Standard Practice for Performance Testing of Shipping Containers and Systems

This standard is issued under the fixed designation D 4169; 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 (e) 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 to withstand the distribution environment. This is accomplished by subjecting them to a test plan consisting of a sequence of anticipated hazard elements encountered in various distribution cycles. This practice is not intended to supplant material specifications or existing preshipment test procedures.

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

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 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:

D 642 Test Method for Determining Compressive Resistance of Shipping Containers, Components, and Unit Loads
D 880 Test Method for Impact Testing for Shipping Containers and Systems
D 951 Test Method for Water Resistance of Shipping Containers by Spray Method
D 996 Terminology of Packaging and Distribution Environments
D 999 Test Methods for Vibration Testing of Shipping Containers
D 4003 Methods of Programmable Horizontal Impact Test for Shipping Containers
D 4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing
D 4728 Test Method for Random Vibration Testing of Shipping Containers
D 5276 Test Method for Drop Test of Loaded Containers by Free Fall
D 5277 Test Method for Performing Programmed Horizontal Impacts Using an Inclined Tester
D 5487 Test Method for Simulated Drop of Loaded Containers by Shock Machines
D 6055 Test Methods for Mechanical Handling of Unitized Loads and Large Shipping Cases and Crates
D 6179 Test Methods for Rough Handling of Unitized Loads and Large Shipping Cases and Crates

2.2 Military Standards:

MIL-STD-2073-1 DOD Standard Practice for Military Packaging

3. Terminology

3.1 Definitions— General definitions for the packaging and distribution environments are found in Terminology D 996.

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 distribution cycle. Level I is a high level of test intensity and has a low probability of occurrence. Level III is a low level of test intensity, but has a correspondingly high probability of occurrence. Level II is between these extremes. For Distribution Cycle 18, DC-18 see MIL-STD-2073-1 for definitions of military levels of protection.

3.2.3 coefficient of restitution—the ratio of the rebound velocity to the impact velocity.

3.2.4 distribution cycle (DC)—the sequential listing of the test schedules employed to simulate the hazard elements.
expected to occur for a specific routing of a shipping unit from production to consumption. See Table 1.

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

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

3.2.6.1 small shipping unit—for DC-18, a small shipping unit is defined as one having no edge dimension or diameter over 60 in. (1.52 m) and a gross weight of 150 lb (68 kg) or less.

3.2.6.2 large shipping unit—for DC-18, a large shipping unit is defined as one having at least one edge dimension or diameter over 60 in. (1.52 m) or a gross weight in excess of 150 lb (68 kg), or it is one that has a gross weight exceeding 100 lb (45 kg) and is secured to a base or to the base of a shipping unit.

3.2.7 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 8.5.

3.2.8 test schedule—the specific procedure to be used, including the three assurance level intensities, and a reference to the test method that is the basis of the schedule.

3.2.8.1 Discussion—The purpose of the schedule is to simulate the forces occurring during any hazard element of the distribution cycle. See Section 9.

3.2.9 total velocity change, \( \Delta V \)—the sum of the impact and rebound velocities.

3.3 Abbreviations:

3.3.1 TOFC—trailer on flatcar.

3.3.2 COFC—container on flatcar.

3.3.3 TL—trucking load.

3.3.4 CL—carload.

3.3.5 LTL—less than truckload.

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 (1-13). 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.

4.2 For Distribution Cycle 18, as referred to in MIL-STD–2073–1, the use of this practice is defined in subsequent sections identified as DC-18.

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 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 avoid unnecessary prehandling.

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.

6. Conditioning

6.1 If the distribution cycle contains climatic conditions that have an effect on the performance characteristics of the product, shipping container, or components such as cushioning, use one of the following procedures. (It should be noted that different atmospheric conditions are likely to exist between the origin and destination points of a distribution cycle, particularly for export/import cycles.):

6.1.1 Conduct the test at standard conditions and compensate for the effects of any climatic condition. Condition the shipping units to a standard atmosphere of \( 73.4 \pm 2^\circ F \) (23 \( \pm 1^\circ C \)) and 50 \( \pm 2 \% \) relative humidity. Condition fiberboard containers in accordance with Practice D 4332. The same atmospheric condition should be used for any assurance level. 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.

6.1.2 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 D 4332, or Test Method D 951, or others (salt, spray, water immersion, humidity, or temperature). The same climatic condition should be used for any assurance level. 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 as necessary during the test plan. For atmospheres other than the Standard Conditioning Atmosphere, the user must determine the appropriate...
<table>
<thead>
<tr>
<th>DC</th>
<th>Distribution Cycle</th>
<th>First</th>
<th>Second</th>
<th>Third</th>
<th>Fourth</th>
<th>Fifth</th>
<th>Sixth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General Cycle—undefined distribution system</td>
<td>Schedule A Handling</td>
<td>Schedule D Stacked Vibration</td>
<td>Schedule F Loose-Load Vibration</td>
<td>Schedule G Rail Switching</td>
<td>Schedule A Handling</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Specially defined distribution system, user specified (see Appendix X2) select from Schedules A through H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Single package environment, up to 100 lb (45.4 kg)</td>
<td>Schedule A Handling</td>
<td>Schedule C Vehicle Stacking</td>
<td>Schedule F Loose-Load Vibration</td>
<td>Schedule E Vehicle Vibration</td>
<td>Schedule A Handling</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Motor freight, single package over 100 lb (45.4 kg)</td>
<td>Schedule A Handling</td>
<td>Schedule C Vehicle Stacking</td>
<td>Schedule F Loose-Load Vibration</td>
<td>Schedule E Vehicle Vibration</td>
<td>Schedule A Handling</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Motor freight, TL, not unitized</td>
<td>Schedule A Handling</td>
<td>Schedule D Stacked Vibration</td>
<td>Schedule E Vehicle Vibration</td>
<td>Schedule A Handling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Motor freight, TL, or LTL—unitized</td>
<td>Schedule A Handling</td>
<td>Schedule D Stacked Vibration</td>
<td>Schedule A Handling</td>
<td>Schedule B Warehouse Stacking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Rail only, bulk loaded</td>
<td>Schedule A Handling</td>
<td>Schedule D Stacked Vibration</td>
<td>Schedule G Rail Switching</td>
<td>Schedule A Handling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Rail only, unitized</td>
<td>Schedule A Handling</td>
<td>Schedule D Stacked Vibration</td>
<td>Schedule G Rail Switching</td>
<td>Schedule A Handling</td>
<td>Schedule B Warehouse Stacking</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Rail and motor freight, not unitized</td>
<td>Schedule A Handling</td>
<td>Schedule C Vehicle Stacking</td>
<td>Schedule E Vehicle Vibration</td>
<td>Schedule G Rail Switching</td>
<td>Schedule F Loose-Load Vibration</td>
<td>Schedule A Handling</td>
</tr>
<tr>
<td>10</td>
<td>Rail and motor freight, unitized</td>
<td>Schedule A Handling</td>
<td>Schedule D Stacked Vibration</td>
<td>Schedule G Rail Switching</td>
<td>Schedule A Handling</td>
<td>Schedule B Warehouse Stacking</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Rail, TOFC and COFC</td>
<td>Schedule A Handling</td>
<td>Schedule G Rail Switching</td>
<td>Schedule D Stacked Vibration</td>
<td>Schedule F Loose-Load Vibration</td>
<td>Schedule A Handling</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Air (intercity) and motor freight (local), over 100 lb (45.4 kg), unitized</td>
<td>Schedule A Handling</td>
<td>Schedule D Stacked Vibration</td>
<td>Schedule E Vehicle Vibration</td>
<td>Schedule A Handling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Air (intercity) and motor freight (local, single package up to 100 lb (45.4 kg)</td>
<td>Schedule A Handling</td>
<td>Schedule C Vehicle Stacking</td>
<td>Schedule F Loose-Load Vibration</td>
<td>Schedule E Vehicle Vibration</td>
<td>Schedule A Handling</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Warehousing (partial cycle to be added to other cycles as needed)</td>
<td>Schedule A Handling</td>
<td>Schedule B Warehouse Stacking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Export/Import shipment for intermodal container or roll on/roll off trailer (partial cycle to be added to other cycles as needed)</td>
<td>Schedule A Handling</td>
<td>Schedule C Vehicle Stacking</td>
<td>Schedule A Handling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Export/Import shipment for palletized cargo ship (partial cycle to be added to other cycles as needed)</td>
<td>Schedule A Handling</td>
<td>Schedule C Vehicle Stacking</td>
<td>Schedule A Handling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Export/Import shipment for break bulk cargo ship (partial cycle to be added to other cycles as needed)</td>
<td>Schedule A Handling</td>
<td>Schedule C Vehicle Stacking</td>
<td>Schedule A Handling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Non-Commercial Government shipments per MIL-STD-2073-1</td>
<td>Schedule A Handling</td>
<td>Schedule B or Schedule C Handling</td>
<td>Schedule A Handling</td>
<td>Schedule H Environmental Hazard</td>
<td>Schedule F Loose-Load Vibration</td>
<td>Schedule A Handling</td>
</tr>
</tbody>
</table>

\* For DC-18, perform the stacking test that results in the highest computed load value.
compressive load factor for warehouse and vehicle stacking, as
the factors given in 11.2 are based on testing under the
Standard test atmosphere.

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 con-
tainers whose shipping history is known.

7.2 In many cases, the acceptance criteria can be the fol-
lowing:
   Criterion 1—Product is damage–free.
   Criterion 2—Package is intact.
   Criterion 3—Both criteria 1 and 2.

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. Procedure

8.1 Define Shipping Unit—Describe shipping unit in terms
of size, weight, and form of construction. See 3.2.6. Determine
whether the container will be manually or mechanically
handled.

8.2 Establish Assurance Level—Specify a level of test
intensity. The level should be one of three pre–established
assurance levels. This must be pre–established based on the
product value, the desired level of anticipated damage that can
be tolerated, the number of units to be shipped, knowledge of
the shipping environment, or other criteria. Assurance Level II
is suggested unless conditions dictate otherwise. Assurance
Level I provides a more severe test than II. Assurance Level III
provides a less severe test than II. The assurance level may be
varied between schedules (see Sections 10-15) if such varia-
tions are known to occur. The test levels used should be
reported. See Section 16.

8.3 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.

8.4 Select Distribution Cycle—Select a Distribution Cycle
from the available standard distribution cycles compiled in
Table 1. Use the DC that most closely correlates with the
projected distribution. When the distribution is undefined,
the general distribution cycle DC–1 should be selected. When
the anticipated distribution is well understood, a special distribu-
tion cycle DC–2 may be specified. In using DC–2, the user
selects test schedules from Section 9 and specifies the test
sequence (see Appendix X2 for more details).

8.5 Write Test Plan— Prepare a test plan by using the
sequence presented in Table 1 for the distribution cycle
selected. Obtain the test intensities from the referenced sched-
ules. The test plan intensity details must take into account the
assurance levels selected as well as the physical description of
the shipping unit. Table 1 thus leads to a detailed test plan
consisting of the exact sequence in which the shipping unit will
be subjected to test inputs. The test schedules associated
with each element reference the existing ASTM test methods
for clarification of the equipment and techniques to be used to
conduct the test.

8.5.1 Sample test plans are provided in Appendix X1.
8.6 Select Samples for Test—See Section 5.
8.7 Condition Samples—See Section 6.
8.8 Perform Tests— Perform tests as directed in reference
ASTM standards and as further modified in the special
instructions for each test schedule.

8.9 Evaluate Results— Evaluate results to determine if the
shipping units meet the acceptance criteria. See Section 7.
8.10 Document Test Results—Document test results by
reporting each step. See Section 16.
8.11 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.

9. Test Schedules

9.1 Test Schedules are categorized as follows:

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Test Schedule</th>
<th>Hazard Element</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Handling - manual and mechanical</td>
<td>drop, impact, stability</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>Warehouse Stacking</td>
<td>compression</td>
<td>11</td>
</tr>
<tr>
<td>C</td>
<td>Vehicle Stacking</td>
<td>compression</td>
<td>11</td>
</tr>
<tr>
<td>D</td>
<td>Stacked Vibration</td>
<td>vibration</td>
<td>12</td>
</tr>
<tr>
<td>E</td>
<td>Vehicle Vibration</td>
<td>vibration</td>
<td>12</td>
</tr>
<tr>
<td>F</td>
<td>Loose Load Vibration</td>
<td>repetitive shock</td>
<td>13</td>
</tr>
<tr>
<td>G</td>
<td>Rail Switching</td>
<td>longitudinal shock</td>
<td>14</td>
</tr>
<tr>
<td>H</td>
<td>Environmental Hazard</td>
<td>cyclic exposure</td>
<td>15</td>
</tr>
</tbody>
</table>

10. Schedule A–Handling—Manual and Mechanical

10.1 There are two types of handling hazard, manual and
mechanical. The manual handling test should be used for single
containers, small parcels, and any shipping container that can
be handled manually, up to a weight of 200 lb (90.7 kg).
Mechanical handling should be used for unitized loads, large
cases and crates, and any shipping container or system that will
be handled by mechanical means. Manual and mechanical
handling are described further in 10.2 and 10.3.

10.2 Manual 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 manual handlings, such as loading,
unloading, stacking, sorting, or palletizing. The main hazards
from these operations are the impacts caused by dropping or
throwing. 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 D 5487 for limitations of the shock
machine method.
10.2.1 For purposes of this procedure, the bottom of a small parcel is the surface on which the parcel rests in its most stable orientation.

10.2.2 Mechanical handling (10.3) may be used when it is anticipated that handling will be by mechanical means only.

10.2.3 Recommended drop heights, the number of drops, the sequence of drops, and the shipping unit orientation at impact are as follows:

Test Method D 5276, D 5487.

**Conditioning**—See Section 6.

<table>
<thead>
<tr>
<th>Shipping Weight, lb (kg)</th>
<th>Drop Height, in. (mm)</th>
<th>Assurance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>0 to 20 (0 to 9.1)</td>
<td>24 (610)</td>
<td>15 (381)</td>
</tr>
<tr>
<td>20 to 40 (9.1 to 18.1)</td>
<td>21 (533)</td>
<td>13 (330)</td>
</tr>
<tr>
<td>40 to 60 (18.1 to 27.2)</td>
<td>18 (457)</td>
<td>12 (305)</td>
</tr>
<tr>
<td>60 to 80 (27.2 to 36.3)</td>
<td>15 (381)</td>
<td>10 (254)</td>
</tr>
<tr>
<td>80 to 100 (36.3 to 45.4)</td>
<td>12 (305)</td>
<td>9 (229)</td>
</tr>
<tr>
<td>100 to 200 (45.4 to 90.7)</td>
<td>10 (254)</td>
<td>7 (178)</td>
</tr>
</tbody>
</table>

**Number of Impacts at Specified Height**

<table>
<thead>
<tr>
<th>Impact Orientation - First Sequence of Distribution Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box</td>
</tr>
<tr>
<td>One top adjacent bottom edges</td>
</tr>
<tr>
<td>Two</td>
</tr>
<tr>
<td>One bottom</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Impacts at Specified Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>One top corner and one adjacent top edge</td>
</tr>
</tbody>
</table>

**Note 1**—On the last impact of the last manual handling sequence in a distribution cycle, the impact should be made at twice the specified height or equivalent velocity change. (This is the final (sixth) drop in the sequence, not an additional drop.) The drop should be in the impact orientation most likely for a drop to occur, usually the largest face or the bottom. For distribution cycles where any drop orientation is possible (that is, small–parcel environment), this drop should be in the most critical or damage–prone orientation, as defined in Test Method D 5276.

**Note 2**—The equivalent velocity change corresponding to the specified drop height used for the shock machine method shall be calculated as specified in Test Method D 5487.

10.2.4 DC-18—Description of this schedule is in accordance with 10.2.3, except that the height of the last impact of the last manual handling sequence is the same as all other impacts (ignore Note 1). Use the first sequence impact orientations for the third handling schedule in DC–18. Use Mechanical Handling (10.3) for large shipping units (see 3.2.6.2). Test small shipping units (see 3.2.6.1) using the following test levels:

<table>
<thead>
<tr>
<th>Shipping Weight, lb (kg)</th>
<th>Drop Height, in. (mm)</th>
<th>Assurance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>0 to 30 (0 to 13.6)</td>
<td>30 (762)</td>
<td>24 (610)</td>
</tr>
<tr>
<td>over 30 to 75 (to 34)</td>
<td>24 (610)</td>
<td>18 (457)</td>
</tr>
<tr>
<td>over 75 to 150 (to 68)</td>
<td>18 (457)</td>
<td>15 (381)</td>
</tr>
</tbody>
</table>

10.3 Mechanical Handling—The test levels and the test method for this schedule of the distribution cycle are intended to determine the ability of large and heavy shipping units and unitized loads to withstand the mechanical handling hazards that occur during loading, unloading, sorting, or stacking. Different test methods are used for large shipping cases and crates versus unit loads. For various types of unit loads, test methods also vary, depending on the method of truck handling: fork, clamp, spade, or pull/pack.

10.3.1 Large Shipping Cases and Crates—Perform the following test sequences:

Test Method—D 6179, D 880, D 4003.

**Conditioning**—See Section 6.

10.3.1.1 Fork Lift Truck Handling—One drop on each opposite base edge in accordance with Method C of Test Methods D 6179 and one drop on each of two opposite base corners in accordance with Method B of Test Methods D 6179.

**Conditioning**—See Section 6.

10.3.1.2 Crane Handling—One drop flat on bottom and one drop on base edge in accordance with Method D of Test Methods D 6179. Use the same drop heights versus shipping unit weight as in 10.3.1.1.

10.3.1.3 Side Impact Test—Impact all four sides of the shipping unit in accordance with Test Method D 880, Procedure B. Alternately, use Test Method D 4003 Method B using a short duration programmer, assuming the coefficient of restitution is 0.0 and the total velocity change is equivalent to the specified impact velocity.

10.3.1.4 Tip Test—In accordance with Method F of Test Methods D 6179.

10.3.1.5 Tipover Test—In accordance with Method G of Test Methods D 6179.

10.3.2 Unitized Loads—Perform the following tests sequences as appropriate for the method of truck handling:

Test Method—D 880, D 4003, D 6055, D 6179.

**Conditioning**—See Section 6.

10.3.2.1 All Methods of Truck Handling—Pick up, transport around test course, and set down in accordance with Test Methods 6055, Method A for fork lift, Method B for spade lift, Method C for clamp, and Method D for pull pack.

<table>
<thead>
<tr>
<th>Assurance Level</th>
<th>Impact Velocity fts/m(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>5.75 (1.75)</td>
</tr>
<tr>
<td>II</td>
<td>4.0 (1.22)</td>
</tr>
<tr>
<td>III</td>
<td>3.0 (0.91)</td>
</tr>
</tbody>
</table>

10.3.2.2 All Methods of Truck Handling—Impact all four sides of the shipping unit in accordance with Test Method D 880 Procedure B. Alternately, use Test Method D 4003 Method B using a short duration programmer, assuming the coefficient of restitution is 0.0 and the total velocity change is equivalent to the specified impact velocity.

<table>
<thead>
<tr>
<th>Assurance Level</th>
<th>Impact Velocity fts/m(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>5.75 (1.75)</td>
</tr>
<tr>
<td>II</td>
<td>4.0 (1.22)</td>
</tr>
<tr>
<td>III</td>
<td>3.0 (0.91)</td>
</tr>
</tbody>
</table>
10.3.2.3 **Fork Lift Truck Handling**—One drop on each opposite base edge in accordance with Method C of Test Methods D 6179.

<table>
<thead>
<tr>
<th>Gross Weight, lb (kg)</th>
<th>Drop Height, in. (mm) Assurance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>over 500 (0 to 226.8)</td>
<td>12 (305) 9 (229) 6 (152) 3 (76)</td>
</tr>
<tr>
<td>over 250 to 500 (to 227) or 24 (610) 18 (457)</td>
<td></td>
</tr>
<tr>
<td>over 150 to 250 (68 to 113) or 30 (762) 24 (610)</td>
<td></td>
</tr>
<tr>
<td>over 66 to 78 (to 1981) or 24 (610) 18 (457)</td>
<td></td>
</tr>
<tr>
<td>over 500 (over 226) or 18 (457) 12 (305)</td>
<td></td>
</tr>
<tr>
<td>over 250 (over 550) or 18 (457) 12 (305)</td>
<td></td>
</tr>
<tr>
<td>over 100 (over 226) or 18 (457) 12 (305)</td>
<td></td>
</tr>
<tr>
<td>over 50 (over 122) or 18 (457) 12 (305)</td>
<td></td>
</tr>
</tbody>
</table>

10.3.3 **DC–18**—For large shipping units, this schedule is intended to provide a number of testing variations describing specific mechanical handling hazards that occur in government distribution for shipping cases, crates, unitized loads, and cylindrical containers. Required tests for rectangular shipping units include: tip/tipover; fork lift truck transport; rotational drops, both edgewise and cornerwise; and lateral impacts. For Assurance Level I, shipping cases and crates and unitized loads shall also be subjected to sling handling, and shipping cases and crates shall be subjected to grabhook handling. For cylindrical shipping units, only rotational edgewise drop tests shall apply. Table 2 shall be used as a guide in determining both the required tests and the sequence to be followed.

10.3.3.1 Tests specific to government shipments include the following:

1. **Shipping Cases, Crates, and Unitized Loads—Tip/Tipover**—Shipping cases and crates shall be subjected to both tip and tipover tests for Assurance Level I, following the requirements of Test Method D 6179 Methods F and G. For unitized loads, only the tip test will be required. The tip test shall be performed for Assurance Level II for all rectangular shipping units. Tip/tipover requirements shall only be required during the first handling sequence of DC–18. The tip test is useful for determining acceptable shipping unit dimension and center of gravity. For tipover, one impact is required on each of two opposite sides, as determined by the initial side having the lowest height-to-width ratio.

2. **Shipping Cases, Crates, and Unitized Loads—Fork Lift Truck Transport**—Pick up, transport around test course as defined in Test Methods D 6055 Method A, for a total of two cycles (round trips) in the case of Assurance Level I, and one cycle for Assurance Level II. Within the minimum 100 ft (30.5 m) obstacle zone, parallel pairs of 1 by 6 in. (25 by 150 mm) boards, of a length to extend completely across the aisle and spaced 54 in. (1.37 m) apart, are laid flat at intervals of 30, 60, and 90 ft (9.1, 18.3, and 27.4 m). Board angles to the truck’s path shall be 90, 60, and 75 degrees respectively, with the left wheel striking first over the second obstacle (board pairs) and the right wheel first over the third.

3. **Shipping Cases, Crates, Unitized Loads and Cylindrical Containers—Rotational Drops**—For edge drops, use Method A of Test Methods D 6179 with a 6 in. (150 mm) height timber edge support. In the case of rectangular shipping units, drops are made on each opposite edge of the unit’s base, for a total of four impacts. For cylindrical shipping units, drops shall be made with the unit on its side, such that impacts occur on top and bottom rims at diagonally opposite quadrants. Care must be taken to prevent the container from rolling on the support. Additional impacts shall be made in the same manner in different quadrants separated by an approximate 90°, for a total of four drops. For corner drops, use Method B of Test Methods D 6179, except that one corner of the shipping unit base shall be supported on a 6 in. (150 mm) height block while the other corner on the same end or side rests on a 12 in. (300 mm) height block. Each corner will be impacted, for a total of four drops. Both edgewise and cornerwise drops shall be performed on large rectangular shipping units. For all rotational drops, test with the lowest drop height indicated by either gross weight or maximum dimension, using the following test levels:

<table>
<thead>
<tr>
<th>Gross Weight, lb (kg) or Maximum Dimension, in (mm)</th>
<th>Drop Height, in. (mm) Assurance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>over 150 to 250 (68 to 113) or 30 (762) 24 (610)</td>
<td></td>
</tr>
<tr>
<td>over 60 to 66 (1524 to 1676) or 24 (610) 18 (457)</td>
<td></td>
</tr>
<tr>
<td>over 500 to 1000 (to 454) or 18 (457) 12 (305)</td>
<td></td>
</tr>
<tr>
<td>over 78 to 90 (to 2286) or 18 (457) 12 (305)</td>
<td></td>
</tr>
<tr>
<td>over 1000 (over 454) or 18 (457) 12 (305)</td>
<td></td>
</tr>
</tbody>
</table>

4. **Shipping Cases, Crates, and Unitized Loads—Lateral Impacts**—Note that this test is to be performed only during the second handling sequence of Distribution Cycle 18. Testing shall be in accordance with Test Method D 880, Procedure B. Alternately, testing may be in accordance with Test Method D 4003, Method B, using a short duration programmer, assuming the coefficient of restitution is 0.0 and the total velocity change is equivalent to the specified impact velocity. Selection of apparatus, as defined within these test methods, shall also be at the option of the package designer/contractor. As a requirement for Assurance Level I, the impact velocity shall be 7.3 ft/s (2.23 m/s). One lateral impact shall be performed on each side (including ends) surface having a dimension less than 9.5 ft.

**TABLE 2 Mechanical Handling for DC–18, Required Tests and Sequence**

<table>
<thead>
<tr>
<th>Shipping Unit</th>
<th>Assurance Level</th>
<th>Tip</th>
<th>Tipover</th>
<th>Forklift Transport</th>
<th>Rotational Drops</th>
<th>Lateral Impacts</th>
<th>Grabhook Handling</th>
<th>Sling Handling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shopping Cases &amp; Crates</td>
<td>I</td>
<td>X</td>
<td>-</td>
<td>2 cycles</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>II</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>1 cycle</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Unitized Loads</td>
<td>I</td>
<td>X</td>
<td>-</td>
<td>2 cycles</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>II</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>1 cycle</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cylindrical</td>
<td>I</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>II</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

^a As referenced in 3.2.2, Assurance Levels I and II equate to military levels of protection A and B, respectively.

^b Test to be performed only during the first handling sequence of DC-18.

^c Test to be performed only during the second handling sequence of DC-18.

^d Test to be performed only during the third handling sequence of DC-18.
ft (2.9 m). A 4 by 4 in. (100 by 100 mm) timber, placed so as to contact the lower edge of the shipping unit, shall be used as an impacting hazard when evaluating unitized loads and demountable shipping cases.

5. Shipping Cases, Crates, and Unitized Loads—Grabhook/Sling Handling—Test shipping cases and crates for grabhook handling, in accordance with Method E of Test Methods D 6055, only for Assurance Level I. Test shipping cases, crates, and unitized loads for sling handling, per Method F of Test Methods D 6055, only for Assurance Level I. Note that this test is performed only during the third handling sequence of DC–18.

11. Schedule B - Warehouse Stacking and Schedule C–Vehicle Stacking

11.1 The test levels and the test methods for these schedules of a distribution cycle are intended to determine the ability of the shipping unit to withstand the compressive loads that occur during warehouse storage or vehicle transport. The required loading must consider the effects of length of time in storage, the alignment or stacking pattern of the container, variability in container strength, moisture content, temperature, previous handling and transportation, method of load support, and vibration. The minimum required loads for typical shipping units which include the combined effects of the above factors are recommended below for Schedule B—Warehouse Stacking and Schedule C—Vehicle Stacking (select test levels for either warehouse or vehicle stacking as defined in the distribution cycle):

Test Method D 642.
Conditioning—73.4 ± 2°F (23 ± 1°C), 50 ± 2% relative humidity in accordance with Practice D 4332.

11.2 Use the following test levels:

<table>
<thead>
<tr>
<th>F Factors Assurance Level Schedule</th>
<th>B—Warehouse</th>
<th>C—Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shipping Unit Construction</td>
<td>I II III</td>
<td>I II III</td>
</tr>
<tr>
<td>1. Corrugated, fiberboard, or plastic container that may or may not have stress-bearing interior packaging using these materials, and where the product does not support any of the load.</td>
<td>8.0 4.5 3.0 10.0 7.0 5.0</td>
<td></td>
</tr>
<tr>
<td>2. Corrugated, fiberboard, or plastic container that has stress-bearing interior packaging with rigid inserts such as wood.</td>
<td>4.5 3.0 2.0 6.0 4.5 3.0</td>
<td></td>
</tr>
<tr>
<td>3. Containers constructed of materials other than corrugated, fiberboard, or plastic that are not temperature or humidity sensitive or where the product supports the load directly, for example, compression package.</td>
<td>3.0 2.0 1.5 4.0 3.0 2.0</td>
<td></td>
</tr>
</tbody>
</table>

4. If the product supports a known portion of the load, the F factor is calculated in the following manner:

\[ F = P(F_p) + C(F_c) \]  

where:
\[ F_p \] = factor given above for compression package (construction Type 3),
\[ P \] = percent of load supported by product,
\[ F_c \] = factor given above for appropriate container construction, and
\[ C \] = percentage of load supported by container.

If a full pallet load is tested, F factors may be reduced by 30%.

11.3 For warehouse stacking and vehicle stacking made up of identical shipping units, load the shipping unit to the computed load value, as calculated below. Remove the load within 3 s after reaching the specified value.

\[ L = M \times J \frac{H - h}{h} \times F \]  

where:
\[ L \] = computed load, lbf or N,
\[ M \] = mass of one shipping unit or individual container, lb or kg,
\[ J \] = 1 lbf/lb or 9.8 N/kg,
\[ H \] = maximum height of stack in storage or transit vehicle (if vehicle stack height is unknown, use 108 in.(2.7 m)), in. or m,
\[ h \] = height of shipping unit or individual container, in. or m, and
\[ F \] = a factor to account for the combined effect of the individual factors described above.

11.4 For vehicle stacking made up of mixed commodities and shipped in an LTL or small package delivery environment, load the shipping unit to the computed load value, as calculated below. Remove the load within 3 s after reaching the specified value. If the average shipping density factor (Mf) for the specific distribution system is not known, use a value of 10 lb/ft³ (160 kg/m³).

\[ L = M_f \times J \frac{I \times w \times h}{K} \times \frac{H - h}{h} \times F \]  

where:
\[ L \] = computed load, lbf or N,
\[ M_f \] = shipping density factor, lb/ft³ or kg/m³,
\[ J \] = 1 lbf/lb or 9.8 N/kg,
\[ H \] = maximum height of stack in transit vehicle (if vehicle stack height is unknown, use 108 in.(2.7 m)), in. or m, see Note 3,
\[ h \] = height of shipping unit or individual container, in. or m,
\[ l \] = length of shipping unit or individual container, in. or m,
\[ w \] = width of shipping unit or individual container, in. or m,
\[ K \] = 1728 in.³/ft³ or 1 m³/m³, and
\[ F \] = a factor to account for the combined effect of the individual factors described above.

Note 3—The value for H, when unknown, is reduced to 54 in.(1.4 m) from 108 in.(2.7 m) for packages under 30 lb(13.6 kg) and 2.0 ft³(0.056 m³) or less in size when applied to a vehicle stacking hazard in LTL shipments.

12. Schedule D - Stacked Vibration and Schedule E - Vehicle Vibration

12.1 The test levels and test methods for these schedules of the distribution cycle are intended to determine the ability of shipping units to withstand the vertical vibration environment during transport, and the dynamic compression forces resulting from vehicle stacking. The test levels and methods account for the magnitude, frequency range, duration, and direction of
vibration. Select a Schedule D–stacked vibration or Schedule E–vehicle vibration (no stacking) test as defined by the distribution cycle. Two test method options are permitted, sine and random. The two methods are not equivalent; they will not necessarily produce the same results. The random test method results in a better simulation of actual transport vibration environments, and is the preferred method for qualification. The sine test method is often used in conjunction with the random method as a means of determining and observing system resonances.

12.2 Schedule D–Stacked Vibration—Perform the test along the vertical axis with the load in the normal shipping orientation. It is permissible to use a concentrated dead load to simulate an upper unit load or mixed commodities. The concentrated load may be calculated from the formulas in 11.3 and 11.4, with the F factor set equal to 1. Recommended intensities and durations for the random tests are given in 12.4, and those for sine tests are given in 12.5.

12.3 Schedule E–Vehicle Vibration—Perform the test for each possible shipping orientation. Recommended intensities and durations for the random tests are given in 12.4, and those for sine tests are given in 12.5.

12.4 Random Test Option:
Test Method D 4728, Method A or B.4
Conditioning—See Section 6.
Special Instructions—The following power spectral densities, as defined by their mode of transport, frequency and amplitude breakpoints, and test durations are recommended. The Truck test is recommended for Distribution Cycles 1, 3, 4, 5 and 6. The Rail test is recommended for Distribution Cycles 7, 8 and 11. A 60 min Truck test followed by a 120 min Rail test is recommended for Distribution Cycles 9 and 10. A 60 min Truck test followed by a 120 min Air test is recommended for Distribution Cycles 12 and 13.

13. Schedule F - Loose Load Vibration
13.1 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 repetitive shocks occurring during transportation of bulk or loose loads. The test levels and test method account for amplitude, direction, and duration of the repetitive shocks. Use the following test levels:

13.2 Use the following test levels:

13.3 DC-18—Description of this schedule is in accordance with 12.2, except that total dwell time for Assurance Levels I and II shall be 2 h if tested in one position, and 3 h if tested in more than one position.

14. Schedule G - Simulated Rail Switching
14.1 The test levels and test methods for this schedule are intended to determine the ability of the shipping unit to withstand the acceleration levels and compressive forces that might occur during rail switching operations.
Test Method D 4003, Test Method A or Test Method D 5277.

Conditioning—See Section 6.

Special Instructions—Three impacts shall be performed. For railcars with standard draft gear, shock durations of 40 ± 10 ms shall be used, as measured on the floor of the carriage. For railcars with long–travel draft gear, shock durations of 300 ± 50 ms shall be used.

Note that Test Method D 5277 is used for standard draft gear only.

For purposes of this test, the coefficient of restitution shall be considered 0.0, and the total velocity change shall be equivalent to the specified impact velocity. Container impact surface should be the same as occurs in actual shipment. If more than one orientation is possible, impact that surface which is known to be most sensitive to damage.

Refer to Test Methods D 4003 or D 5277 for specific instructions on how to instrument and conduct the test.

14.2 Procedure—Load shipping unit on carriage against bulkhead. Total backload shall be equivalent to a minimum of 3 ft lineal (0.9 m) of cargo. The package used as backload in contact with the test package must be identical to the test package.

14.3 Test Levels—Allow the carriage to impact a cushioned barrier in accordance with the following assurance levels:

<table>
<thead>
<tr>
<th>Assurance Level</th>
<th>Number of Impacts</th>
<th>Impact Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2</td>
<td>8 mph (3.58 m/s)</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>6 mph (2.68 m/s)</td>
</tr>
<tr>
<td>III</td>
<td>2</td>
<td>4 mph (1.79 m/s)</td>
</tr>
</tbody>
</table>

14.4 Procedure Modification—If more detailed information is available on backload or shock characteristics it is recommended that the above procedure be modified to use such information. The specified backload and shock characteristic are intended to simulate the conditions that occur on rail cars equipped with standard type draft gear.

15. Schedule H - Environmental Hazard

15.1 This schedule is intended to provide for the anticipated and often rapid changes in ambient conditions associated with the military distribution of material. This hazard schedule determines the susceptibility of the total pack to the effects of moisture, temperature shock, or the combined effects of cyclic exposure. The result of conditioning may involve the observation/measurement of moisture or water within packs, evidence of corrosion on packaged items, or compromise of the enclosure’s structural integrity such that physical protection can no longer be ensured. Testing shall be in accordance with Test Method D 951, where spray intensities of 4 + 1 in/ h(100+25 mm/h) are used for Assurance Level I and 2 + 0.5 in/h(50 + 10 mm/h) for Level II.

15.2 Test levels shall be as follows:

<table>
<thead>
<tr>
<th>Assurance Level</th>
<th>Temperature, °F (°C)</th>
<th>Water Spray Duration, h</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>120 to 130 (49 to 54)</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>50 to 60 (10 to 15)</td>
<td>X 2</td>
</tr>
</tbody>
</table>

15.3 When specified in the contract, this test should be performed as part of the complete distribution cycle for the smallest complete shipping unit, as part of the contract.

16. Report

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

16.1.1 Reference to this practice,
16.1.2 Description of product and shipping unit,
16.1.3 Distribution cycle (DC) and test plan,
16.1.4 Assurance levels and rationale,
16.1.5 Number of samples tested,
16.1.6 Conditioning used,
16.1.7 Acceptance criteria,
16.1.8 Vibration option used, random or sine,
16.1.9 Random vibration power spectral density plot, if used,
16.1.10 Variation from recommended procedures, and
16.1.11 Condition of specimens after test.

16.2 Government Shipments—In addition to 16.1.2-16.1.11, the complete report includes:

16.2.1 Party, other than contractor, performing testing,
16.2.2 Testing facility used, other than contractor’s,
16.2.3 Government representative witnessing testing, and
16.2.4 When environmental hazard is performed for other than smallest complete shipping unit (see 15.3).

17. Precision and Bias

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

18. Keywords

18.1 compression test; distribution cycle; distribution environment; drop test; mechanical handling; package; packaging; random vibration; shipping container; shipping unit; vibration
X1. Appendix-Example Test Plans

X1.1 The following examples will serve to illustrate the use of this practice:

X1.2 Example A—Test a packaged consumer product. The moderate value and volume of shipment are typical of other products in the shipper’s line. No damage is acceptable and the package must be in good condition after the test. The fiberboard packaged product weighs 28 lb (12.7 kg), is 9 in. (0.23 m) high, and palletized 63 in. (1.6 m) high for storage and LTL shipment. The product does not support any of the load.

X1.2.1 Step 1, Define Shipping Unit—Shipping unit to be tested is a typical pallet load.

X1.2.2 Step 2, Establish Assurance Level—Assurance Level II will be used, based on value and volume of shipment.

X1.2.3 Step 3, Determine Acceptance Criteria at Assurance Level II:

Criterion 1—No product damage.

Criterion 2—All packages in saleable condition.

X1.2.4 Step 4, Select Test Schedules—DC-6 will be used for this palletized, LTL shipment.

X1.2.5 Step 5, Write Test Plan:

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Test Schedule</th>
<th>Test Methods</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A Handling - Mechanical</td>
<td>D 6055 Method A</td>
<td>Pick up, transport around test course, set down, 5 cycles. Horizontal impact all four sides, 4.0 ft/s (1.22 m/s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D 880 Procedure B</td>
<td>Rotational drop, one impact on two opposite base edges from 6 in. (0.152 m).</td>
</tr>
</tbody>
</table>
|          |               | D 6179 Method C | “Truck” PSD profile, 0.52 g rms, duration 180 min. Test a column stack of seven individual containers.

X1.2.6 Step 6, Select Samples for Test—Select representative samples.

X1.2.7 Step 7, Condition Samples—Condition to 23 ± 1°C, 50 ± 2% relative humidity, in accordance with Practice D 4332.

X1.2.8 Step 8, Perform Tests—Perform tests in accordance with the test plan in Step 5, as directed in the referenced ASTM standards and in the special instructions for each test schedule.

X1.2.9 Step 9, Evaluate Results—Examine products and packages to determine if the acceptance criteria have been met.

X1.2.10 Step 10, Document Test Results—Write a report to cover all steps in detail, in accordance with Section 16.

X1.3 Example B—Product to be tested is identical to the product from Example A, except that it will be shipped individually through the small parcel–surface distribution system. Additional information is that the container is 18 in. (0.46 m) long and 18 in. (0.46 m) wide. Height is 9 in. (0.23 m) and weight is 28 lb (12.7 kg).

X1.3.1 Step 1, Define Shipping Unit—Shipping unit to be tested is a single package.

X1.3.2 Step 2, Establish Assurance Level—Assurance Level II will be used, based on value and volume of shipment.

X1.3.3 Step 3, Determine Acceptance Criteria at Assurance Level II:

Criterion 1—No product damage.

Criterion 2—All packages in saleable condition.

X1.3.4 Step 4, Select Test Schedules—DC-3 will be used for this single package shipment of less than 100 lb (45.4 kg).

X1.3.5 Step 5, Write Test Plan:

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Test Schedule</th>
<th>Test Method</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A Handling—Manual</td>
<td>D 5276</td>
<td>One drop on top, two drops on adjacent bottom edges, two drops on diagonally opposite bottom corners, one drop on bottom, drop height 13 in. (330 mm).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D 642</td>
<td>Compression to 589 lb (2620 N) (M=10.0 lb/ft², H=54 in., F=7.0).</td>
</tr>
<tr>
<td>2</td>
<td>C Vehicle Stacking</td>
<td>D 999</td>
<td>20 min on bottom, 10 min on each of two adjacent sides.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D 4728, Method A or B</td>
<td>“Truck” PSD profile, 0.52 g rms, duration 60 min on each of three adjacent sides.</td>
</tr>
<tr>
<td>3</td>
<td>F Loose Load Vibration</td>
<td>D 999, Method A1 or A2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>E Vehicle Vibration</td>
<td>D 4728, Method A or B</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>A Handling—Manual</td>
<td>D 5276</td>
<td>One drop on vertical edge, two drops on adjacent side faces, one drop on top corner, one drop on adjacent top edge, drop height 13 in. (330 mm). One drop on bottom, drop height 26 in. (660 mm).</td>
</tr>
</tbody>
</table>

X1.3.6 Step 6, Select Samples for Test—Select representative samples.

X1.3.7 Step 7, Condition Samples—Condition to 23 ± 1°C, 50 ± 2% relative humidity, in accordance with Practice D 4332.

X1.3.8 Step 8, Perform Tests—Perform tests in accordance with the test plan in Step 5, as directed in the referenced ASTM standards and in the special instructions for each test schedule.

X1.3.9 Step 9, Evaluate Results—Examine products and packages to determine if the acceptance criteria have been met.

X1.3.10 Step 10, Document Test Results—Write a report to cover all steps in detail, in accordance with Section 16.
X2. Using the DC-2 Distribution Cycle

X2.1 The DC-2 distribution cycle is used when an anticipated distribution is well understood and other cycles, DC-3 through DC-18, are not sufficiently descriptive. The understanding of distribution may be developed in several ways, including: measurement of the environment with appropriate instrumentation; careful observation of the various hazard elements in distribution; reference to published authoritative information; product damage reports; or a combination thereof.

X2.2 The user of DC-2 is allowed complete flexibility in developing a test plan that accurately reflects the anticipated distribution. This includes the ability to vary Assurance Levels between test schedules for each hazard element, as presently stated in 8.2 for application to any Distribution Cycle. The ability to modify test levels or other details within a test schedule is also permitted in DC-2 when experience has shown it more accurately correlates with actual experience.

X2.2.1 The following hypothetical examples illustrate instances where such flexibility is useful.

X2.2.1.1 Example 1—For truckload shipments of palletized loads stacked two-high on trailers from a manufacturer to a customer, a thorough study of handling at both ends of the shipping cycle (manufacturer and customer) has shown the following: no significant impacts against the sides of the loads, only against the ends; seldom any more than one rotational drop of the load on a base edge; small amount of lift truck handling by the manufacturer but a moderate amount by the customer; and no warehousing/stacking of loads in storage by either manufacturer or customer.

(1) The user of DC-2 develops a test plan that includes a modified Schedule A Mechanical Handling at the beginning and at the end of the distribution cycle but does not include a compression test, as follows:

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Schedule</th>
<th>Test Method</th>
<th>Details of Test and Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>modified A-handling by the manufacturer</td>
<td>D 6055 Method A</td>
<td>Pick up, transport around test course, set down 3 times</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D 880 Procedure B</td>
<td>Incline impact on each end of the palletized load at 4 ft/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D 6179 Method C</td>
<td>Rotational drop, impact on other end base edge from 6 in.</td>
</tr>
<tr>
<td>2</td>
<td>D-transport stacked vibration</td>
<td>D 4728 Method A</td>
<td>Truck PSD profile, 0.52 g rms, duration 3 h, two loads high</td>
</tr>
<tr>
<td>3</td>
<td>modified A-handling by customer</td>
<td>D 6055 Method A</td>
<td>Pick up, transport around test course, set down 5 times</td>
</tr>
</tbody>
</table>

(2) Comparing this test plan to X1.2 Example A where DC-6 was used, the number of tests and intensities are somewhat less.

X2.2.1.2 Example 2—Following reports of an unacceptable amount of corner damage in shipments of a consumer product direct from the manufacturer to the consumer via small parcel carriers, a thorough study of handling and transport has been made. Subsequent corner drop tests revealed that a drop of 42 in. high is needed to produce the type of damage reported and instrumented shipments have verified some drops at that height. The packaged product weighs 43 lb, and outside dimensions of the container are 24 in. length by 10 in. width by 42 in. depth (end-opening 32 ECT grade box). The container and interior corrugated packaging pieces provide all of the support in compression, and the container is marked with “This Way Up” arrows in normal depth direction. There is no reported damage to the corrugated containers due to excessive compressive loads, and instrumented shipments verify that the container is almost always in a normal depth orientation (42 in. dimension upright) during transportation. The user of DC-2 develops a test plan that simulates the anticipated distribution, as follows:

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Schedule</th>
<th>Test Method</th>
<th>Details of Test and Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>modified A-handling by shipper and carrier</td>
<td>D 5276</td>
<td>Drop test from 21 in. high in six orientations as described in table of 10.2.3 First Sequence of Distribution Cycles</td>
</tr>
<tr>
<td>2</td>
<td>C-stacking in truck</td>
<td>D 642</td>
<td>Compression test to 642 lb (M=10.0 lb/ft³, H=108 in., F=7.0)</td>
</tr>
<tr>
<td>3</td>
<td>F-loose load vibration</td>
<td>D 999 A2</td>
<td>40 min on bottom</td>
</tr>
<tr>
<td>4</td>
<td>E-truck vibration</td>
<td>D 4728</td>
<td>180 min on bottom, 0.52 g rms</td>
</tr>
</tbody>
</table>
Drop test from 21 in high in five orientations as described in table of 10.2.3 Second Sequence of Distribution Cycles. Drop once from 42 in. high on the most damage-prone corner.

Comparing to X1.3 Example B where DC-3 was used, this test plan’s Assurance Levels vary between test schedules in the sequence, drop test heights are higher than any listed in the table of 10.2.3 for the shipping weight involved, compression strength is checked for full trailer height of 108 in. (rather than 54 in. height), and vibration tests are conducted in only one orientation rather than three.

REFERENCES


