Designation: E1704 – 95 (Reapproved 2010)

Standard Guide for Specifying Acoustical Performance of Sound-Isolating Enclosures[1]

This standard is issued under the fixed designation E1704; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 The guide covers the development of criteria for the acoustical performance of a broad variety of acoustical enclosures by identifying information necessary to unambiguously describe acoustical performance. This guide is not a standard ASTM specification for a sound-isolating enclosure.

1.2 Excluded from the scope of this guide are technical considerations for enclosure design that do not pertain directly to acoustical performance.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C423 Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method

C634 Terminology Relating to Building and Environmental Acoustics

E336 Test Method for Measurement of Airborne Sound Attenuation between Rooms in Buildings

E413 Classification for Rating Sound Insulation

E596 Test Method for Laboratory Measurement of Noise Reduction of Sound-Isolating Enclosures

2.2 *ANSI Standards:*

ANSI S1.4 Specification for Sound Level Meters[3]

ANSI S3.1 Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms[3]

ANSI S3.6 Specification for Audiometers[3]

ANSI S12.31–S12.35 Methods for Determining the Sound Power Levels of Machines and Equipment[3]

2.3 *ISO Standard:*

ISO 3741–3745 Acoustics—Methods for Determining the Sound Power Levels of Machines and Equipment[4]

2.4 *Government Standard:*

29 CFR 1910.95 Occupational Noise Exposure [Occupational Safety and Health Administration][5]

2.5 *Other Standard:*

VDI 2711 Schallschutz durch Kapeslung [Verein Deutscher Ingeireure, Beuth Verlag GmbH, Berlin] [German] [Noise Control by the Use of Enclosures][6]

3. Terminology

3.1 *Definitions:*

3.1.1 Standard definitions of acoustical terms may be found in Terminology C634.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *A-weighted sound pressure level*—sound pressure level measurements made with the A-weighting filter applied as defined in ANSI S1.4, denoted L_{PA} in this guide.

3.2.2 *C-weighted sound pressure level*—sound pressure level measurements made with the C-weighting filter applied as defined in ANSI S1.4, denoted L_{PC} in this guide.

3.2.3 *enclosure*—a structure, usually free-standing, which substantially or completely encloses a given space or object. This does not include barrier walls, partitions within a building, or other partial structures.

3.2.4 *enclosure-generated noise*—sound created by the operation of the enclosure systems, such as lighting and ventilation.

3.2.5 *level reduction*—for the purposes of this guide, the arithmetic difference between sound pressure levels at a specific location before and after the installation of the enclosure, expressed in decibels.

[1] This guide is under the jurisdiction of ASTM Committee E33 on Building and Environmental Acoustics and is the direct responsibility of Subcommittee E33.03 on Sound Transmission.

Current edition approved May 1, 2010. Published August 2010. DOI: 10.1520/E1704-95R10.

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

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

[4] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

[5] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

[6] Available from Beuth Verlag GmbH, Burggrafenstrasse 4-7, 1000 Berlin 30.

3.2.6 *level reduction specification*—specification of the acoustical performance of an enclosure by stating the reduction in sound pressure level caused by the enclosure.

3.2.7 *personnel enclosure*—an enclosure designed to keep sound energy from personnel or equipment therein. Examples of personnel enclosures include but are not limited to audiometric booths, in-plant offices, broadcast booths, and acoustical test chambers.

3.2.8 *pre-installation sound pressure levels*—the sound pressure levels, as a function of frequency, that are present prior to the installation of the enclosure. In most cases this is determined by measuring the ambient sound pressure levels in the host area but in some cases, such as new construction, the sound pressure levels must be predicted.

3.2.9 *sound pressure level specification*—specification of the acoustical performance of an enclosure by stating the maximum sound pressure levels that shall exist after installation.

3.2.10 *source enclosure*—an enclosure designed to keep sound energy from personnel or equipment on the outside. Such applications include, but are not limited to, equipment silencing, secure communications, music practice, and acoustical testing.

4. Summary of Guide

4.1 An explanation of the determination and subsequent specification of acoustical performance of sound-isolating enclosures is presented.

4.2 Two types of specifications are described in this guide. The recommended method (sound pressure level specification) is to specify the maximum permissible sound pressure levels that may be present after installation of the enclosure. The alternate method (level reduction specification) is to specify the enclosure's level reduction.

4.3 The type of specification selected depends largely on the enclosure application and the data available. A sound pressure level specification usually applies to a specific site, while the level reduction specification may have broader application. Also, the sound pressure level specification is more appropriate where specific sound pressure levels are required, while the level reduction specification reflects a more general interest in amounts of noise level reduction.

4.4 Some guidance is provided in Appendix X1 on selecting a specification type based on the enclosure application and the information available.

4.5 Substantial guidance is given on the essential acoustical data that must be compiled.

4.6 A non-mandatory model specification Appendix X2 is included that embraces both specification types. It also serves as a guide for identifying and gathering information necessary to the manufacturer for designing the enclosure.

5. Significance and Use

5.1 This guide can be used to produce a specification for the acoustical performance of an enclosure.

5.2 This guide is intended for those familiar with basic concepts of acoustics.

5.3 Although this guide provides detailed guidance in matters relating to specification of acoustical enclosures, it is not a substitute for the experience and judgment of an acoustical or noise control professional.

5.3.1 This guide calls for measurements common within acoustical practice.

5.3.2 The more critical the performance requirements of the enclosure, the more the user should consider seeking the services of an acoustics or noise control professional.

5.4 The specifying of a sound-isolating enclosure has three sequential steps:

5.4.1 Determine the sound pressure levels that exist at specific locations prior to the introduction of the enclosure,

NOTE 1—In the case of new construction, the sound pressure level is often estimated from the sound power levels of noise-emitting equipment and a general description of the acoustical properties of the environment.

5.4.2 Determine the maximum permissible sound pressure levels that must exist at the same locations after the introduction of the enclosure, and

5.4.3 Determine the required enclosure level reduction. The required isolation is related to the difference between the sound pressure levels before and after the introduction of the enclosure.

5.5 Many specifications are for multiple enclosures or enclosures with multiple functions, or both. It is beyond the scope of this guide to provide detailed guidance for every possible combination. Separate specifications for each source-enclosure-receiver combination should be used in such a case.

5.6 The type of specification that should be selected depends both on the purpose of the enclosure and how crucial its performance is. In general:

5.6.1 If exceeding a particular maximum permissible sound pressure level spectrum would render the enclosure unsuccessful, a sound pressure level specification should be used.

5.6.1.1 This guide assigns all phases of acoustical design are delegated to the supplier. Compliance is usually more easily verified than with the level reduction method.

5.6.2 If the criteria for the success of the enclosure are less stringent or not related to a specific maximum permissible spectrum, a level reduction specification may be used.

6. Recommended Specifications

6.1 The sound pressure level specification specifies the maximum permissible sound pressure levels that may exist either inside or outside the enclosure after installation. Pre-installation sound pressure levels must also be presented.

6.1.1 Maximum sound pressure levels should be specified in one-third-octave bands whenever possible to allow a detailed fit to the requirements. Octave band sound pressure levels are appropriate where the noise spectrum is broad band and free of prominent tones.

6.1.2 The desired post-installation sound pressure level may also be described by a single number descriptor, such as

A-weighted sound pressure level or NC or RC ratings.[7] In this event, the pre-installation one-third-octave band sound pressure levels at or around the installation site shall also be provided.

NOTE 2—Other single number ratings for noise may also be available. For further information see ASHRAE Handbook.[7]

6.1.3 Measured sound pressure levels are preferred. When not available, such as in the case of new construction, the following information is usually considered an acceptable substitute to allow estimation of sound pressure levels:

6.1.3.1 The rated or measured sound power level (here denoted L_W) of equipment and,

6.1.3.2 A description of the host environment, including the relative locations of sources of noise, personnel, and the enclosure. Some loss of accuracy should be expected.

6.1.4 Inaccurate measurement of sound pressure levels can result from unsteady or intermittent sources of noise during measurement, changes in site conditions after measurement (for example, significant sources of noise arising between measurement and installation), strong low-frequency content ($L_{PC} - L_{PA} > 15$), and general inexperience with acoustical measurements.

6.1.5 Maximum permissible sound pressure levels are often prescribed for particular applications by standards or regulatory documents. A short list includes, but is not limited to, hearing conservation regulations, architectural specifications, human comfort, speech intelligibility, speech privacy, and acoustical test standards. Common specific cases are cited in Appendix X1.

6.1.6 The maximum permissible interior or exterior sound pressure levels should not be exceeded with all sources of enclosure-generated noise in normal operation.

6.2 The level reduction specification identifies the minimum permissible level reduction to be provided by the enclosure. This type specification is often used by a buyer who has already determined the isolation needed to meet his sound pressure level requirements. Using this type of specification without such analysis could result in unacceptable results.

6.2.1 Level reduction $I(f)$ can be approximated as follows:

$$I(f) = L_1 - L_2 + SF$$

where:

L_1 = pre-installation sound pressure level in a given band,
L_2 = post-installation sound pressure level in a given band, and
SF = safety factor.

6.2.1.1 The safety factor helps ensure compliance by accounting for unforeseen complications due to changes in site conditions, or unusual acoustical interactions of the enclosure and the space. The more critical the successful performance of the enclosure, the larger the selected safety factor should be. Typical values are:

Not Critical....	SF = 0 dB
Moderate....	SF = 3 dB
Conservative....	SF = 6 dB

NOTE 3—In practice safety factor size varies with frequency as well as with importance. The user should consider applying stringent safety factors only in bands where they are most needed in order to avoid over-designing the enclosure.

6.2.1.2 The introduction of the enclosure may significantly alter the sound field near the noise source, increasing both the effective value of L_1 and the required level reduction. This effect is important when either the physical volume or the sound absorption coefficients of the surfaces around the noise source are reduced by a factor of two or more. In this case, detailed information on noise source and its pre-installation surroundings should accompany the specification. In addition, a larger safety factor should be considered.

6.2.2 The level reduction of enclosures is typically quantified by the manufacturer in laboratory prototype testing. Noise reduction (NR) is measured per Test Method E596, and noise isolation class (NIC) is calculated per Classification E413. For the purposes of this guide, noise reduction data are an acceptable equivalent for level reduction.

6.2.2.1 Custom designs are typically not tested, due to cost.

6.2.2.2 The actual enclosure being specified may differ in certain particulars from prototypes tested.

6.2.2.3 Because of variations in manufacturing materials and methods and changes in test standards, test results should be no older than five years.

6.2.2.4 Laboratory noise reduction data obtained in accordance with Test Method E596 in prototype testing are often accepted as performance verification.

6.2.3 An enclosure may provide the required level reduction without achieving a particular sound pressure level spectrum in the protected space. As an example, sound pressure levels inside an enclosure will be considerably higher when the enclosure is located in a high ambient noise area.

7. Other Noise Control Properties of Enclosures

7.1 *Vibration Isolation*—The effectiveness of an enclosure can be compromised by structure-borne noise bypassing the acoustical barrier through adjacent building structures. Enclosures should be isolated from adjacent structures by means of flexible connections.

7.1.1 Vibrations that can be felt by the hand are an indication that measurements of vibration levels are necessary.

NOTE 4—In typical installations, structure-borne vibration treatments are part of the enclosure. Special cases, for example, broadcast studios, generally require measurement or analysis of structure-borne vibration patterns of the host environment prior to specification, or both, where applicable.

NOTE 5—The L_a measurement and treatment of structure-borne vibration are difficult. Measurements are complicated and an ineffective treatment can actually be counterproductive. In critical situations an expert should be consulted.

7.2 *Interior Sound Absorption*—Most applications benefit from sound absorption within the enclosure. Insufficient sound absorption has two effects: a more reverberant sound field can affect speech intelligibility and the ability to localize sound generated within the enclosure. Low sound absorption can reduce sound isolation performance.

7.2.1 Sound absorption is properly expressed in terms of the sound absorption coefficient of the absorbing surfaces determined in a laboratory in accordance with Test Method C423.

[7] *ASHRAE Handbook, Fundamentals*, Chapter 7, American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, Georgia.