Designation: D7386 – 16

Standard Practice for Performance Testing of Packages for Single Parcel Delivery Systems[1]

This standard is issued under the fixed designation D7386; 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 practice provides a uniform basis of evaluating, in a laboratory, the ability of shipping units, weighing up to but not exceeding 150 lb (68 kg), intended for the single parcel delivery system to withstand the hazards associated with the distribution environment. This is accomplished by subjecting them to a test plan consisting of a sequence of anticipated hazard elements encountered in the distribution cycles. This practice is not intended to supplant material specifications or existing pre-shipment test procedures.

1.2 The suitability of this practice for use with hazardous materials has not been determined.

1.3 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.

1.4 *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 and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in 1.1.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D951 Test Method for Water Resistance of Shipping Containers by Spray Method

D996 Terminology of Packaging and Distribution Environments

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

D5265 Test Method for Bridge Impact Testing

D5487 Test Method for Simulated Drop of Loaded Containers by Shock Machines

D6179 Test Methods for Rough Handling of Unitized Loads and Large Shipping Cases and Crates

D6344 Test Method for Concentrated Impacts to Transport Packages

D6653 Test Methods for Determining the Effects of High Altitude on Packaging Systems by Vacuum Method

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *acceptance criteria*—the acceptable quality level that must be met after the shipping unit has been subjected to the test plan. See Section 7.

3.2.2 *assurance level*—the level of test intensity based on its probability of occurring in a typical shipment.

3.2.3 *hazard element*—a specific event that occurs in a shipment that may pose a hazard to a shipping unit. The element will usually be simulated by a single test schedule. See Section 9.

3.2.4 *shipping unit*—the smallest complete unit that will be subjected to the distribution environment, for example, a shipping container and its contents.

3.2.5 *single parcel delivery system*—distribution carrier that transports packages weighing up to 150 lb through ground and/or air transport systems.

3.2.6 *test plan*—a specific listing of the test sequence to be followed to simulate the hazards anticipated during the distribution cycle of a shipping unit. Included will be the test intensity and number of sequential tests to be conducted. See 8.1.

3.2.7 *test schedule*—the specific procedure to be used, including the three assurance level intensities (if applicable), and a reference to the test method that is the basis of the schedule.

3.2.8 *unitizing bag*—a bag made of a poly material, measuring approximately 39 by 27 in. (991 by 686 mm), used to contain and transport several small sized packages and envelopes.

[1] This practice 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.

4. Significance and Use

4.1 This practice provides a guide for the evaluation of shipping units in accordance with a uniform system, using established test methods at levels representative of those occurring in actual distribution. The recommended test levels are based on available information on the shipping and handling environment, and current industry/government practice and experience. The tests should be performed sequentially on the same containers in the order given. For use as a performance test, this practice requires that the shipping unit tested remain unopened until the sequence of tests are completed. If used for other purposes, such as package development, it may be useful to open and inspect shipping units at various times throughout the sequence. This may, however, prohibit evaluating the influence of the container closure on container performance.

5. Test Specimen

5.1 Test specimens consist of representative samples of complete shipping units, including actual contents. Products with blemishes or minor defects may be used if the defective component is not to be studied by the test and if the defect is documented in the report. Dummy or simulated test loads are acceptable if testing the actual product might be hazardous. If a dummy load is used, it should be instrumented to determine if the fragility level of the actual product has been exceeded. Take care to duplicate the load characteristics of the actual product, and to avoid unnecessary handling.

5.2 Care must be taken to ensure that no degradation has occurred to either the product or the package if the test packages have been shipped to the test site. If any doubt exists as to the condition of the package, repack the product in new packaging material before testing.

5.3 The number of test replications depends on the desired objectives of the testing and the availability of duplicate products and shipping containers. Replicate testing is recommended to improve the reliability of the test results.

5.4 *Identification of Package Test Specimen Members:*

5.4.1 *Small Containers Bagged for Transport by Carrier, Sacks and Bags*—Small packaged products (smaller than 800 in.^{3} (13 110 cc) and less than 10 lb (4.5 kg) and the longest dimension of the package is 14 in. (356 mm) or less) shipped through the single package environment are traditionally unitized with other packaged-products in transport bags by the parcel delivery carriers. The procedure for the identification of the members of 'packaged-products defined as test sample TS-1' (bags and sacks) as shown in Fig. 1 shall be as follows:

5.4.1.1 With the empty unitizing bag laying flat:

(1) Label the surface that is facing up as Face 1.

(2) Turn the bag over and mark the opposite face as Face 3.

(3) Label the opening of the bag as Face 2.

(4) Label the opposite end of Face 2 as Face 4.

(5) Label one of the side faces as Face 5.

(6) Label the opposite side face as Face 6.

5.4.1.2 Place the test specimen in the center of the unitizing bag along with the following:

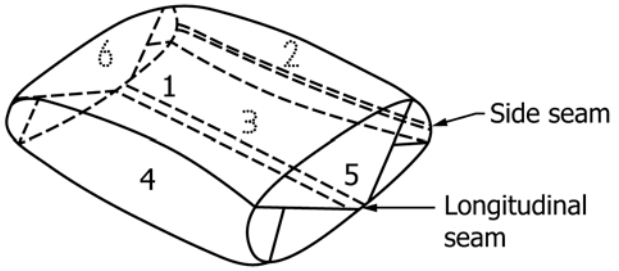


FIG. 1 Members of Sacks and Bags

(1) Three express envelopes from a carrier such as USPS, FedEx, or UPS, each filled with 25 sheets of copy paper.

(2) One padded mailer measuring 10.5 by 14.0 in. (267 by 356 mm) filled with 50 sheets of copy paper.

(3) One padded mailer measuring 12.5 by 15.0 in. (317 by 381 mm) filled with 50 sheets of copy paper.

(4) One each of the following box sizes in the following table are constructed from single wall 32 ECT or 200 bursting test corrugated fiberboard, with all void space filled with paper, sand, foam, etc. to achieve the specified weight and to prevent shifting of the dummy packages.

Box Size	Specified Weight
8 by 5 by 2 in. (203 by 127 by 51 mm)	1 lb (0.4 kg)
9 by 6 by 2 in. (229 by 152 by 51 mm)	1 lb (0.4 kg)
11 by 11 by 4 in. (279 by 279 by 102 mm)	2 lb (0.9 kg)
11 by 8 by 4 in. (279 by 203 by 102 mm)	2 lb (0.9 kg)
7 by 6 by 4 in. (179 by 152 by 102 mm)	4 lb (1.8 kg)
12 by 12 by 3 in. (305 by 305 by 76 mm)	4 lb (1.8 kg)
8 by 8 by 8 in. (203 by 203 by 203 mm)	10 lb (4.5 kg)
6 by 6 by 6 in. (152 by 152 by 152 mm)	2 lb (0.9 kg)
10 by 5 by 5 in. (254 by 127 by 127 mm)	2 lb (0.9 kg)

5.4.2 *Rectangular Containers*—The procedure for identification of the members (faces, edges, and corners) of rectangular containers as shown in Fig. 2 shall be as follows:

5.4.2.1 Place the container in its most stable riding orientation with one of the smallest faces directly in front of the observer.

5.4.2.2 Label the surface that is facing up as Face 1.

5.4.2.3 Label the right side as Face 2.

5.4.2.4 Label the bottom as Face 3.

5.4.2.5 Label the left side as Face 4.

5.4.2.6 Label the end nearest the observer as Face 5.

5.4.2.7 Label the end farthest from the observer as Face 6.

5.4.3 *Cylindrical Containers*—The procedure for identification of the members (top, bottom, sidewall, and chimes) of cylindrical containers as shown in Fig. 3 shall be as follows:

5.4.3.1 Place the container in its intended shipping position.

5.4.3.2 Label the surface that is facing up as Face 1.

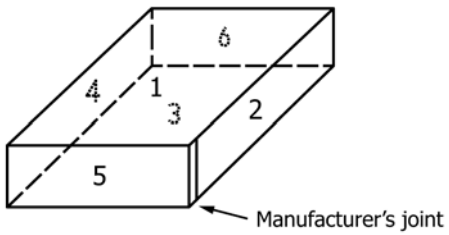


FIG. 2 Members of Rectangular Containers

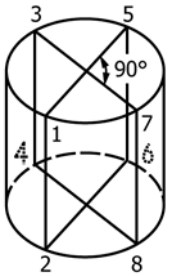


FIG. 3 Members of Cylindrical Containers

5.4.3.3 Turn the container over and label the opposite side (bottom) as Face 3.

5.4.3.4 Draw two perpendicular lines across the diameter of the container on Faces 1 and 3. Connect the lines so there are four equidistant lines on the sidewall of the container.

5.4.3.5 Label the line to the observer's right as Face 2.

5.4.3.6 Label the line on the observer's left as Face 4.

5.4.3.7 Label the line nearest the observer as Face 5.

5.4.3.8 Label the line farthest from the observer as Face 6.

6. Conditioning

6.1 Conduct the test at standard conditions and compensate for the effects of any climatic condition. Condition containers in accordance with Practice D4332 and document the actual conditions used. A conditioning period of 72 h, or sufficient time to reach equilibrium of all parts of the package and product is recommended. Tests should be conducted in the conditioned atmosphere whenever possible. If not possible, conduct the tests as soon after removal from the conditioning atmosphere as practicable. Recondition the shipping units to the standard atmosphere as necessary during the test plan.

6.2 In some circumstances, it may be necessary to conduct some or all of the tests at special climatic conditions, such as those given in Practice D4332, or Test Method D951, or others (salt, spray, water immersion, humidity, or temperature). The same climatic condition should be used for any assurance level. A conditioning period of 24 h, or sufficient time to reach equilibrium of all parts of the package and product is recommended. Tests should be conducted in the conditioned atmosphere whenever possible. If not possible, conduct the tests as soon after removal from the conditioning atmosphere as practicable. Recondition the shipping units as necessary during the test plan.

7. Acceptance Criteria

7.1 Acceptance criteria must be established prior to testing and should consider the required condition of the product at receipt. The organizations conducting the test may choose any acceptance criteria suitable for their purpose. It is advisable to compare the type and quantity of damage that occurred to the test specimens with the damage that occurs during actual distribution and handling or with test results of similar containers whose shipping history is known.

7.2 In many cases, the acceptance criteria can be the following:

Criterion 1—Product is damage-free.
Criterion 2—Package is intact.
Criterion 3—Both criteria 1 and 2.

7.2.1 Often, this means that the shipping container and its contents are suitable for normal sale and use at the completion of the test cycle. Detailed acceptance criteria may allow for accepting specified damage to a product or its package. The form and content of acceptance criteria may vary widely, in accordance with the particular situation. Methods may range from simple pass-fail judgments to highly quantitative scoring or analysis systems.

8. Hazard Elements and Test Schedules for Single Parcel Shipments

8.1 The Hazard Elements and Test Schedules are categorized as follows:

Schedule	Hazard Element	Test	Section
A	Handling—manual and automated	Drop, impact	10
D	Vibration	Vibration and Vibration under load	11
I	Impact, stability	Bridged impact	12
J	Impact, stability	Hazard impact	13
K	Low pressure	High altitude	14
L	Impacts, punctures	Concentrated impacts	15
M	Impacts	Tip-over impacts	16
N	Drops	Rotational edge drops	17

9. Procedure

9.1 Describe shipping unit in terms of size, weight, and form of construction. See 3.2.6. Use the following criteria to define the package test sample(s).

9.1.1 Is the test specimen smaller than 800 in.^{3} (13 110 cc) AND less than 10 lb (4.5 kg) AND the longest dimension of the package is 14 in. (356 mm) or less AND the carrier unitizes small and light shipping units in a bag with other small and light shipping units?

9.1.1.1 If Yes, the test specimen is defined as TS-1.

9.1.1.2 If No, proceed to 9.1.2.

9.1.2 Is the test specimen's shortest dimension 8 in. (203 mm) or less, AND the next shortest dimension is four (4) or more times larger than the shortest dimension AND the cubic volume of the package is more than 800 in.^{3} (13 110 cc)?

9.1.2.1 If Yes, the test specimen is defined as TS-2.

9.1.2.2 If No, proceed to 9.1.3.

9.1.3 Is the test specimen's longest dimension 36 in. (914 mm) or more AND both the other dimensions are 20 % or less of that of the longest dimension?

9.1.3.1 If Yes, the test specimen is defined as TS-3.

9.1.3.2 If No, the test specimen is defined as TS-4.

9.1.4 See flow chart in Fig. 4 for description and examples for package description and type determination.

9.2 *Determine Acceptance Criteria*—Acceptance criteria are related to the desired condition of the product and package at the end of the distribution cycle. See Section 7.

9.3 *Write Test Plan*—Prepare a test plan by using the sequence presented in Table 1 for the test specimen defined in 8.1.

9.4 *Select Samples for Test*—See Section 5.

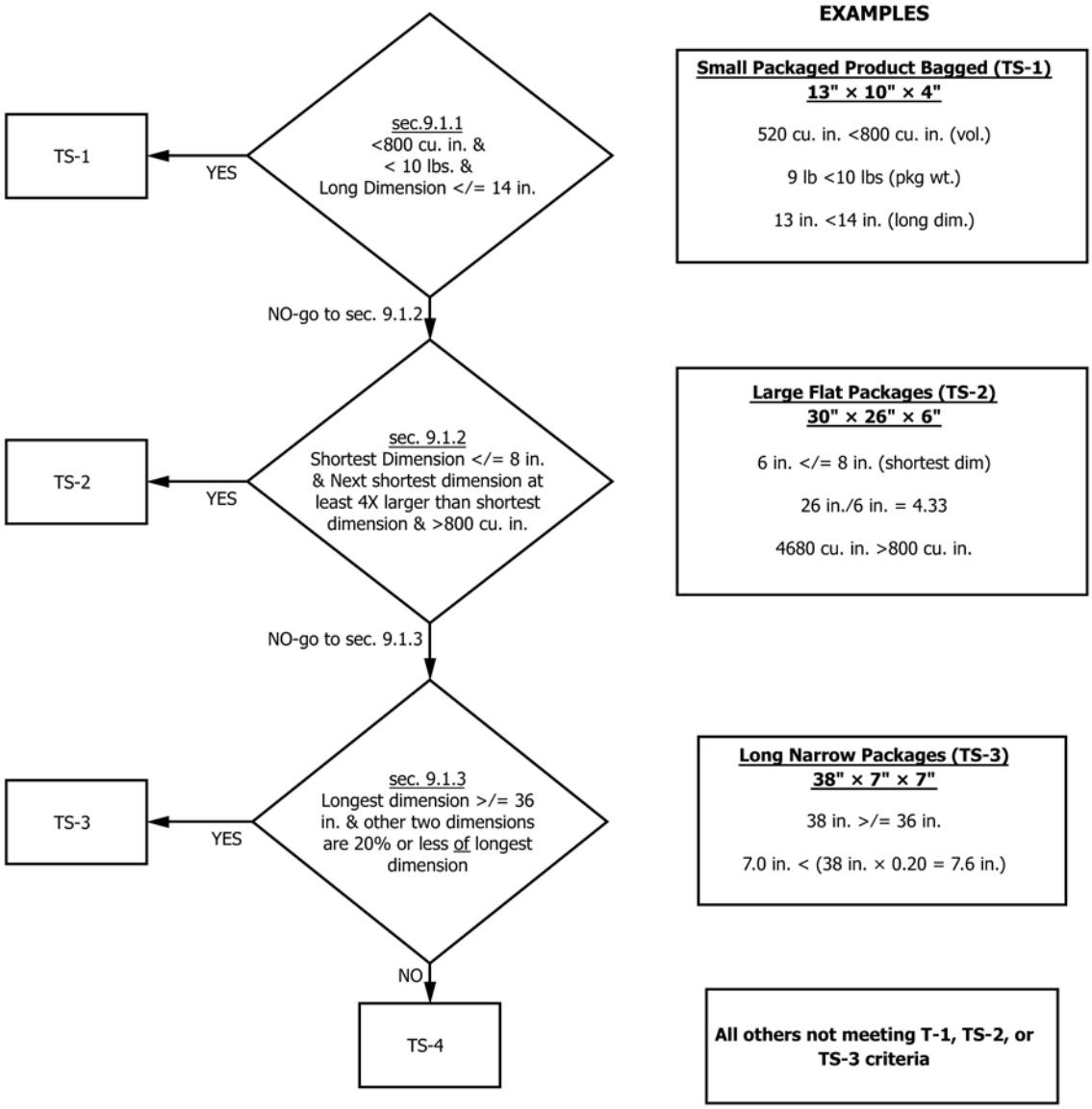


FIG. 4 Shipping Unit Description

TABLE 1 Test Plan Schedule

NOTE 1—Precondition samples in accordance with Section 6 of this practice.

Test Specimen	Description	Performance Test Schedule Sequence (see Section 8)									
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
TS-1	Small packaged-products bagged for transport	A1[A]	D2[B]	K[A,C]	A4[B]	D3[A]	A3[A]				
TS-2	Large flat packaged products	A1	D1	K[C]	A2	M	N	J	D3	A3	L
TS-3	Long narrow packaged products	A1	D1	K[C]	A2	M	N	I	D3	A3	L
TS-4	All other packaged-products	A1	D1	K[C]	A2	D3	A3	L			

[A] IMPORTANT—Test specimen must be removed from unitizing bag before conducting test.
[B] Test specimen must be placed in the unitizing bag before performing test.
[C] DO NOT use if package and/or product are not affected by pressure change.

9.5 *Condition Samples*—See Section 6.

9.6 *Perform Tests*—Perform tests as directed in reference ASTM standards and as further modified in the special instructions for each test schedule.

9.7 *Evaluate Results*—Evaluate results to determine if the shipping units meet the acceptance criteria. See Section 7.

9.8 *Document Test Results*—Document test results by reporting each step. See Section 18.

9.9 *Monitor Shipments*—When possible, obtain feedback by monitoring shipments of the container that was tested to ensure that the type and quantity of damage obtained by the laboratory testing correlates with the damage that occurs in the distribution cycle. This information is very useful for the planning of subsequent tests of similar shipping containers.

10. Schedule A (A1, A2, A3, and A4)—Handling

10.1 *Handling*—The test levels and the test method for this schedule of the distribution cycle are intended to determine the ability of the shipping unit to withstand the hazards occurring during transport, such as loading, unloading, stacking, sorting, pickup, and delivery. The main hazards from these operations are shocks caused by impacts with other packages or solid objects and/or free-fall drops. Size, weight, and shape of the shipping unit will affect the intensity of these hazards. Two test method options are permitted, free fall and simulated drop test using shock machines. While the two methods produce similar results, the shock machine method produces more control of orientations of impact; see Test Method D5487 for limitations of the shock machine method.

10.1.1 For purposes of this procedure, the bottom of a parcel is the surface on which the parcel rests in its most stable orientation and is not dependent upon label or orientation arrows (see 5.4).

10.1.2 Recommended drop heights, number of drops, the sequence of drops, and the shipping unit orientation at impact for each test schedule sequence are shown in Table 2.

11. Schedule D (D1, D2, and D3)—Vibration

11.1 The test levels and test methods for these test schedules are intended to determine the ability of shipping units to withstand the vibration conditions that exist in the distribution environment and the dynamic compressive forces resulting from mixed commodity loads in a trailer. The test levels and methods account for the magnitude, frequency range, duration, and direction of vibration. If more detailed information is available on the transport vibration environment or the damage history of the shipping unit, it is recommended that the following vibration procedure be modified to use such information.

11.2 *Schedule D1—Vibration Under Compressive Load*—For all shipping units except for bagged.

11.2.1 A compressive load is to be placed on the top surface of the test specimen during each sequence of the vibration test to simulate a mixed commodities load on top of the shipping unit during transport.

11.2.2 Calculate the compressive load for each of the three testing orientations using the formula in 11.2.3 and distribute the load evenly over the entire surface of the parcel.

NOTE 1—To prevent unnecessary damage to the test sample due to the calculated weight shifting and/or bouncing during the vibration, it is permissible to secure the weight to the sample. This can be performed with the use of several lightly wrapped layers of the stretch film. Side supports can also be used as long as they do not affect the compressive performance of the test sample.

11.2.3 *Compressive Load Calculation:*

TABLE 2 Recommended Drop Test Sequence and Drop Heights

Sequence A1						
Orientation	1-70 lb			71-150 lb		
	A.L. I	A.L. II	A.L. III	A.L. I	A.L. II	A.L. III
Edge 3–4	20 in. (508 mm)	14 in. (356 mm)	12 in. (305 mm)	16 in. (406 mm)	12 in. (305 mm)	8 in. (203 mm)
Edge 3–6	20 in. (508 mm)	14 in. (356 mm)	12 in. (305 mm)	16 in. (406 mm)	12 in. (305 mm)	8 in. (203 mm)
Corner 3–4–6	20 in. (508 mm)	14 in. (356 mm)	12 in. (305 mm)	16 in. (406 mm)	12 in. (305 mm)	8 in. (203 mm)
Face 3	20 in. (508 mm)	14 in. (356 mm)	12 in. (305 mm)	16 in. (406 mm)	12 in. (305 mm)	8 in. (203 mm)
Corner 2–3–5	26 in. (660 mm)	20 in. (508 mm)	16 in. (406 mm)	20 in. (508 mm)	16 in. (406 mm)	12 in. (305 mm)
Edge 4–6	26 in. (660 mm)	20 in. (508 mm)	16 in. (406 mm)	20 in. (508 mm)	16 in. (406 mm)	12 in. (305 mm)
Sequence A2						
Orientation	1-70 lb			71-150 lb		
	A.L. I	A.L. II	A.L. III	A.L. I	A.L. II	A.L. III
Edge 2–3	26 in. (660 mm)	20 in. (508 mm)	16 in. (406.4 mm)	20 in. (508 mm)	16 in. (406.4 mm)	12 in. (305 mm)
Corner 2–3–6	26 in. (660 mm)	20 in. (508 mm)	16 in. (406.4 mm)	20 in. (508 mm)	16 in. (406.4 mm)	12 in. (305 mm)
Edge 2–5	20 in. (508 mm)	14 in. (356 mm)	12 in. (305 mm)	16 in. (406.4 mm)	12 in. (305 mm)	8 in. (203 mm)
Edge 3–5	20 in. (508 mm)	14 in. (356 mm)	12 in. (305 mm)	16 in. (406.4 mm)	12 in. (305 mm)	8 in. (203 mm)
Corner 3–4–5	20 in. (508 mm)	14 in. (356 mm)	12 in. (305 mm)	16 in. (406.4 mm)	12 in. (305 mm)	8 in. (203 mm)
Face 1	20 in. (508 mm)	14 in. (356 mm)	12 in. (305 mm)	16 in. (406.4 mm)	12 in. (305 mm)	8 in. (203 mm)
Sequence A3						
Orientation	1-70 lb			71-150 lb		
	A.L. I	A.L. II	A.L. III	A.L. I	A.L. II	A.L. III
Edge 1–2	20 in. (508 mm)	14 in. (356 mm)	12 in. (305 mm)	16 in. (406 mm)	12 in. (305 mm)	8 in. (203 mm)
Corner 1–4–6	20 in. (508 mm)	14 in. (356 mm)	12 in. (305 mm)	16 in. (406 mm)	12 in. (305 mm)	8 in. (203 mm)
Edge 3–4	26 in. (660 mm)	20 in. (508 mm)	16 in. (406 mm)	20 in. (508 mm)	16 in. (406 mm)	12 in. (305 mm)
Edge 3–6	26 in. (660 mm)	20 in. (508 mm)	16 in. (406 mm)	20 in. (508 mm)	16 in. (406 mm)	12 in. (305 mm)
Corner 3–4–6	26 in. (660 mm)	20 in. (508 mm)	16 in. (406 mm)	20 in. (508 mm)	16 in. (406 mm)	12 in. (305 mm)
Face 3	38 in. (965 mm)	32 in. (813 mm)	20 in. (508 mm)	26 in. (660 mm)	24 in. (610 mm)	20 in. (508 mm)

Sequence A4 (for bagged smalls only)	
Orientation	Drop Height
Face 3	14 in. (356 mm)
Face 1	14 in. (356 mm)
Face 2	14 in. (356 mm)
Face 6	20 in. (508 mm)
Face 4	20 in. (508 mm)
Face 3	32 in. (813 mm)

$$L = Mf \times J \times ((l \times w \times h)/K) \times ((H - h)/h) \times F \quad (1)$$

where:

L = minimum required test load = lb (N),
Mf = shipping cargo density factor = 12.0 lb/ft^3 (192.22 kg/m^3),
J = conversion factor = 1 lbf per lb (9.8 N/kg),
l = length of shipping unit = in. (m),
w = width of shipping unit = in. (m),
K = conversion factor = 1728 in.^{3}/ft^3 (1 m^3/1 m^3),
H = maximum stack height = 108.0 in. (2.74 m),
h = height of shipping unit as tested = in. (m), and
F = 0.5.

11.2.3.1 Use the calculated compressive load, rounded up to the nearest whole number, unless one of the following conditions exists:

(1) If the compressive load calculation is less than 25 lb (11.3 kg), do not use a compressive load during the vibration test.

(2) If the compressive load calculation is more than 300 lb (137 kg), use 300 lb as the compressive load for the vibration testing.

11.2.4 Perform the test with Face 1 or 3 down for 60 min, Face 2 or 4 down for 30 min and Face 5 or 6 down for 30 min.

11.2.5 Recommended intensity for the random test is given in 11.5.

11.3 *Schedule D2—Vibration Under Compressive Load*—For *small* shipping units bagged for transport (TS-1).

11.3.1 Place the test specimen unitizing bag on the center of the vibration table with Face 1 or 3 in the down orientation. Place another unitizing bag, which is filled with 80 lb (37 kg) of sand (recommend using ten individual 8-lb (3.6 kg) bags of sand), distributed evenly on top of the test specimen.

11.3.2 Perform test for 30 min using the recommended intensity for the random test in 11.5.

11.3.3 Rotate the unitizing bag 90° so Face 2 or 4 is in the down orientation then reposition the second unitizing bag loaded with 80 lb (37 kg) on top of the test specimen.

11.3.4 Perform test for 30 min using the recommended intensity for the random test in 11.5.

11.4 *Schedule D3—Vibration Without a Compressive Load:*

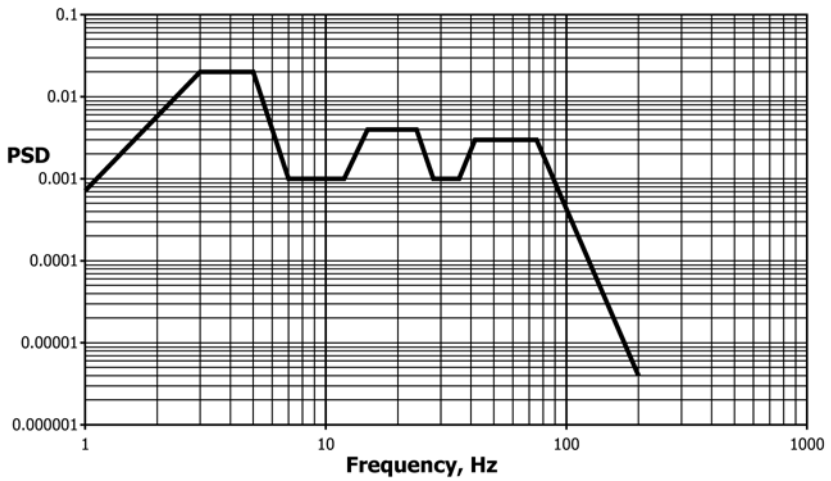
11.4.1 Center test specimen on vibration table with Face 3 of the test specimen in the down orientation. Perform test for 30 min using the random vibration profile provided in 11.6.

11.5 *D1 and D2—Random Vibration Test—Over the Road Trailer:*

11.5.1 *Special Instructions*—The power spectral densities shown in Fig. 5, as defined by their mode of transport, frequency and amplitude breakpoints, and test durations are recommended in 11.2.4 and 11.3.4. See Note 2.

NOTE 2—See Bibliography items (3) and (4) for source of technical rationale for psd profile.

11.6 *D3—Random Vibration Test—Pick-up and Delivery Vehicle:*



Frequency Hz	Power Spectral Density Level, g^2/Hz
1	0.0007
3	0.02
5	0.02
7	0.001
12	0.001
15	0.004
24	0.004
28	0.001
36	0.001
42	0.003
75	0.003
200	0.000004
Overall, g rms	0.53

FIG. 5 Power Spectral Densities—Over the Road Trailer

11.6.1 *Special Instructions*—The power spectral densities shown in Fig. 6, as defined by their mode of transport, frequency and amplitude breakpoints, and test durations are recommended in 11.4.1. See Note 2.

12. Schedule I—Bridge Impact

12.1 This test method is intended to determine the capability of a long package with a narrow cross-section to resist impact near its center when the package is supported only at its ends. This method allows the operator to select from two test options: Option A employs the use of a free-fall drop tester, and Option B employs the use of simulated mechanical impact testing equipment (SMITE). The two procedures are designed to impart the same amount of kinetic energy at impact; therefore each procedure yields the same damage producing potential.

12.2 Materials shipped in long, narrow packages are liable to damage as a result of impact near their midpoint when only the ends are supported. This type of damage can occur during shipment of packaging of mixed dimensions. It is particularly prevalent during conveyer line transport and sortation. This test method provides a means of determining resistance to such damage.

12.3 *Test Method D5265:*

12.3.1 *Special Instructions*—This method is designed to simulate a package of specific weight impacting another package with an equivalent force of 12 ft-lb (16.3 J). Studies of the shipping environment being simulated here have shown that a majority of package to package impacts occur from an angle edge. Therefore, this test should be performed with the angle edge of the impacting missile. This is different from the method described in Test Method D5265.

13. Schedule J—Hazard Drop

13.1 The test levels and test methods for this schedule is intended to determine the ability of shipping units to withstand impacts to the center of large flat faces.

13.2 *Option A—Free-Fall Drop Tester:*

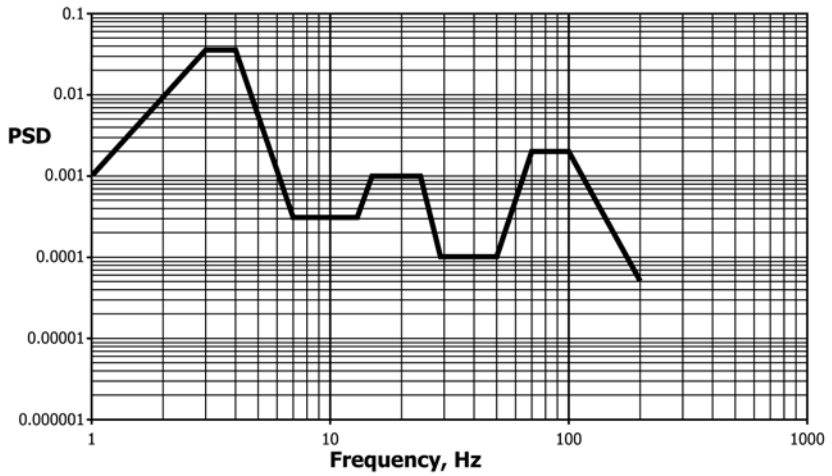
13.2.1 *Impactor*—Composed of hardwood, with a mass of 9.0 ± 0.4 lb (4.1 ± 0.2 kgw) and dimensions of 12 × 12 × 12 in. (300 × 300 × 300 mm). The impactor shall have at least one bottom edge covered by angle iron. The box shall be filled with the specified weight and void fill to keep the weight in place.

13.2.2 Place the test specimen on a rigid surface such as steel or concrete so that one of the largest faces is facing up. Find the geometric center of the box. Draw a pencil line parallel to the longest dimension on the face and across the midpoint of the shortest dimension of the face—this identifies the center of the large face.

13.2.3 Position the impactor above the drop table or sling it suitably so that the following conditions are met:

13.2.3.1 The edge of the impactor strikes the center of the package, as identified above.

13.2.3.2 The bottom edge of the impactor is the required drop height above the upper surface of the package being tested.



Frequency Hz	Power Spectral Density Level, g^2/Hz
1	0.001
3	0.035
4	0.035
7	0.0003
13	0.0003
15	0.001
24	0.001
29	0.0001
50	0.0001
70	0.002
100	0.002
200	0.00005
Overall, g rms	0.46

FIG. 6 Power Spectral Densities—Pick-up and Delivery Vehicle

TABLE 3 Bridge Impact Testing Data

Option A—Free-Fall Method		
Drop Height of Missile, 9.0 lb (4.1 kg)	V_i	Kinetic Energy
16.0 in. (406 mm)	111 in./s (2.8 m/s)	12 ft-lb (16.3 J)
Option B—SMITE		
Drop Height of Missile, 50 lb (22.68 kg)	V_i	Kinetic Energy
4.5 in. (114.3 mm)	58.94 in./s (1.49 m/s)	18.75 ft-lb (25.4 J)

13.2.4 Drop the impactor from a free-fall drop height sufficient to produce a specified impact velocity. Recommended impact velocities are provided in 13.2.6. Due to energy conservation, the potential energy before drop is equal to the kinetic energy at impact.

13.2.5 Equate an impact velocity to a free-fall drop height, or vice versa, as follows:

$$h = V_i^2/2g \quad \text{(solving for free} - \text{fall drop height)}$$
$$V_i = \sqrt{2\,gh} \quad \text{(solving for impact velocity)}$$

where:

h = free-fall drop height, in.(m),
V_i = measured impact velocity, in./s (m/s), and
g = acceleration due to gravity, 386 in./s (9.8 m/s)

13.2.6 See Table 4 for recommended drop heights of impactor.

14. Schedule K—High Altitude

14.1 The test levels and test methods for this section is intended to determine the effects of pressure differential when packaged products are transported via certain modes of transport (such as feeder aircraft or ground over high mountain passes). The results of the tests are intended to be used for qualitative purposes.

14.2 *Test Method D6653:*

14.2.1 This test should be included for products and packages that could be sensitive to a low pressure environment, for example, sealed flexible non-porous packages, liquid containers, or porous packages that may be packed in such a manner as to be adversely affected by low pressure environments. This test may be deleted from the DC when testing shipping units contain primary packages that have a porous material (porous packaging material is defined in Terminology F1327).

14.2.2 Test the packages to the expected altitude levels encountered during shipment. If these are not known precisely, use levels recommended by Test Method D6653 of pressure equivalent to 14 000 ft (4267 m) for a period of 60 min. The test duration and pressure levels may be modified based on knowledge of the shipping environment, product value, desired damage level acceptances, or other criteria as described in Test Method D6653.

TABLE 4 Hazard Drop Testing Data

Option A—Free-Fall Method		
Drop Height of Missile, 9.0 lb (4.1 kg)	V_i	Kinetic Energy
16.0 in. (406 mm)	111 in./s (2.8 m/s)	12 ft-lb (16.3 J)

15. Schedule L—Concentrated Impacts

15.1 The test method is intended to evaluate the ability of packaging to resist the force of concentrated impacts from outside sources, such as those encountered in various modes of transportation and handling. These impacts may be inflicted by adjacent freight jostling against the package in a carrier vehicle, by accidental bumps against other freight when loaded or unloaded from vehicles, by packages bumping against one another during sorting on conveyors or chutes, or many other circumstances.

15.2 *Test Method D6344:*

15.2.1 This test method covers procedures and equipment for testing complete filled transport packages for resistance against concentrated low-level impacts typical to those encountered in the single parcel shipping environment. The test is most appropriate for packages such as thin fluted/lighter grade corrugated boxes.

15.2.2 This test method is intended to determine the ability of packaging to protect contents from such impacts, and to evaluate if there is sufficient clearance or support or both between the package wall and its contents.

15.2.3 *Special Instructions*—Vertical fall distance of the impacting mass shall be 36 in. (914.4 mm). The test should be conducted on the geometric center of any face of the shipping container where there is possibility of the mass deflecting the container wall sufficiently that the mass will damage the surface of the packaged item. It is acceptable to impact the center of a taped seam instead of the geometric center of a face.

16. Schedule M—Tip Over Test

16.1 *Test Methods D6179 (Method G):*

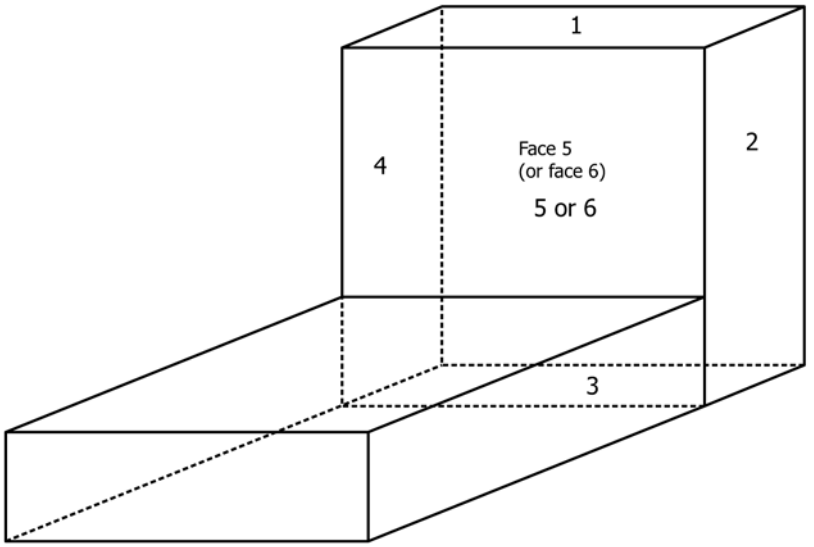
16.1.1 Use a case or crate fully loaded with the actual contents. If use of actual contents is not practical, a dummy load of the same total mass, size, and weight distribution may be substituted. The contents or simulated load shall be blocked, braced, and cushioned in place and the package closed normally as for shipment.

16.1.2 Place the test item in the predetermined attitude on the impact surface (such as standing on its base or one of its smaller faces).

16.1.3 The test item shall be slowly tipped until it falls freely without thrust onto the face opposite that of load application.

16.1.4 Examine the test item and record any external signs of damage.

16.1.5 Repeat the test with the test item standing on, or impacting onto other appropriate faces. In the case of tall test items, the repeat tests shall be carried out with the test item standing on its normal base and toppling onto each side face in turn (see Fig. 7). In the case of flat test items (or tall test items where the normal base is not defined), the tests shall be carried out with the test item standing on each smaller face in turn and impacting onto each of the larger faces.



Stand on Face	Tilt over Edge	Topple onto Face
1	1–5	5
2	2–5	5
3	3–5	5
4	4–5	5
1	1–6	6
2	2–6	6
3	3–6	6
4	4–6	6

Stand on Face	Tilt over Edge	Topple onto Face
1	1–5	5
2	2–5	5
3	3–5	5
4	4–5	5
1	1–6	6
2	2–6	6
3	3–6	6
4	4–6	6

FIG. 7 Test Sequence for Flat Cases and Crates

17. Schedule N—Rotational Edge Drop Test

17.1 *Test Methods D6179 (Method A):*

17.1.1 Raise one end of the case or crate and set it upon a timber or other support, placed at right angles to the length of the case or crate. The height of the support shall be sufficient to ensure that there will be no support for the base between the ends of the test item when dropping takes place, but should not be high enough to cause the test item to slide on the support when the drop end is raised for the drop. Raise the other end of the test item successively to prescribed heights and release to fall freely on the impact surface. Where test items are tall or top heavy, provision must be made to prevent the test item from tipping over after the drop is made.

17.1.2 Perform one rotational edge drop from each opposite supported edge.

17.1.3 Use the following drop heights:

	Drop Height (in.) Assurance Levels		
Gross Weight	I	II	III
0–100 lb (0–45.4 kg)	24 in. (610 mm)	18 in. (457 mm)	12 in. (305 mm)
101–150 lb (45.4–68 kg)	12 in. (305 mm)	9 in. (229 mm)	6 in. (127 mm)

18. Report

18.1 Report fully all the steps taken. At a minimum, the report should include:

18.1.1 Reference to this practice,

18.1.2 Description of product and shipping unit,

18.1.3 Package test specimen and test plan,

18.1.4 Assurance levels and rationale,

18.1.5 Number of samples tested,

18.1.6 Conditioning used,

18.1.7 Acceptance criteria,

18.1.8 Vibration option used, random or sine,

18.1.9 Random vibration power spectral density plot, if used,

18.1.10 Variation from recommended procedures,

18.1.11 Condition of specimens after test,

18.1.12 Party performing testing, and

18.1.13 Testing facility used.

19. Precision and Bias

19.1 The precision and bias of this practice are dependent on those of the various test methods used, and cannot be expressly determined.

20. Keywords

20.1 compression test; distribution cycle; distribution environment; drop test; mechanical handling; package; package test specimen; packaging; random vibration; shipping container; shipping unit; single parcel; vibration

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