



## Standard Methods for Vibration Testing of Shipping Containers<sup>1</sup>

This standard is issued under the fixed designation D 999; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 These 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.<sup>2,3</sup>

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 *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.

1.4 These 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.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:

D 4169 Practice for Performance Testing of Shipping Containers and Systems<sup>4</sup>

<sup>1</sup> These methods are under the jurisdiction of ASTM Committee D-10 on Packaging and are the direct responsibility of Subcommittee D10.22 on Handling and Transportation.

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<sup>2</sup> Military Standard Environmental Test Methods, MIL-STD-810D, Method 514, Vibration, available from Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA 19120.

<sup>3</sup> 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., 11 W. 42nd St., 13th Floor, New York, NY 10036.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 15.09.

D 4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing<sup>4</sup>

E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality of a Lot or Process<sup>5</sup>

#### 2.2 ISO Standards:

ISO 2247 Packaging—Complete, filled transport packages—Vibration test at fixed low frequency<sup>6</sup>

ISO 8318 Packaging—Complete, filled transport packages—Vibration tests using a variable frequency<sup>6</sup>

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *resonance*—a vibration of large amplitude in a mechanical system caused by a relatively small periodic stimulus of the same or nearly the same period as the natural vibration period of the system.

#### 3.2 Definitions of Terms Specific to This Standard:

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

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

3.2.3 *repetitive shock*—impacts of a package on a test platform which occur cyclically from input vibration.

### 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.

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

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 14.02.

<sup>6</sup> Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

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.

## 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 of 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 the vertical motion.

5.3 *Methods B and C—Resonance Tests* (also suitable for Method A 1):

5.3.1 *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 a sinusoidal vibration in the vertical linear plane at controlled accelerations or displacements, or both, over a controlled continuously variable range of frequencies. (A rotary motion of the platform is not acceptable.) Suitable fixtures and attachment points shall be provided to rigidly attach the test container to the platform for Method B. Restraints shall be provided to restrain the horizontal motion of the test specimens on the platform without restricting the vertical motion of the specimen(s), for Method C.

5.4 *Instrumentation*—Accelerometers, signal conditioners, and data display or storage devices are required to measure and control the accelerations at the test surface in Methods B and C. Instrumentation may also be desirable for monitoring the response of the containers and packaged items. The instrumentation system shall have a response accurate to within  $\pm 5\%$  over the range specified for the test. Detailed information on suitable instrumentation may be found in the *Shock and Vibration Handbook*.<sup>7</sup>

5.5 *Conditioning Apparatus*—Adequate facilities shall be provided for conditioning test specimens at selected humidity and temperature prior to or during the test, or both, in accordance with the requirements of the applicable specification.

## 6. Safety Precautions

6.1 These test methods may produce severe mechanical responses of the test specimens. Therefore, fences, barricades, and other restraints must have sufficient strength and must be adequately secured. Operating personnel must remain alert to potential hazards and take necessary precautions for their safety. Stop the test immediately if a dangerous condition should develop.

## 7. Test Specimens

7.1 The test specimen shall consist of the container, as intended for shipment, loaded with the interior packaging and the actual contents for which it was designed. Blemished or rejected products may be used, if the defect is recorded prior to the test. Dummy test items should be used for developmental testing when necessary, but may not be used for final acceptance testing.

NOTE 3—Surrogate material may be used when actual product is unacceptable for use (for example, package testing for hazardous materials).

7.2 Sensors and transducers may be applied with the minimum possible alteration of the test specimen, to obtain data on the container or packaged item. When it is necessary to observe

<sup>7</sup> Harris, C. M., and Crede, C. E., *Shock and Vibration Handbook*, McGraw-Hill, New York, NY, 1976, Chapter 16.