty components.

### A-3.1 Uncertainty on Acoustic Parameters

**A-3.1.1 Apparent Spatially Averaged Sound-Pressure Level.** This paragraph describes the uncertainty components that, based upon current knowledge, are the most important with respect to the apparent spatially averaged sound-pressure level.

**A-3.1.1.1** The parameter describing the Type A uncertainty is the standard error of the estimated $L_{Aeq}$. This is found from a standard analysis of variance and designated as $U_A$.

**A-3.1.1.2** The following are considered uncertainty components of Type B:

$U_{B1}$ = calibration of the acoustic instruments
$U_{B2}$ = tolerances on the chain of acoustic instrumentation
$U_{B3}$ = uncertainty on the acoustic conditions for microphone mounting
$U_{B4}$ = uncertainty on the distance from microphone to source
$U_{B5}$ = uncertainty on the acoustic impedance of air
$U_{B6}$ = uncertainty on the acoustic emission of source due to changing weather conditions, if measured outdoors
$U_{B7}$ = unaccounted-for background-noise correction

[1] This Appendix has been adapted from a draft document to revise ASME PTC 19.1 supplement that has since been published as ASME PTC 19.1-2013. ASME PTC 19.1-2013 has in turn been substantially harmonized with the ISO/IEC Guide 98-3.

**Table A-3.1.1.3-1 Examples of Possible Values of Type B Uncertainty Components Relevant for Apparent Spatially Averaged Sound-Pressure Level**

| Component | Possible Typical Range (±*a*) | Possible Typical Standard Uncertainty | Possible "Worst Case" Standard Uncertainty |
|---|---|---|---|
| $U_{B1}$ calibration | ±0.3 dB | 0.2 dB | 0.3 dB |
| $U_{B2}$ instrument | ±0.3 dB | 0.2 dB | 0.4 dB |
| $U_{B3}$ mount | ±0.5 dB | 0.3 dB | 0.9 dB |
| $U_{B4}$ distance | ±0.1 dB | 0.1 dB | 0.2 dB |
| $U_{B5}$ impedance | ±0.2 dB | 0.1 dB | 0.3 dB |
| $U_{B6}$ weather | ±0.7 dB | 0.4 dB | 0.9 dB |
| $U_{B7}$ background | equals the applied correction | e.g., 0.1 dB | 0.8 dB |

For all of the Type B uncertainties mentioned here, a rectangular distribution of possible values is assumed for simplicity with a range described as $\pm a$. The standard deviation for such a distribution is

$$U = \frac{a}{\sqrt{3}} \tag{A-1}$$

**A-3.1.1.3** In Table A-3.1.1.3-1, possible values of the standard uncertainty components are given as examples. They can be used as guidance for evaluations to be made in actual cases.

The combined standard uncertainty is found as the root sum of the squared components

$$U_C = \sqrt{U_A^2 + U_{B1}^2 + U_{B2}^2 + \ldots} \tag{A-2}$$

Taking an example where the standard error on the estimated $L_{Aeq}$ ($U_A$) is 0.5 dB (typical) or 1.5 dB (worst), the combined standard uncertainties can be found as $U_C$ = 0.8 dB (typical) and $U_C$ = 2.2 dB (worst). In cases with pronounced source or site effects, a larger uncertainty is to be expected.

**A-3.1.2 Directivity.** As an example of the standard uncertainty on the directivity, $\sqrt{2}$ times the combined standard uncertainty of the apparent sound pressure can be used in cases where a more detailed uncertainty analysis is not made.

**A-3.1.3 Octave or One-Third Octave Band Spectra.** For the octave or one-third octave band, the $U_A$ for each band is the standard error on the averaged band level, computed as the standard deviation divided by $\sqrt{(N-1)}$, where $N$ is the number of measured spectra ($N > 5$).

In Table A-3.1.1.3-1, the value $U_{B3}$ in octave bands or one-third octave bands must be considered to be much larger than for A-weighted sound level; estimated typical values are 1.2 dB and 1.7 dB for octave band and one-third octave bands, respectively.

**A-3.1.4 Tonality.** For tonality, $U_A$ for each tone is the standard error on the averaged maximum tone level. The value of $U_{B3}$ can be estimated to be 1.7 dB.

# NONMANDATORY APPENDIX B GENERAL GUIDANCE FOR SOUND-PRESSURE LEVEL MEASUREMENTS

## B-1 FACTORS AFFECTING SOUND-PRESSURE LEVEL

The sound-pressure level near a source is a function of the source characteristics and the environment. Important source characteristics are the directivity and near-field sound-pressure levels. For indoor measurements, important considerations are the proximity of reflecting surfaces, acoustical absorption, and room volume. Methods developed in ANSI/ASA S1.13, should be followed for all indoor measurements.

Important outdoor considerations are the ambient temperature, wind velocity and direction, relative humidity, nearby reflecting surfaces, and intervening terrain. Measurements of sound-pressure levels change with the interference from such test environment variables.

In a laboratory setting, environmental factors can be controlled or accounted for, and more precise measurements can be made. Measurements using this Code are not expected to be made in laboratory settings.

## B-2 DETERMINING ENVIRONMENTAL CORRECTIONS

The environmental correction based on room absorption, here designated as $K_{2A}$, may be calculated using eq. B-1 (Johnson, Sr., Robert S. and Brittain, Frank H.). When detailed information on acoustical properties of the room walls is not known, the absorption coefficient, $\bar{\alpha}_R$, may be estimated from Table B-2-1 by substituting the mean sound-absorption coefficient, $\alpha_R$.

The sound-pressure level is measured 3 ft (1.0 m) from the equipment skid at a height of 5 ft ± 1 ft (1.5 m ± 0.3 m) above the ground.

The sound source is assumed to consist of pumps, compressors, generators, gas turbines, and electric motors (often with the last two driving the first three, etc.) mounted on a common skid or mounted independently. It also applies to the totality of equipment inside an enclosure, in which case the enclosure's outside surface would be considered the sound source. The enclosure can be a floor-mounted enclosure, a skid-mounted enclosure, or a partial enclosure. With a floor-mounted enclosure, the skid and equipment would not be visible. If the enclosure is skid mounted, the sound source would include both the enclosure and skid. The governing parameter is the volume of the equipment enclosure relative to the volume of the equipment room

$$K_{2A} = 10\log_{10}\left[1 + 4\frac{(S_{ms})}{S_R\bar{\alpha}_R + S_E\bar{\alpha}_E + 4mV_R}\right]\left[\ln\left(\frac{V_R}{V_E}\right) + 1\right]^{-1}, \text{ dB} \tag{B-1}$$

where

$m$ = air attenuation constant = 0.00208, $m^{-1}$

$S_E$ = surface area of the equipment enclosure, $m^2$

$S_{ms}$ = measurement surface area of an imaginary parallelepiped from the enclosure, and surrounding the enclosure, $m^2$

$S_R$ = surface area of the room, $m^2$

$V_E$ = volume of the equipment enclosure, $m^3$

$V_R$ = volume of the equipment room, $m^3$

$\bar{\alpha}_E$ = outside surface absorption coefficient of the equipment enclosure

$\bar{\alpha}_R$ = surface absorption coefficient of room walls

NOTE: The definition of $m$ is from Kuttruff: Table 6.1, p. 150.

**Table B-2-1 Approximate Values of the Mean Sound Absorption Coefficient, $\alpha_R$**

| Mean Sound Absorption Coefficient, $\alpha_R$ | Room Description |
|---|---|
| 0.05 | Nearly empty with smooth, hard walls of concrete, brick, plaster, or tile |
| 0.10 | Partially empty with smooth walls |
| 0.15 | Right cuboid machinery or industrial with furniture |
| 0.20 | Irregularly shaped machinery or industrial with furniture |
| 0.25 | Machinery or industrial with upholstered furniture and sound-absorbing material on part of ceiling or walls |
| 0.30 | Sound-absorbing ceiling with no sound-absorbing material on walls |
| 0.35 | Sound-absorbing materials on both ceiling and walls |
| 0.50 | Large amounts of sound-absorbing materials on ceiling and walls |

In planning a series of far-field sound-pressure measurements using ANSI/ASA S12.18, the purpose of the measurements should be kept clearly in mind. Whether General Method 1 or the Precision Method 2 is selected depends upon the required accuracy of the measurements. In many situations, the measurement procedure of the general method may be entirely adequate. The precision method is used when more precise measurements are required or for an analysis of the sound-pressure levels in frequency bands from measurements made under prescribed meteorological and ground conditions over an appropriate time interval.

Selection of far-field receiver positions may be difficult if, between the source component and the desired receiver location, there exists intervening terrain, vegetation, or barriers, or if there are reflective surfaces nearby. The field data report should indicate all factors that the surveyor judges to be significant, and reasons for any adjustments to far-field positions.

If it is not possible to completely shut down the component under test, or if high or variable background-noise levels exist at the desired receiver location, the contribution of the component may be indeterminate. In the case of far-field sound-pressure level surveys, a "traverse" test may be conducted. This is a series of receiver measurement locations that traverse the distance between the far-field position most proximate to the component and the desired distant receiver position. A sufficient number of traverse test locations should be selected such that a clear trend for sound level with increasing distance can be determined. Also, it is convenient, for trend-analysis purposes, to select locations at distances from the component under test that follow a geometric progression, e.g., positions at 50 ft (15.3 m), 100 ft (30.5 m), 200 ft (61 m), 400 ft (122 m), and 800 ft (244 m) from the source envelope.

# PERFORMANCE TEST CODES (PTC)

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| PTC 6A-2000 (R2016) | Appendix A to PTC 6, The Test Code for Steam Turbines |
| PTC 6 | PTC 6 on Steam Turbines – Interpretations 1977-1983 |
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| PTC 47.1-2017 | Cryogenic Air Separation Unit of an Integrated Gasification Combined Cycle Power Plant |

| | |
|---|---|
| PTC 47.4-2015 | Power Block of an Integrated Gasification Combined Cycle Power Plant |
| PTC 50-2002 (R2014) | Fuel Cell Power Systems Performance |
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