Designation: D7387 – 13

Standard Test Method for Vibration Testing of Intermediate Bulk Containers (IBCs) Used for Shipping Liquid Hazardous Materials (Dangerous Goods)[1]

This standard is issued under the fixed designation D7387; 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 This test method covers vibration testing of filled intermediate bulk containers (IBCs) intended to contain liquid hazardous materials (dangerous goods) and is suitable for testing IBCs of any design or material with any means of closure. This test method has been used by the United States Department of Transportation (DOT) to test and qualify IBCs for shipping hazardous materials. The test method is used to determine that the IBCs maintain integrity and to prevent leakage or spillage of contents during shipping. This test method should be used as a screening tool or as a design qualification test. Other vibration methods are available to more closely simulate vibration experienced in transportation.

1.2 This test method is appropriate for testing IBCs ranging from 450 to 3000 L (119 to 793 gal). Packagings of smaller sizes should be tested using Test Methods D999 or other applicable methods.

1.3 The ISO 2247 standard may not meet the requirements for this test method.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.5 *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:*[2]

D996 Terminology of Packaging and Distribution Environments

D999 Test Methods for Vibration Testing of Shipping Containers

D4169 Practice for Performance Testing of Shipping Containers and Systems

D4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing

2.2 *ISO Standards:*[3]

ISO 2247 Packaging—Complete, Filled Transport Packages—Vibration Test at Fixed Low Frequency

2.3 *Regulatory Documents:*[4]

CFR 49 United States Department of Transportation Code of Federal Regulations Title 49, Transportation, Parts 100–199

2.4 *United Nations Document:*[5]

United Nations Recommendations on the Transport of Dangerous Goods—Model Regulations

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

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

Current edition approved Feb. 1, 2013. Published April 2013. Originally approved in 2007. Last previous edition approved in 2007 as D7387–07. DOI: 10.1520/D7387-13.

[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 U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.

[5] Available from United Nations, 866 United Nations Plaza, New York, NY 10017.

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

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

3.2.3 *resonance, n*— a condition during a vibration test, when the forcing (input) frequency of the table equals the resonant frequency of the IBC and will produce the highest transmissibility level.

NOTE 1—Testing close to or at the resonant frequency of the IBC may cause excessive, violent, and uncontrollable movement of the IBC. For this method, testing at or near the resonant frequency is overly severe and may cause damage or failure to the container not likely to be experienced in transportation.

4. Significance and Use

4.1 Shipping containers are exposed to complex dynamic stresses when subjected to vibration present in 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 failure of the container and spillage or leakage of contents. Identification of critical frequencies and the nature of package stresses can aid in minimizing the effect of these occurrences.

4.3 This vibration test is based on methods currently used for the qualification of IBCs in CFR 49 and has demonstrated successful use in transportation.

4.4 Exposure to vibration can affect the shipping container, its means of closure, and its contents. This test method allows 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 This test method is suitable for individual filled containers that are transported unrestrained on the bed of a vehicle.

4.6 This test method is not intended for testing intermediate bulk containers at a frequency that causes the container to go into resonance.

5. Apparatus

5.1 *Vertical Motion Vibration Machine*—This test is to be conducted with vibration test equipment that provides vertical vibration, and is capable of producing frequencies in the range of 2 to at least 5 Hz, with a fixed double amplitude displacement of 25 mm (1 in.) ± 1 mm. The test machine shall have a platform with a known mass and with a horizontal surface of sufficient strength and rigidity so that all points of the surface will follow the vertical motion of the supporting structure when loaded with the IBC. The test surface shall protrude beyond the IBC on all sides and shall have hardness adequate for its intended use (recommend at least equal to oak wood) firmly attached to a mild steel structure. The platform shall be supported by a mechanism that moves the platform so the motion is a vertical sinusoidal input. (A rotary motion of the platform is not acceptable.) The vibration test machine shall be equipped with fences, barricades, or other restraints to keep the IBC from falling off the platform without restricting its vertical motion.

5.1.1 *Shim*—A metal shim with the following specification is used in determining when the shipping container is leaving the testing platform by a sufficient amount:

5.1.1.1 *Width*—50 mm (2.0 in.) minimum.

5.1.1.2 *Thickness*—1.6 mm (1⁄16 in.).

5.1.1.3 *Length*—254 mm (10 in.) minimum.

5.2 Fig. 1 shows an intermediate bulk container on a test apparatus.

5.3 *Instrumentation*—Instrumentation of the test unit and table as described below is not required but may be used to obtain additional data.

5.3.1 Accelerometers, signal conditioners, and data display or storage devices may be used to measure and control the

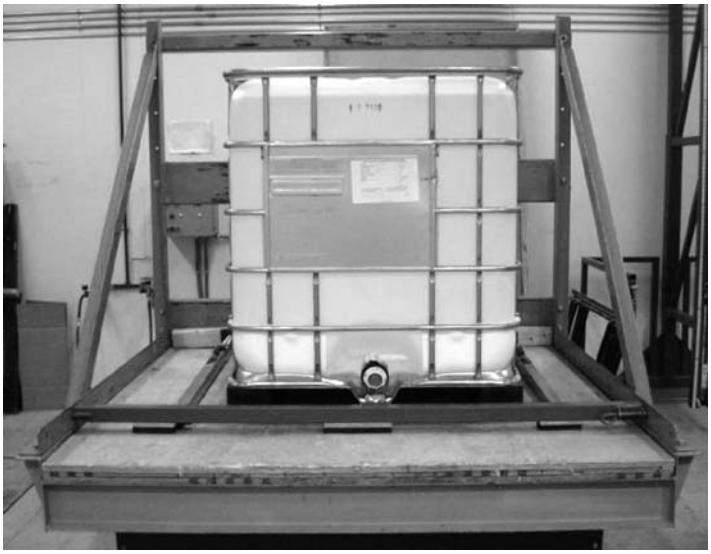

FIG. 1 Intermediate Bulk Container Test Specimen on Vibration Machine

accelerations at the test surface or on various locations of the intermediate bulk container to measure response. They are not required to conduct the test.

5.3.2 If an instrumentation system is used, it is recommended that it shall have a response accurate to within ±5 % over the range specified for the test.

5.3.3 Accelerometers should be small and light weight enough as to not influence the response of the item being measured nor influence the results of the test. Detailed information on suitable instrumentation may be found in the *Shock and Vibration Handbook*.[6]

6. Safety Precautions

6.1 This test method may produce severe mechanical responses from the IBC. Therefore, fences, barricades, and other restraints must have sufficient strength and must be adequately secured to prevent excess horizontal movement of the IBC. 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. For example, causing the container to go into resonance during testing may result in uncontrollable responsive bouncing. This may also lead to a dangerous situation, overtesting, or premature failure, and safety issues to testing personnel and equipment.

7. Test Specimens

7.1 The test specimen shall consist of a sample of the intermediate bulk container, representative for the design type, closed as intended for shipment and filled with water (water and antifreeze solution with a specific gravity between 0.95 and 1.05 is acceptable) as a standard test medium. IBCs with blemishes or minor dents may be used if the defect does not affect the validity of the test and the defects are recorded prior to the test. Prototype IBCs may be used for developmental testing when necessary, but may not be used for final design qualification testing.

7.2 Sensors and transducers may be applied with the minimum possible alteration of the test specimen, to obtain data on the response of the container.

7.3 A minimum of one sample must be used to meet the regulatory requirement.

8. Conditioning

8.1 Condition IBCs prior to the test or during the test, or both, in accordance with the requirements of the applicable specification. When no conditioning requirements are given, and the container materials are climatically sensitive, a conditioning atmosphere is recommended (see Practice D4332 for standard and special conditions).

8.2 For IBC types 31A, 31B, 31N, 31H1, 31H2, 31HA1, 31HB1, 31HN1, 31HA2, 31HB2, 31HN2 and 31HH2, the following standard conditioning requirements shall be observed during the test:

8.2.1 Atmospheric temperature and temperature of the test medium between 15°C and 20°C, and

8.2.2 Relative humidity (r.h.) between 30 % and 70 %,

8.3 For IBC types 31HC1, 31HD1, 31HF1, 31HG1 and 31HD2, the following standard conditioning requirements shall be observed for at least 24 h prior and during the test (see 6.5.6.3.1 of United Nations Model Regulations):

23 ± 2°C and 50 % ± 2 % r.h., or
20 ± 2°C and 65 % ± 2 % r.h., or
27 ± 2°C and 65 % ± 2 % r.h.

8.3.1 If documented in the test report, more stringent conditioning is allowed prior and during the test in comparison to these standard requirements.

9. Procedure

9.1 Place the shipping container on the test machine platform in its normal shipping orientation. The shipping container should be centered on the platform.

9.2 Restraining devices are required to prevent the container from moving horizontally off the test platform or to prevent excessive rocking. Restraining devices may affect the vertical movement of the shipping container and attention should be given to how restraints are used and where they are placed. Extremely high forces may develop during the test, so the strength of the restraining device should be sufficient to stop the container from vibrating off of the platform in the horizontal direction. If the test equipment incorporates a backstop (fence), the shipping container should not be placed directly against the backstop. Placing the shipping container directly against the backstop may affect the dynamic movement of the shipping container during the test. It is recommended to provide a maximum clearance of 50 mm between the intermediate bulk container and the restraining device in each horizontal direction of movement at the start of the test.

9.3 Orient and adjust the restraining devices to allow free horizontal movement of the container.

9.4 Start the vibration of the platform at a frequency of approximately 2 Hz, and steadily increase the frequency. After the container initially begins to separate from the platform, the test frequency should be adjusted to maximize the number of points at which the shim can be inserted under the container without causing the container to go into resonance.

NOTE 2—The separation of the intermediate bulk container from the platform may not be visually apparent but in most situations a change in the sound the container makes, due to the container leaving the platform, may assist in indicating the appropriate test frequency. However, the shim must be used in all tests to determine the proper test frequency.

NOTE 3—Caution should be used when determining the proper test frequency. Inserting the shim underneath the shipping container may cause excessive movement of the IBC.

9.5 The shim must be inserted a minimum of 100 mm (4.0 in.) under the IBC when determining the proper test frequency. It may be necessary to apply slight horizontal force to insert the metal shim under the intermediate bulk container.

9.6 The location of the shim placement must be described and recorded. It is recommended that at least two corners of the

[6] Harris, C. M., *Shock and Vibration Handbook*, McGraw-Hill, New York, NY, 1988, Chapter 16.

intermediate bulk container leave the test platform. The placement of the shim and a description of the separation of the IBC from the platform should be included as part of the test report.

9.7 The shim must be capable of being inserted between the IBC and test platform throughout the duration of the test. Periodically check to make sure the proper separation is maintained. Adjustments to the test frequency may be needed to maintain proper separation of the IBC because of the IBC shifting and movement or physical changes to the IBC. When adjustments are made they should be recorded.

9.8 Continue the test at the test frequency for the length of time stated in the applicable specification, if any, or for a predetermined period, or until a predetermined amount of damage may be detected. The test may be stopped momentarily to inspect for damage.

NOTE 4—When no test duration is specified, a test duration of 1 h is recommended. Practice D4169 may also be referred to for test durations.

9.9 Inspect the container and its contents and record any damage or deterioration resulting from the test.

10. Report

10.1 The report shall include the following:

10.1.1 Identification and description of the intermediate bulk containers tested including the capacity, mass, dimensions, materials of construction and any other pertinent details and a reference to the design type specification.

10.1.2 Purpose of the test and the applicable performance specification, if any.

10.1.3 Test frequency and duration used.

10.1.4 Verification of compliance with the test method or describe any deviations.

10.1.5 Number of replications of each test.

10.1.6 Conditioning parameters the IBCs were subjected to, both prior and during the test.

10.1.7 Any other test the specimens were subjected to prior to this test.

10.1.8 Description of the apparatus including the platform material and any instrumentation used, including the date of last calibration.

10.1.9 Detailed descriptions and photographs of the fixturing used in the test.

10.1.10 Describe where the shim was inserted under the intermediate bulk container and any adjustments made to the test frequency during the test.

10.1.11 Results of the test.

10.1.12 Document any failure or cracks to the container, leaks from closure, denting or permanent deformation of sidewalls, excessive bulging, and so forth, using pictures.

11. Precision and Bias

11.1 *Precision*—No information is presented about the damage-producing ability of these methods, since the results are usually non-quantitative.

11.2 *Bias*—The procedures in these methods have no bias because there is no accepted reference material or procedure.

12. Keywords

12.1 dangerous goods; liquids; hazardous materials; intermediate bulk container; packaging; vibration