Designation: E756 − 05 (Reapproved 2023)

Standard Test Method for Measuring Vibration-Damping Properties of Materials[1]

This standard is issued under the fixed designation E756; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method measures the vibration-damping properties of materials: the loss factor, η, and Young's modulus, *E*, or the shear modulus, *G*. Accurate over a frequency range of 50 Hz to 5000 Hz and over the useful temperature range of the material, this method is useful in testing materials that have application in structural vibration, building acoustics, and the control of audible noise. Such materials include metals, enamels, ceramics, rubbers, plastics, reinforced epoxy matrices, and woods that can be formed to cantilever beam test specimen configurations.

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

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E548 Guide for General Criteria Used for Evaluating Laboratory Competence (Withdrawn 2002)[3]

2.2 *ANSI Standard:*

S2.9 Nomenclature for Specifying Damping Properties of Materials[4]

3. Terminology

3.1 *Definitions*—Except for the terms listed below, ANSI S2.9 defines the terms used in this test method.

3.1.1 *free-layer (extensional) damper*—a treatment to control the vibration of a structural by bonding a layer of damping material to the structure's surface so that energy is dissipated through cyclic deformation of the damping material, primarily in tension-compression.

3.1.2 *constrained-layer (shear) damper*—a treatment to control the vibration of a structure by bonding a layer of damping material between the structure's surface and an additional elastic layer (that is, the constraining layer), whose relative stiffness is greater than that of the damping material, so that energy is dissipated through cyclic deformation of the damping material, primarily in shear.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *glassy region of a damping material*—a temperature region where a damping material is characterized by a relatively high modulus and a loss factor that increases from extremely low to moderate as temperature increases (see Fig. 1).

3.2.2 *rubbery region of a damping material*—a temperature region where a damping material is characterized by a relatively low modulus and a loss factor that decreases from moderate to low as temperature increases (see Fig. 1).

3.2.3 *transition region of a damping material*—a temperature region between the glassy region and the rubbery region where a damping material is characterized by the loss factor passing through a maximum and the modulus rapidly decreasing as temperature increases (see Fig. 1).

3.3 *Symbols*—The symbols used in the development of the equations in this method are as follows (other symbols will be introduced and defined more conveniently in the text):

[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.

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[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] The last approved version of this historical standard is referenced on www.astm.org.

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

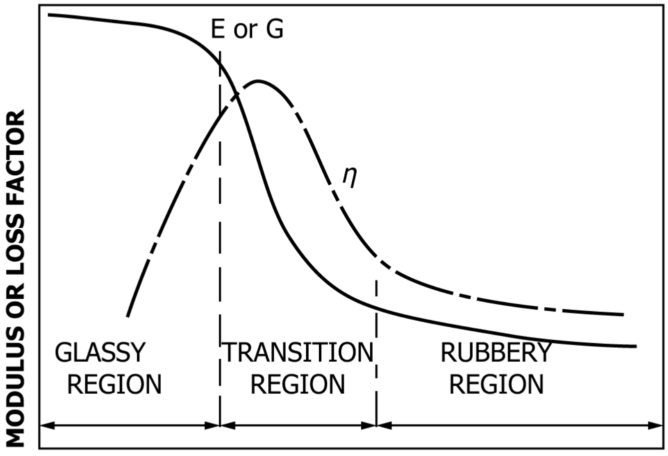

FIG. 1 Variation of Modulus and Material Loss Factor with Temperature
(Frequency held constant)
(Glassy, Transition, and Rubbery Regions shown)

E = Young's modulus of uniform beam, Pa
η = loss factor of uniform beam, dimensionless
E_1 = Young's modulus of damping material, Pa
η_1 = loss factor of damping material, dimensionless
G_1 = shear modulus of damping material, Pa

4. Summary of Method

4.1 The configuration of the cantilever beam test specimen is selected based on the type of damping material to be tested and the damping properties that are desired. Fig. 2 shows four different test specimens used to investigate extensional and shear damping properties of materials over a broad range of modulus values.

4.1.1 Self-supporting damping materials are evaluated by forming a single, uniform test beam (Fig. 2a) from the damping material itself.

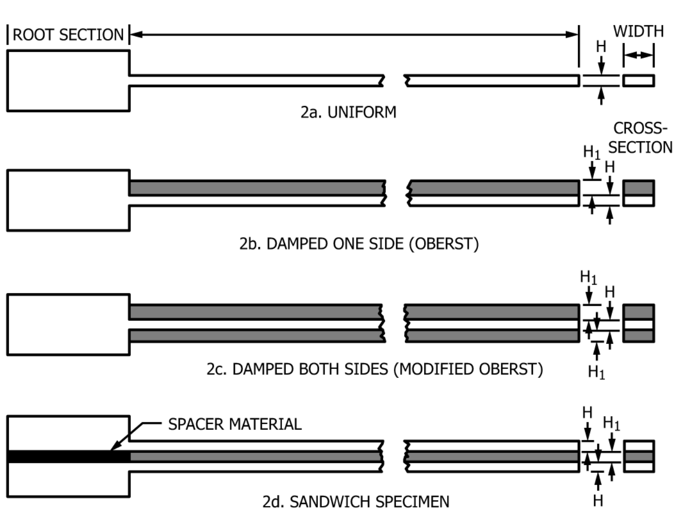

FIG. 2 Test Specimens

4.1.2 Non–self-supporting damping materials are evaluated for their extensional damping properties in a two-step process. First, a self-supporting, uniform metal beam, called the base beam or bare beam, must be tested to determine its resonant frequencies over the temperature range of interest. Second, the damping material is applied to the base beam to form a damped composite beam using one of two test specimen configurations (Fig. 2b or Fig. 2c). The damped composite beam is tested to obtain its resonant frequencies, and corresponding composite loss factors over the temperature range of interest. The damping properties of the material are calculated using the stiffness of the base beam, calculated from the results of the base beam tests (see 10.2.1), and the results of the composite beam tests (see 10.2.2 and 10.2.3).

4.1.3 The process to obtain the shear damping properties of non-self-supporting damping materials is similar to the two step process described above but requires two identical base beams to be tested and the composite beam to be formed using the sandwich specimen configuration (Fig. 2d).

4.2 Once the test beam configuration has been selected and the test specimen has been prepared, the test specimen is clamped in a fixture and placed in an environmental chamber. Two transducers are used in the measurement, one to apply an excitation force to cause the test beam to vibrate, and one to measure the response of the test beam to the applied force. By measuring several resonances of the vibrating beam, the effect of frequency on the material's damping properties can be established. By operating the test fixture inside an environmental chamber, the effects of temperature on the material properties are investigated.

4.3 To fully evaluate some non-self-supporting damping materials from the glassy region through the transition region to the rubbery region may require two tests, one using one of the specimen configurations (Fig. 2b or Fig. 2c) and the second using the sandwich specimen configuration (Fig. 2d) (See X2.6).

5. Significance and Use

5.1 The material loss factor and modulus of damping materials are useful in designing measures to control vibration in structures and the sound that is radiated by those structures, especially at resonance. This test method determines the properties of a damping material by indirect measurement using damped cantilever beam theory. By applying beam theory, the resultant damping material properties are made independent of the geometry of the test specimen used to obtain them. These damping material properties can then be used with mathematical models to design damping systems and predict their performance prior to hardware fabrication. These models include simple beam and plate analogies as well as finite element analysis models.

5.2 This test method has been found to produce good results when used for testing materials consisting of one homogeneous layer. In some damping applications, a damping design may consist of two or more layers with significantly different characteristics. These complicated designs must have their constituent layers tested separately if the predictions of the mathematical models are to have the highest possible accuracy.