Designation: D3332 − 99 (Reapproved 2023)

Standard Test Methods for Mechanical-Shock Fragility of Products, Using Shock Machines[1]

This standard is issued under the fixed designation D3332; 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 determination of the shock fragility of products. This fragility information may be used in designing shipping containers for transporting the products. It may also be used to improve product ruggedness. Unit or consumer packages, which are transported within an outer container, are considered to be the product for the purposes of these test methods. Two test methods are outlined, as follows:

1.1.1 Test Method A is used first, to determine the product's critical velocity change.

1.1.2 Test Method B is used second, to determine the product's critical acceleration.

1.2 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.

1.3 *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.* For specific precautionary statements, see Section 6.

1.4 *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]

D996 Terminology of Packaging and Distribution Environments

D2463 Test Method for Drop Impact Resistance of Blow-Molded Thermoplastic Containers

D3580 Test Methods for Vibration (Vertical Linear Motion) Test of Products

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

D5112 Test Method for Vibration (Horizontal Linear Motion) Test of Products

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

E680 Test Method for Drop Weight Impact Sensitivity of Solid-Phase Hazardous Materials

3. Terminology

3.1 *Definitions*—General definitions for packing and distribution are found in Terminology D996.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *acceleration of gravity (g)*—386.1 in./s^2 (9.806 m/s^2).

3.2.2 *critical acceleration (A_c)*—the maximum-faired acceleration level for a minimum velocity change of 1.57 ΔV_c (see 9.3), above which product failure (or damage) occurs. A product usually has a different critical acceleration for each direction in which it is tested.

3.2.3 *critical velocity change (V_c)*—the velocity change (see 9.2) below which product failure is unaffected by shock-pulse maximum-faired acceleration or waveform. A product usually has a different critical velocity change for each direction in which it is tested.

3.2.4 *damage*—product failure that occurs during a shock test. Damage can render the product unacceptable because it becomes inoperable or fails to meet performance specifications when its appearance is unacceptably altered, or some combination of these failure modes occurs.

3.2.5 *damage boundary*—See Annex A3.

3.2.6 *fairing*—The graphical smoothing of the amplitude of a recorded pulse still containing high frequency components even though electronic filtering may have been performed. This amplitude is used to evaluate the basic recorded pulse features with respect to the specified pulse. (see Figs. A1.1 and A2.1)

[1] These test methods are under the jurisdiction of ASTM Committee D10 on Packaging and are the direct responsibility of Subcommittee D10.13 on Interior Packaging.

Current edition approved Oct. 1, 2023. Published October 2023. Originally approved in 1988. Last previous edition approved in 2016 as D3332 – 99 (2016). DOI: 10.1520/D3332-99R23.

[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.

3.2.7 *shock pulse programmer*—a device used to control the parameters of the acceleration versus time shock pulse generated by a shock test machine.

3.2.8 *shock test machine drop height*—the distance through which the carriage of the shock test machine falls before striking the shock pulse programmer.

4. Significance and Use

4.1 These test methods are intended to provide the user with data on product shock fragility that can be used in choosing optimum-cushioning materials for shipping containers or for product design modification.

5. Apparatus

5.1 *Shock Test Machine:*

5.1.1 The machine shall consist of a flat horizontal test surface (carriage) of sufficient strength and rigidity to remain flat and horizontal under the stresses developed during the test. The test surface shall be guided to fall vertically without rotation or translation in other directions.

5.1.2 The machine shall incorporate sufficient carriage drop height to produce the shock pulses given in 9.2 and 9.3. Drop height control shall be provided to permit reproducibility within ±0.25 in. (±6 mm).

5.1.3 The machine shall be equipped to produce shock pulses at the carriage as specified in 9.2 and 9.3.

5.1.4 Means shall be provided to arrest the motion of the carriage after impact to prevent secondary shock.

5.2 *Instrumentation:*

5.2.1 *Acceleration*—An accelerometer, signal conditioner, and data storage apparatus are required to record acceleration-time histories. The accelerometer shall be attached rigidly to the base structure of the product or to the fixture, at or near a point at which the fixture is fastened to the carriage. If the fixture is sufficiently rigid to not distort the shock pulse imparted to the product, the accelerometer may be mounted on the carriage. In some cases, when a product contains heavy resiliently supported masses that will distort the shock pulses severely, it may be necessary to precalibrate the shock machine. The accelerometer is fastened to the carriage in this case, and a rigid mass weighing the same as the product is subjected to a series of shock pulses. The instrumentation system shall have sufficient response to permit measurements in the following ranges.

5.2.1.1 *Test Method A*—5 Hz or less to at least 1000 Hz.

5.2.1.2 *Test Method B*—1 Hz or less to at least 330 Hz.

5.2.1.3 *Accuracy*—Reading to be within ±5 % of the actual value.

5.2.1.4 *Cross-Axis Sensitivity*—Less than 5 % of the actual value.

5.2.2 *Velocity*—Instrumentation to measure the velocity change of the shock table is required. This may be a device that integrates the area electronically under the shock pulse waveform. Alternatively, it can be measured by photodiode-type devices that measure shock table impact and rebound velocity. Calculation that assumes the shock pulse to be a perfect geometric figure is usually grossly inaccurate and should not be used.

6. Precautions

6.1 These test methods may produce severe mechanical responses in the test specimen. Operating personnel must therefore remain alert to potential hazards and take necessary safety precautions. The test area should be cleared prior to each impact. The testing of hazardous material or products may require special precautions that must be observed. Safety equipment may be required, and its use must be understood before starting the test.

7. Sampling

7.1 Sampling procedures and the number of test specimens depend on the specific purposes and needs of the testing. Sample size determination based on Practice E122 or other established statistical procedures is recommended.

8. Conditioning

8.1 If temperature and humidity conditioning is required for the product being tested, refer to Practice D4332 for standard conditioning procedures. Unless otherwise specified, conduct all tests with the same conditions prevailing.

9. Procedure

9.1 Mount the product to be tested on the carriage of the shock test machine. The product should be supported by a fixture similar in shape and configuration to the cushion that will support the product in its shipping container. The fixture should be as rigid as possible so as not to distort the shock pulse imparted to the product. Fasten the fixture and product securely to the carriage so that it will not leave the surface of the carriage during the shock test.

NOTE 1—The points at which the fixture supports the product are very important because the dynamic response of the product is influenced strongly by the location of these support points

NOTE 2—If the orientation of the product can change during handling impacts, a test may be required for each of the directions in which the input shock can occur. Multidirectional tests are recommended since most products have different fragilities in different orientations.

9.2 *Test Method A—Critical Velocity Change Shock Test:*

9.2.1 *Scope*—This test method is used to determine the critical velocity change (V_c) portion of the damage boundary plot of a product.

9.2.1.1 To ensure that the components of a product only respond to the velocity change of the pulse, a shock pulse having any waveform and a duration (T_p) not longer than 3 ms should be used to perform this test. Pulse durations as short as 0.5 ms may be required when testing small, very rigid products (see Note 3). Shock pulse waveform is not limited since the critical velocity portion of the damage boundary is unaffected by shock pulse shape. Since they are relatively easy to control, shock pulses having a half sine shock waveform are normally used.

NOTE 3—In general: $T_p \leq 167 / f_c$

where:

T_p = maximum shock test machine pulse duration in ms, and
f_c = component natural frequency in Hz.

For example, a component of a product with a natural frequency below 56 Hz can be effectively tested on a shock machine with a 3 ms duration