Designation: D5277 – 22

Standard Test Method for Performing Programmed Horizontal Impacts Using an Inclined Impact Tester[1]

This standard is issued under the fixed designation D5277; 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 the procedures for reproducing and comparing shock damage, such as that which may result from rail switching or pallet marshalling impacts, using an incline impact tester. It is suitable for simulating the types of shock pulses experienced by lading in rail switching of rail cars with standard draft gear, but not for those with long travel draft gear or cushioned underframes. The test method can also be used for pallet marshalling tests.

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 hazards 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]

D664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration

D880 Test Method for Impact Testing for Shipping Containers and Systems

D996 Terminology of Packaging and Distribution Environments

D4003 Test Methods for Programmable Horizontal Impact Test for Shipping Containers and Systems

D4169 Practice for Performance Testing of Shipping Containers and Systems

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

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 terms and definitions used in this test method may be found in Terminology D996.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *programming material*—a resilient elastomer with characteristics suitable to control the shock pulse generated, or any other suitable means of control.

3.2.2 *velocity change*—the sum of the velocity at impact and the rebound velocity.

4. Significance and Use

4.1 This test method is for use in evaluating the capability of a container or shipping system to withstand sudden shocks and crushing forces, such as those generated from rail switching impacts or pallet marshalling, or to evaluate the capability of a container and its inner packing, or shipping system, to protect its contents during the sudden shocks and crushing forces resulting from rail switching or pallet marshalling impacts. This test method may also be used to compare the performance of different container designs or shipping systems. The test may also permit observation of the progressive failure of a container or shipping system and damage to the contents. See Practice D4169 for additional guidance.

4.2 This test method is not suitable for reproducing impact resulting from the switching of rail cars using long-travel draft gear or cushioned underframes. Refer to Test Methods D4003 (revised) as a more suitable method for testing under these circumstances, or when more precise control of shock inputs is required.

[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.

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[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.

5. Apparatus

5.1 *Inclined Impact Test Equipment,* conforming to the following requirements:

5.1.1 The incline track, backstop, and carriage shall conform to the requirements of Method D880, except that the backstop need not have a solid steel plate surface or a solid integral mass at least 50 times the mass of the test specimen.

5.1.1.1 No removable hazard shall be fitted.

5.1.1.2 In lieu of steel wheels, wheels of polyoxymethylene (Delrin) plastic may be used in order to reduce noise and improve shock pulse recording.

5.1.2 A programming material or device is required to shape and control the shock pulse seen by the test specimen(s). This material or device may be fastened to either the backstop or the impacting face of the bulkhead. Any material or device may be used, provided that is yields a repeatable, controllable test. Package cushionings of suitable elasticity have been found to be satisfactory.

5.1.3 The carriage shall be fitted with a bulkhead at a 90-degree ± 30 min (90 ± ½-degree) angle to the top surface of the carriage. The bulkhead shall be fitted so that, upon release, either the bulkhead impacts first on the programming material, or the carriage and bulkhead impact on the programming material at the same time. The bulkhead shall be attached securely to the carriage and shall be sufficiently rigid to withstand impact shocks without significant distortion.

5.1.4 When specified, a backload suitable to reproduce the crushing forces from other products impacting the test unit shall be provided. This will necessitate sufficient carriage and bulkhead strength, as well as rigidity in the backstop, to withstand the additional forces generated without significant distortion. The face of this backload that contacts the test specimen shall replicate a backload of the same product in dimension, area of contact, and resilience.

5.1.5 To prevent secondary impacts, the test apparatus shall be fitted with a means of arresting the motion of the carriage after the primary impact.

5.1.6 Instrumentation shall be provided to determine the velocity at impact and the rebound velocity to an accuracy of ± 5 %. Additional instrumentation shall be provided to record the shock pulse shape, magnitude, and duration. The shock recording instrumentation shall have a frequency response at least 20 times the frequency being recorded, a cross-axis sensitivity maximum of 5 % of full scale, and an accuracy of ± 2 % of the actual values as measured.

5.1.6.1 Instrumentation sensors shall be placed on the outside of the carriage bulkhead within 6 in. (150 mm), measured perpendicularly to the programming material.

5.1.6.2 Optional instrumentation may include optical or mechanical timing devices for measuring the carriage impact and rebound velocities for determining the total velocity change. If used, this system shall have a response for each velocity measurement accurate to within ± 2.5 % of the actual value.

5.1.7 *Conditioning Apparatus*—Adequate facilities shall be provided for conditioning test specimens at the proper humidity and temperature prior to testing, in accordance with the specification covering the containers or shipping systems to be tested.

5.1.7.1 *Conditioning*—Depending on the purpose of the tests, containers may be conditioned prior to the programmed impact test by either a different physical test, water immersion, exposure to water spray, or exposure to standard or other fixed conditions of air temperature or humidity. It is recommended that special atmospheres for conditioning be selected from those given in Practice D4332. Unless otherwise specified, fiberboard or paperboard containers shall be conditioned in accordance with the preconditioning and standard conditioning atmospheres specified in Practice D4332 (see also Practice D4169 for additional guidance).

5.1.7.2 Where the moisture content of fiberboard containers is determined, it should be determined in accordance with Test Method D664.

6. Hazards

6.1 This test method may produce severe mechanical responses in the test specimen and apparatus. 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 materials 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 The test specimens and number of samples shall be chosen to permit an adequate determination of representative performance. Practice E122 is recommended.

7.2 In the absence of any sampling plan, at least three representative specimens should be selected for performance evaluation.

8. Test Specimens

8.1 When the protective capability of a container or shipping system is to be evaluated, it is preferable to pack the container with the actual contents for which it was designed (Note 1). When the integrity of a container or shipping system is to be evaluated, pack the container or shipping system with either the actual contents or a load simulating the contents. Regardless of which procedure is used, close the container or shipping system in the same manner that will be used in preparing it for shipment.

NOTE 1—Where the use of actual contents is not feasible because of excessive cost or danger, a dummy load simulating the contents with respect to dimensions, center of gravity, moment of inertia, density, flow characteristics, etc. may be used.

9. Procedure

9.1 Prior to initiating the test, write a test plan that includes the following information.

9.1.1 State the number of impacts the test unit will receive (Note 2).

NOTE 2—The number of impacts to which a product will be subjected in transit may range from 1 to more than 15. The velocity changes may range from 1 to 10 mph (1.6 to 16.1 kph). The duration of the impact shocks is dependent on both the draft gear of the rail cars used to transport the product and the draft gear of impacting or impacted rail cars. For standard draft gears, this will range from 30 to 50 milliseconds. The acceleration levels observed are normally a function of the velocity change and pulse duration. The accelerations corresponding to the above durations are in the range of 15 g (147 m/s^2). Because rail car switching impacts may occur many times during a shipment, it is recommended that a test consist of a number of lower level impacts or an incremental series of increasing impact magnitude, rather than a single large magnitude impact. This type of testing also provides better information by bracketing the failure between two impact levels.

9.1.2 State the velocity change for each impact.

9.1.3 State the pulse duration of the impact shock.

9.1.4 State the mass, configuration, and friction characteristics of the backload, if used (Note 3).

NOTE 3—The backload weight/friction requirement is not well defined due to insufficient environmental measurement of lading force levels. Through preliminary testing, backload pressures ranging from 0.3 to 1.0 psi (2 to 7 kPa) on the container impacting surface have created damage levels normally observed in the distribution environment. These pressures are based on a coefficient of friction of 0.5. See Appendix X1 for additional information.

9.1.5 State whether conditioning is required and the conditioning to be used, if any, including the preconditioning and conditioning atmosphere required.

9.1.6 Use a suitable test procedure for pallet marshalling impact tests; one is set out in Test Methods D4003.

9.2 After the test parameters have been established, place dummy weights equivalent to the test unit specimen on the carriage at the center position of the specimen mounting surface, with the face or edge that is to receive the impact positioned firmly against the upright bulkhead. Use a duplicate specimen, if available. Then backload the dummy weight with the backload weights, where specified, to represent the backload conditions specified in the test plan. Impact the carriage from various pullback distances into the selected programmer to achieve the desired velocity changes (impact plus rebound velocity). Record these pullback distances.

NOTE 4—The type of programmer material or device used shall be selected on the basis of the shock pulse, waveform, and duration desired.

9.2.1 This pretesting is not required if the testing parameters are known from previous experience.

9.3 Replace the dummy load with the test specimen and place it on the center of the carriage, with the face or edge that is to receive the impact positioned firmly against the upright bulkhead. Backload the test specimen with additional product or the dummy weight.

9.4 Test the containers that have been conditioned in the conditioned atmosphere or immediately upon removal from that atmosphere.

9.5 Pull the carriage back the distance necessary to achieve the desired velocity change (impact plus rebound velocity) for a single impact. Measure to determine both the velocity change of the carriage and the acceleration time profile of the carriage bulkhead.

9.6 The packaging, shipping system, and product may be inspected for damage after each impact.

9.7 Subject the test unit to the number of impacts, and at velocity changes, specified in the test plan, or until failure occurs. Each axis of concern can be evaluated as specified in 9.2 through 9.7.

10. Report

10.1 Report the following information:

10.1.1 Reference to this test method, noting any deviations from the test method.

10.1.2 Dimensions of the container or shipping system under testing; complete structural specifications; kinds of materials; description and specifications for blocking and cushioning, if used; spacing, size, and kind of fasteners; method of closing and strapping, if any; and tare and gross masses.

10.1.3 Description of the contents of the container or shipping system under testing and, if not tested with the actual contents intended to be shipped, description of these actual contents.

10.1.4 Number of specimens tested per sample.

10.1.5 Method of conditioning the container, if any.

10.1.6 Description of apparatus, backload, and special instrumentation, including whether the wheels were made from steel or Delrin. Where other values for F than those recommended in Appendix X1 are used, state of the value.

10.1.7 Pullback distance used for each test.

10.1.8 Measured velocity change, velocity at impact, shock pulse amplitude, duration, and waveform of each test.

10.1.9 Detailed record of the test results for each container or shipping system, including damage to the container or shipping system and contents, together with any other observation that may assist in interpreting the results correctly or aid in improving the design of the container or shipping system or the method of packaging, blocking, or bracing.

10.1.10 Statement to the effect that all tests were conducted in full compliance with the requirements of this test method, or noting any variations and their details.

10.1.11 Name and address of the testing agency, date, and signature of a responsible representative of the testing agency.

11. Precision and Bias

11.1 *Precision:*

11.1.1 This test method is usually conducted to determine if a container or shipping system completes the prescribed test without specified damage. With this situation, no statement can be made about the precision because the results merely state whether there is conformance to the criteria for success.

11.1.2 When the test is conducted to determine the input stress required to cause a specified type of damage, the precision depends largely upon the item being tested. The equipment, instrumentation, fixturing, methodology, and personnel also play important roles in precision. A research report indicates that there can be considerable variability between replicate tests for vertical impacts; it is believed that similar conclusions are true for horizontal impacts.