Designation: D1596 − 14 (Reapproved 2023)

Standard Test Method for Dynamic Shock Cushioning Characteristics of Packaging Material[1]

This standard is issued under the fixed designation D1596; 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 covers a procedure for obtaining dynamic shock cushioning characteristics of packaging materials through acceleration-time data achieved from dropping a falling guided platen assembly onto a motionless sample. This test method does not address any effects or contributions of exterior packaging assemblies.

1.2 The data acquired may be used for a single point or for use in developing a dynamic cushion curve for the specific material being tested. Such data may be used for comparison among different materials at specific input conditions, or qualifying materials against performance specifications. Caution should be used when attempting to compare data from different methods or when using such data for predicting in-package performance. Depending upon the particular materials of concern, correlation of such data (from among differing procedures or for predicting in–package performance) may be highly variable.

NOTE 1—Alternative and related method for possible consideration is Test Method D4168.

1.3 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.

1.4 *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.*

1.5 *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

D4168 Test Methods for Transmitted Shock Characteristics of Foam-in-Place Cushioning Materials

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

E105 Guide for Probability Sampling of Materials

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

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *acceleration, n*—the rate of change of velocity of a body with respect to time, measured in in./s^2 (m/s^2).

3.2.2 *displacement, n*—the magnitude of movement of a body, point, or surface from a fixed reference point, measured in inches (metres).

3.2.3 *dynamic cushion curve, n*—a graphic representation of dynamic shock cushioning or transmitted shock (in *G*'s) over a variety of static loading conditions (psi or kg/square m) for a specific cushioning material thickness (or structure) at a specific equivalent free fall drop height.

3.2.3.1 *Discussion*—Such representations can encompass the average response readings in *G*'s of a number of drops, the average of drops, two to five for each test phase, or represent a single, specific drop number in a drop sequence (that is, first or third drop data).

3.2.4 *equivalent free-fall drop height, n*—the calculated height of free fall in vacuum required for the dropping platen to attain a measured or given impact velocity.

[1] This test method is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.13 on Interior Packaging.

Current edition approved Oct. 1, 2023. Published October 2023. Originally published in 1959. Last previous edition approved in 2021 as D1596 – 14 (2021). DOI: 10.1520/D1596-14R23.

[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.

3.2.5 *equivalent free-fall impact velocity, n*—the calculated impact velocity of the dropping platen if it were to free fall in a vacuum from a specific test drop height.

3.2.6 *platen drop height, n*—the actual drop height of the test machine platen required to obtain an equivalent free fall impact velocity.

3.2.7 *reaction mass, n*—a mass, consisting of the impact surface and any other rigidly attached mass that reacts in an opposing manner to the forces produced during the impact of the dropping platen on the impact surface.

3.2.8 *static loading, n*—the applied mass in pounds (kilograms) divided by the area, measured in square inches (metres) to which the mass is applied (lbs/in.^{2} or kg/m^2). Sometimes referred to as static stress loading.

3.2.9 *velocity, n*—the rate of change of position of a body in a specified direction with respect to time, measured in inches per second (metre per second).

3.3 *Symbols:*

3.3.1 *g*—symbol for the acceleration due to the effects of the earth's gravitational pull. While somewhat variable, it is usually considered a constant of value 386 in./s^2 or (9.8 m/s^2).

3.3.2 *G*—symbol for the dimensionless ratio between an acceleration in length per time squared units and the acceleration of gravity in the same units.

4. Summary of Test Method

4.1 An apparatus having a guided dropping platen capable of having variable mass, inputs a dynamic force into a test specimen placed on a rigid impact surface at a predetermined impact velocity that equates to a free fall drop height. An accelerometer rigidly mounted to the dropping platen and connected to a data acquisition system records the shock experienced (acceleration-time history) during the impact on the test specimen. By changing the variables, such as impact velocity, static loading (dropping platen mass), and the number of test impacts for any given test, dynamic shock cushioning characteristics (cushion curves) of the packaging material can be developed.

5. Significance and Use

5.1 Dynamic cushioning test data obtained by this test method are applicable to the cushioning material and not necessarily the same as obtained in a package. In addition to the influence of the package, the data can also be affected by the specimen area, thickness, loading rate, and other factors.

6. Apparatus

6.1 *Testing Machine:*

6.1.1 Any guided vertical drop testing system that will produce test conditions conforming to the requirements specified in this section is acceptable. The system shall consist of a rigid flat faced dropping platen, a rigid flat impact surface whose face is parallel to the dropping platen face.

NOTE 2—Lack of rigidity can cause undesirable vibrations in the apparatus that are recorded in the acceleration-time curve. This condition has also been a suspected cause for discontinuities in dynamic data where the mass of the dropping platen is varied at constant height. The existence of flexing in the apparatus often can be verified with aid of high-speed video and subsequently corrected.

6.1.2 The dropping platen should have provisions for firmly mounting additional mass to adjust its total mass to a desired value. Its mass may be determined by consideration of the static loading of the items the dynamic test is simulating. Various testing systems will have different ranges of testing capability, both for drop height and static loadings.

6.1.3 All dropping platens are influenced by guide system friction and air resistance. The significance of these effects varies with the type of apparatus and the mass on the dropping platen. For this reason, the equivalent free fall impact velocity of the dropping platen is equated to a free fall drop height rather than an actual platen drop height. (*Example*—Using the formula in 11.2, a 30 in. (0.7 m) free fall is equated to a 152 in./s (3.9 m/s) impact velocity of the dropping platen.)

6.2 *Reaction Mass:*

6.2.1 The testing machine shall be attached to a reaction mass. The reaction mass shall be sufficiently heavy and rigid so that not more than 2 % of the impact acceleration is lost to the reaction mass while conducting dynamic tests. The rigid impact surface should be in intimate contact with the reaction mass so that the two bodies move as one (surface preparation or grouting may be required). This performance may be verified by using shock sensors, one located on the dropping platen and one on the impact surface or on the reaction mass immediately next to the impact surface to measure the acceleration levels. The ratio of the measured impact acceleration of the reaction mass divided by the measured acceleration of the dropping platen shall be equal to or less than 2 %.

6.2.2 As an alternative to measuring the acceleration level of the reaction mass for each test condition, the reaction mass is acceptable if it is 50 times the maximum mass of the dropping platen. Neither the depth nor the width of such a mass shall be less than half the length.

6.3 *Instrumentation and Shock Sensors:*

6.3.1 Instrumentation is required to measure the impact velocity to an accuracy of ±2 % of the true value.

6.3.2 Accelerometers, signal conditions, and data storage apparatus are required to monitor acceleration versus time histories. The instrumentation systems shall have the following minimum properties:

6.3.2.1 Frequency response range from 2 Hz or less to at least 1000 Hz.

6.3.2.2 Accuracy reading to be within ±5 % of the actual value.

6.3.2.3 Cross axis sensitivity less than 5 % of full scale.

7. Sampling

7.1 The choice of sampling plans for materials depends on the purpose of the testing. Practice E105 is recommended.

7.2 The number of test specimens for each condition of test (for example, static loading) depends on the desired degree of precision and the availability of materials. Practice E122 and many statistical tests provide excellent guidance on the choice of sample size. It is recommended that at least three replicate test specimens be used for each initial test condition. Then,