Designation: E2963 – 22

Standard Test Method for Laboratory Measurement of Acoustical Effectiveness of Ship Noise Treatments Laboratory Measurement of Acoustical Effectiveness for Marine Bulkhead and Deck Treatments[1]

This standard is issued under the fixed designation E2963; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

This test method is designed to measure the acoustical effectiveness of treatments that are intended to reduce airborne noise on ships. Such treatments would be applied to compartment structural partitions such as bulkheads, decks, and side shells. To fully characterize the acoustical performance of a treatment, five parameters must be assessed: transmission loss, radiation efficiency, acceptance, absorption, and damping. This test method focuses on the assessment of the first three of these parameters. Tests discussed in this method are based on the Test Method E90 setup and procedure. This test method is not intended to be a replacement of Test Method E90; conversely, this method builds on the E90 method that is now well established. Similarly, this test method does not replace absorption testing discussed in Test Method C423, nor damping testing discussed in Test Method E756. The use of these standards is strongly encouraged to assess absorption and damping, respectively, if these are the primary features of the noise control material.

1. Scope

1.1 This test method covers the laboratory measurement of the acoustical effectiveness of treatments installed on ship bulkheads, decks, and side shells. Measurements are focused on assessing changes in transmission loss, radiation efficiency, and acceptance that occur when treatments are applied. Measurements of changes to absorption and damping are addressed in Appendix X1 and Appendix X2, respectively.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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

1.4 Any material that is to be installed on a marine division must meet appropriate fire, combustibility, and other applicable SOLAS, USCG, IMO, Navy, or other required non-acoustical standards and specifications. See Appendix X3 for additional information.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

C634 Terminology Relating to Building and Environmental Acoustics

E90 Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

E756 Test Method for Measuring Vibration-Damping Properties of Materials

[1] This test method is under the jurisdiction of ASTM Committee E33 on Building and Environmental Acoustics and is the direct responsibility of Subcommittee E33.10 on Structural Acoustics and Vibration.

Current edition approved April 1, 2022. Published April 2022. Originally approved in 2014. Last previous edition approved in 2016 as E2963 – 16. DOI: 10.1520/E2963-22.

[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.

2.2 *ANSI Standards:*[3]

ANSI S1.4-1983 (R2006) Specification for Sound Level Meters

ANSI S1.6-1984 (R2011) Preferred Frequencies, Frequency Levels, and Band Number for Acoustical Measurements

ANSI S1.8-1989 (R2011) ,Reference Quantities for Acoustical Levels

ANSI S1.11-2004 (R2009) Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters

ANSI S1.43-1997 (R2007) Specifications for Integrating-Averaging Sound Level Meters

2.3 *ISO Stadnard:*[4]

ISO 16063-1:1998 , Methods for the Calibration of Vibration and Shock Transducers

3. Terminology

3.1 *Definitions*—Terms used in this standard are defined either in Terminology C634 or within this standard. The definition of terms explicitly given within this standard take precedence over definitions given in Terminology C634. The definitions within Terminology C634 and this standard take precedence over any other definitions of defined terms found in any other documents, including other documents that may be referenced in this standard.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *acceptance, n*—a measure of the vibration velocity level induced in a structure that is exposed to a diffuse sound field composed of one or more frequencies (see Eq 6).

3.2.2 *acoustical effectiveness, n*—a measure of the change in a particular acoustical parameter that is created by the addition of a material to the base structure.

3.2.3 *radiation efficiency, n*—a measure relating the sound pressure level in a diffuse sound field that is produced by a vibrating structural surface, referenced to a specified vibration velocity level, when that surface is moving in an oscillatory motion at one or more frequencies (see Eq 8).

3.2.4 *test or 'base' structure, n*—The structure representing a bulkhead, deck, or shell of a ship.

3.2.4.1 *Discussion*—The base structure is typically constructed with steel or aluminum stiffened plating, though other construction types are possible. This is the structure to which treatments are applied.

3.3 *Symbols:*

A = room constant, m^2
S = area of partition (structure under test), m^2
a = acceleration, m/s^2
c = speed of sound in air, m/s
dB = decibels
f = frequency, Hz
p = pressure, Pa
v = velocity, m/s
L_a = vibration acceleration level, dB re: 10 $\mu m/s^2$
L_p = sound pressure level, dB re: 20 µPa. Lv – velocity level, dB re: 10 nm/s (that is, 10^{-8} m/s)
L_A = acceptance in decibels referenced to 20 µPa/10 nm/s
L_σ = radiation efficiency in decibels
TL = transmission loss in decibels
ΔX = change in the quantity "X" between treated and non-treated test cases
α = sound absorption coefficient
η = loss factor, (no dimensions)
ρ = density, kg/m^3

3.4 All levels expressed in decibels have a reference quantity. A level expressed in decibels is 10 times the common logarithm of the ratio of a squared quantity divided by a squared reference quantity. For example, the reference quantity for sound pressure level is 20 micropascals. The abbreviated level is written as dB re: 20 µPa

4. Summary of Test Method

4.1 The effectiveness of a given treatment is determined by comparing the acoustical properties of a given structure with and without the treatment applied. Measurements are first performed on a 'baseline' test structure (that is, without the treatment in place). The treatment is then added to the structure and tests are repeated. The differences in acoustical parameters between the treated and non-treated structures determine the acoustical effectiveness of the treatment.

4.2 The general test setup discussed in Test Method E90 shall be used. Two adjacent reverberation rooms are arranged with an opening between them in which a test partition is installed.

4.3 Transmission loss, acceptance, and radiation efficiency (as well as absorption and damping) are all functions of frequency, and measurements are made in a series of frequency bands.

4.4 For measurement of transmission loss, Test Method E90 shall be used to test both the treated and non-treated structures. Fig. 1 presents a schematic diagram of the test setup, for reference purposes.

4.5 For the measurement of acceptance, the same test setup discussed in Test Method E90 is used with accelerometers attached to the test structure. An approximately diffuse sound field is produced in the source room; the space- and time-averaged sound pressure levels are measured in this room. The vibration levels of the test structure are simultaneously measured to produce a space- and time-averaged vibration level of the structure (see Fig. 2). These quantities (sound pressure level and test structure vibration level) are combined to determine the acceptance for the test structure, as shown in Section 13.

4.6 For the measurement of radiation efficiency, the same test setup discussed in Test Method E90 is used. Accelerometers are located on the test structure along with an electromechanical vibration exciter. The vibration exciter drives the structure, which then radiates sound into the receiver room. The sound field produced in this room is considered to be diffuse. The room's space- and time-averaged sound pressure levels are measured, as well as the structure's space- and

[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, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.