Standard Test Methods for Vibration Testing of Shipping Containers[1]

This standard is issued under the fixed designation D999; 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 These test methods cover vibration tests of filled shipping containers. Such tests may be used to assess the performance of a container, with its interior packing and means of closure, both in terms of its strength and of the protection it provides its contents when it is subjected to vibration such as it experiences in transportation. These procedures are suitable for testing containers of any form, material, kind, design of interior packing, means of closure, and any size and weight. They are not intended for determining the response of products to vibration for product design purposes, nor are they intended for tests of products in their operational configuration as other more suitable procedures are available for these purposes.[2,3]

1.2 The following methods appear:

Method A1—Repetitive Shock Test (Vertical Motion).
Method A2—Repetitive Shock Test (Rotary Motion).
Method B—Single Container Resonance Test.
Method C—Palletized Load, Unitized Load, or Vertical Stack Resonance Test.

1.3 For testing of intermediate bulk containers (IBCs) containing liquid hazardous materials, refer to Test Method D7387.

1.4 These test methods fulfill the requirements of International Organization for Standardization standards ISO 8318 and ISO 2247. *The ISO standards may not meet the requirements for these methods.*

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *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.* Specific precautionary statements are given in Section 6.

2. Referenced Documents

2.1 *ASTM Standards:*[4]

D996 Terminology of Packaging and Distribution Environments
D3580 Test Methods for Vibration (Vertical Linear Motion) Test of Products
D4169 Practice for Performance Testing of Shipping Containers and Systems
D4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing
D7387 Test Method for Vibration Testing of Intermediate Bulk Containers (IBCs) Used for Shipping Liquid Hazardous Materials (Dangerous Goods)
E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

2.2 *ISO Standards:*

ISO 2247 Packaging—Complete, Filled Transport Packages—Vibration Test at Fixed Low Frequency[5]
ISO 8318 Packaging—Complete, Filled Transport Packages—Vibration Tests Using a Variable Frequency[5]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in these test methods, see Terminology D996.

3.1.2 *double amplitude, n*—the maximum value of a sinusoidal quantity (peak-to-peak).

3.1.3 *octave, n*—the interval between two frequencies having a ratio of two (2).

[1] These test methods are under the jurisdiction of ASTM Committee D10 on Packaging and are the direct responsibility of Subcommittee D10.21 on Shipping Containers and Systems - Application of Performance Test Methods.

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[2] Military Standard Environmental Test Methods, MIL-STD-810F, Method 514, Vibration, available from www.dodssp.daps.mil/dodssp.htm.

[3] International Electrotechnical Commission Recommendation, Publication 68-2-6, Part 2, Test F: Vibration, Basic Environmental Testing Procedures for Electronic Components and Electrical Equipment, available from American National Standards Institute, Inc., 25 W. 43rd St., 4th Floor, New York, NY 10036.

[4] 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.

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

3.1.4 *power spectral density (PSD), n*—used to quantify the intensity of random vibration in terms of mean-square acceleration per unit of frequency. The units are g^2/Hz ((m/s^2)^2/Hz), where g is the acceleration of gravity, equal to 386 in./s^2 (9.8 m/s^2). Power spectral density is the limiting mean square value in a given rectangular bandwidth divided by the bandwidth, as the bandwidth approaches zero.

3.1.5 *repetitive shock, n*—impacts of a package on a test platform which occur cyclically from input oscillatory motion.

3.1.6 *resonance, n*—for a system undergoing forced vibration, the frequency at which any change of the exciting frequency, positive and negative, in the vicinity of the exciting frequency causes a decrease in the response of the system.

4. Significance and Use

4.1 Shipping containers are exposed to complex dynamic stresses when subjected to vibration present in all transportation vehicles. Approximating the actual damage, or lack of damage, experienced in shipping may require subjecting the container(s) and contents to vibration inputs.

4.2 Resonant responses during shipment can be severe and may lead to package or product failure. Identification of critical frequencies, and the nature of package stresses can aid in minimizing the effect of these occurrences.

4.3 Vibration tests should be based on representative field data. When possible, the confidence level may be improved by comparing laboratory test results with actual field shipment data. It is highly recommended that one understand the most common failures to one's products and packaging in distribution, and then attempt to replicate those failures in the laboratory. Once such replication is established, then that test can become the minimum necessary test for future packaged products to pass.

4.4 Exposure to vibration can affect the shipping container, its interior packaging, means of closure, and contents. These tests allow analysis of the interaction of these components. Design modification to one or more of these components may be utilized to achieve optimum performance in the shipping environment.

4.5 *Methods A1 and A2, Repetitive Shock Tests,* are suitable for tests of individual containers that are transported unrestrained on the bed of a vehicle and may be suitable for tests of containers that might be subjected to repetitive shocks due to magnification of vibrations in unit loads or stacks.

NOTE 1—Methods A1 and A2 produce different vibration motions, and therefore, will generate different forces which may result in different damage modes and intensities. Results from these two methods may not correlate with one another.

4.6 *Method B, Single Container Resonance Test,* tests or determines the ability of an individual container and its interior packaging to protect the contents from transportation vibration, particularly when the container and its contents might exhibit resonant responses.

NOTE 2—Individual products that are palletized might be better tested using Method C.

4.7 *Method C, Palletized Load, Unitized Load or Vertical Stack Resonance Test,* covers the determination of the presence and the effects of resonance in palletized loads and multiple-unit stacked loads, and whether or not the strength of the containers is sufficient to withstand dynamic loads when stacked.

4.8 Any or all of these test methods may be employed, as determined by the appropriate performance specification, with test intensities, frequency ranges, and test durations as called for in the specification. Although these tests do not simulate the shipping environment, they are intended to create the damage-producing potential of the shipping environment. Results of any one of these methods may differ from the results of the others.

5. Apparatus

5.1 *Method A1—Repetitive Shock Test (Vertical Motion):*

5.1.1 *Vibration Test Machine,* with a platform having a horizontal surface of sufficient strength and rigidity so that the applied vibrations are essentially uniform over the entire test surface when loaded with the test specimen. The platform shall be supported by a mechanism that vibrates it so the motion is approximately a vertical sinusoidal input. (A rotary motion of the platform is not acceptable.) The double amplitude displacement of the vibration shall be fixed at or controlled to 1 in. (25 mm), and the frequency shall be variable within the range from 2 to at least 5 Hz (cycles per second). The vibration test machine shall be equipped with fences, barricades, or other restraints to keep the test specimen from falling off the platform without restricting its vertical motion.

5.2 *Method A2—Repetitive Shock Test (Rotary Motion):*

5.2.1 *Vibration Test Machine,* with a platform having a horizontal surface of sufficient strength and rigidity so that the applied vibrations are essentially uniform over the entire test surface when loaded with the test specimen. The platform shall be supported by a mechanism that vibrates it so that the motion is a rotational input with the vertical component approximately sinusoidal. The double amplitude displacement of the vibration shall be fixed at 1 in. (25 mm), and frequency shall be variable from 2 to at least 5 Hz (cycles per second). The vibration test machine shall be equipped with fences, barricades, or other restraints to keep the test specimen from falling off the platform without restricting its vertical motion.

5.3 *Metal Shim:*

5.3.1 A metal shim is used in Methods A1 and A2 for determining when the shipping container is leaving the testing platform by a sufficient amount as described in Section 9.

5.3.2 Specifications for metal shim used in Methods A1 and A2:

Width: 50 mm (20. in.) minimum
Thickness: 1.6 mm (1⁄16 in.)
Length: 254 mm (10 in.) minimum

5.4 *Methods B and C—Resonance Tests:*

5.4.1 *Vibration Test Machine,* with a platform having a horizontal surface of sufficient strength and rigidity so that the applied vibrations are essentially uniform over the entire test surface when loaded with the test specimen. The platform shall be supported by a mechanism capable of producing vibration in