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Standard Specification for Testing of Hazardous Materials Packagings¹

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1. Scope

1.1 This standard covers the testing of packagings to United Nations standards intended for transportation of hazardous materials, excepting packagings for radioactive substances, cylinders and other receptacles for gases, packagings for net masses exceeding 400 kg (880 lb) or capacities exceeding 450 L (120 gallons).

1.2 The following safety hazards caveat pertains only to the test method portions, Sections 8–14, of this specification: *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.* See also A1.2

2. Referenced Documents

2.1 ASTM Standards:

D 685 Practice for Conditioning Paper and Paper Products for Testing²

D 775 Test Method for Drop Test for Loaded Boxes²

D 959 Method of Drop Test for Filled Bags²

D 996 Terminology of Packaging and Distribution Environments²

D 997 Test Method for Drop Test for Loaded Cylindrical Containers²

D 999 Test Methods for Vibration Testing of Shipping Containers²

D 4169 Practice for Performance Testing of Shipping Containers and Systems²

D 4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing²

D 4577 Test Method for Compression Resistance of a Container Under Constant Load²

E 4 Practices for Force Verification of Testing Machines³

2.2 ISO Standard:

ISO 535 Determination of Water Absorption of Paper and Board (Cobb Method)⁴

2.3 ANSI/ASQC Document:

ANSI/ASQC Z-1.15 Generic Guidelines for Quality Systems⁴

2.4 TAPPI Standard:

TAPPI T441 Water Absorptiveness of Sized (Non-bibulous) Paper and Paperboard (Cobb Test)⁵

2.5 United Nations Document:

ST/SG/AC.10/1 Recommendations on the Transport of Dangerous Goods⁶

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *bags*—flexible packagings made of paper, plastic film, textiles, woven materials or other suitable materials.

3.1.2 *barrels*—receptacles of circular cross-section, with bulging walls. Wooden barrels are constructed with staves and ends of natural wood, and are held together with hoops of metal or wood.

3.1.3 *boxes*—packagings with complete rectangular or polygonal faces, made of metal, wood, plywood, reconstituted wood, fiberboard, plastic, or other suitable material.

3.1.4 *closures*—devices which close an opening in a receptacle.

3.1.5 *combination packaging*—a combination of packagings for transport purposes, consisting of one or more inner packagings secured in an outer packaging.

3.1.6 *composite packagings*—packagings consisting of an outer packaging and an inner receptacle so constructed that the inner receptacle and the outer packaging form an integral packaging. Once assembled it remains, thereafter, an integrated single unit; it is filled, stored, transported and emptied as such.

3.1.7 *drums*—flat-ended or convex-ended cylindrical packagings made of metal, fiberboard, plastic, plywood, or other suitable materials.

3.1.7.1 *Discussion*—This definition also includes packagings of other shapes made of metal or plastic, for example, round taper-necked packagings or pail-shaped packagings. *Jerricans* are not covered by this definition.

3.1.8 *inner packagings*—packagings for which an outer packaging is required for transport.

3.1.9 *inner receptacles*—receptacles which require an outer

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² *Annual Book of ASTM Standards*, Vol 15.09.

³ *Annual Book of ASTM Standards*, Vols 03.01, 04.02, and 08.03.

⁴ Available from American National Standards Institute, 11 W. 42nd St., 13th Fl., New York, NY 10036.

⁵ Available from the Technical Association of the Pulp and Paper Industry, P.O. Box 105113, Atlanta, GA 30348.

⁶ Available from United Nations, 866 United Nations Plaza, New York, NY 10017.

packaging in order to perform their containment function.

3.1.10 *jerricans*—metal or plastic packagings of rectangular or polygonal cross-section.

3.1.11 *maximum capacity*—the maximum inner volume of packagings.

3.1.12 *outer packaging*—the outer protection of a composite or combination packaging together with any absorbent materials, cushioning, and any other components necessary to contain and protect receptacles or inner packagings.

3.1.13 *packages*—the complete product of the packing operation, consisting of the packaging and its contents prepared for transport.

3.1.14 *packagings*—receptacles and any other components or materials necessary for the receptacle to perform its containment function.

3.1.15 *receptacles*—containment vessels for receiving and holding substances or articles, including any means of closing.

3.1.15.1 *Discussion*—The following explanations and examples are meant to assist in clarifying the above definitions:

(a) The *inners* of *combination packagings* are always termed *inner packagings* not *inner receptacles*. A glass bottle is an example of such an *inner packaging*.

(b) the *inners* of *composite packagings*, are normally termed *inner receptacles*. For example, the *inner* of a plastic receptacle with outer steel drum composite packaging (plastic material) is such an *inner receptacle* since it is normally not designed to perform a containment function without its *outer packaging* and is not therefore an *inner packaging*.

4. Significance and Use

4.1 Packagings successfully tested to this specification meet only the performance standards established for international transportation of hazardous materials, based on recommendations of the United Nations Committee of Experts on the Transport of Dangerous Goods, as endorsed by the United Nations Economic and Social Council.

4.2 Packages successfully tested to this specification may not meet national regulatory requirements nor withstand the North American distribution environment. It is strongly recommended that tests required by national regulations and additional sequential tests, as detailed in Practice D 4169 for Assurance Level 1 for the planned system of distribution, be carried out to further establish suitability of the package.

4.3 Tests prescribed are of varying degrees of severity, depending on the degree of hazard presented by the proposed contents, and are grouped as follows:

Packing Group I Substances presenting great danger

Packing Group II Substances presenting medium danger

Packing Group III Substances presenting minor danger

Substances and articles which are hazardous are assigned to a specific packing group in UN ST/SG/AC.10/1 or in international or national regulations.

5. Test Specimens

5.1 Test specimens shall consist of packagings prepared for transport including inner packagings of combination packagings. Test specimens of packagings which are in production shall be representative samples taken at random.

6. Conditioning

6.1 Standard conditioning shall be at $23 \pm 2^\circ\text{C}$ ($73 \pm 4^\circ\text{F}$). For packagings fabricated from paper, paperboard, or fiberboard, conditioning shall be in accordance with Practice D 685.

6.2 High temperature conditioning shall be at $40 \pm 2^\circ\text{C}$ ($104 \pm 4^\circ\text{F}$) in accordance with Practice D 4332.

6.3 Low temperature conditioning shall be at $-20 \pm 2^\circ\text{C}$, ($-4 \pm 4^\circ\text{F}$), in accordance with Practice D 4332.

6.4 The packaging, prepared as for testing, shall be conditioned for at least 7 min/L (qt) or/dm³(200 min/ft³) of maximum capacity or 24 h whichever is longer. Longer times shall be used if necessary to ensure that packagings and contents reach equilibrium with the conditioning atmosphere and are maintained in that condition for a minimum of four hours.

7. Filling and Closure Procedures

7.1 Liquids:

7.1.1 Packagings intended for the containment of liquids shall be filled to 98 % of their maximum capacity with water at $23 \pm 2^\circ\text{C}$ ($73 \pm 4^\circ\text{F}$) for subsequent testing at normal and high temperatures unless otherwise specified.

7.1.2 Plastic packagings, with the exception of bags and expanded polystyrene boxes, intended for the containment of liquids shall be filled with a solution which remains liquid at -18°C (0°F) and has a minimum density of 1 g per cm³(specific gravity at least 1) for testing at low temperatures.

7.2 Solids:

7.2.1 Packagings intended for the containment of solids shall, unless otherwise specified, be filled to not less than 95 % of their maximum capacity with the intended contents or with other substances with similar physical properties (mass, particle size, etc.). Mass as tested shall be not less than the shipping mass. It is permissible to use additives such as bags of lead shot to achieve the required total package mass, as long as they are placed so that the results are not invalidated.

7.3 Each packaging shall be closed for testing in the same manner as it would be closed for actual shipment. All closures shall be installed using the techniques or torques specified by the closure manufacturer, container manufacturer or shipper.

8. Compatibility Test

8.1 Unless otherwise specified, the compatibility test shall be performed on plastic packagings prior to initial use of the packaging for each hazardous material to be carried. Evidence of satisfactory user experience may be accepted in lieu of performance of this test.

8.2 Perform the compatibility test in accordance with Annex A1. The storage temperature and the duration of storage are set out in this test method.

8.3 Following the specified storage period and weighing, remove the hazardous material, fill and reclose the packaging as specified in Section 6; perform the drop test appropriate to the type of packaging and the intended contents, as specified in Section 9; perform the stacking test as specified in Section 10; perform the hydrostatic test for packagings intended for the containment of liquids as specified in Section 11; and perform the leak resistance test as specified in Section 12.

8.4 *Criteria for Passing Test*—The packages shall show no

evidence of stress cracking or crazing, oxidation, embrittlement, vapor pressure build-up, collapse of walls, seepage, or other defect likely to cause or indicate premature failure. The packaging shall pass the tests specified in 8.3.

9. Drop Test

9.1 The drop test shall be performed on all types of packagings prior to initial use and, where specified, at periodic intervals.

9.2 Tests shall conform to Test Method D 775, Method D 959 (procedure A without beam hazard), or Test Method D 997 (without hazard), as applicable.

9.3 *Test Preparation*—The packagings shall be filled and closed with the procedures specified in Section 7.

9.4 Drop Height:

9.4.1 For solids and liquids, if the test is performed with the solid or liquid to be carried, or with another substance having essentially the same physical characteristics, or for liquids if the test is performed with water and the intended liquid contents have a density not exceeding 1.2 g/cm³ (specific gravity not exceeding 1.2), the drop height shall be as specified below:

	Packing Group I	Packing Group II	Packing Group III
Drop Height	1.8 m (70.9 in.)	1.2 m (47.2 in.)	0.8 m (31.5 in.)

9.4.2 Where packagings are filled with water and the density of the intended liquid contents is more than 1.2 g/cm³ (specific gravity more than 1.2), to obtain the drop height in meters, multiply the relative density (specific gravity) by 1.5 for Packing Group I products, by 1.0 for Packing Group II products or by 0.67 for Packing Group III products. Round up the drop height to the first decimal. See below:

	Packing Group I	Packing Group II	Packing Group III
Drop Height	dx1.5 m (59.1 in.)	dx1.0 m (39.4 in.)	dx0.67 m (26.4 in.)

9.5 Test Procedure:

9.5.1 Drop the packages from the heights specified in 9.4, in the conditioning atmosphere or immediately following removal from the conditioning atmosphere. Following the drop, examine the exterior of each package for evidence of leakage, spillage, and damage.

9.5.2 *Steel Drums, Aluminum Drums, Plywood Drums, Wooden Barrels and Steel Jerricans*—Test six packagings. No conditioning is required. Drop test three packages, one drop each, diagonally on the chime or, if the packaging has no chime, on a circumferential seam or edge. Drop test three additional packages, one drop each, on the weakest part not tested by the first drop, for example a closure or, for some cylindrical drums, the welded longitudinal seam of the drum body. Perform drop tests in accordance with Test Method D 997 without the beam hazard.

9.5.3 *Fiberboard Drums*—Test six drums, conditioned in accordance with 6.1. Drop test three packages, one drop each, diagonally on the chime or, if the packaging has no chime, on a circumferential seam or edge. Drop test three additional packages, one drop each, on the weakest part not tested by the first drop, for example a closure. Perform drop tests in accordance with Test Method D 997 without the beam hazard.

9.5.4 *Plastic Drums, Plastic Jerricans, Plastic Composite Packagings*—Test six packages conditioned in accordance

with 6.3. Drop test three packages, one drop each, diagonally on the chime or, if the packaging has no chime, on a circumferential seam or edge. Drop test three additional packages, one drop each, on the weakest part not tested by the first drop, for example a closure. Perform drop tests in accordance with Test Method D 997 without beam hazard if cylindrical in shape, or Test Method D 775 if rectangular in shape.

9.5.5 *Wooden Boxes, Plywood Boxes, Reconstituted Wood Boxes, Steel Boxes and Expanded Plastic Boxes*—Test five boxes, one box for each drop. No conditioning is required. Drop individual boxes flat on bottom, top, one long side, one short side. Drop box diagonally on bottom corner. Perform drop tests in accordance with Test Method D 775.

9.5.6 *Fiberboard Boxes*—Test five boxes, one for each drop, conditioned in accordance with 6.1. Drop individual boxes flat on bottom, top, one long side, one short side. Drop box diagonally on the manufacturer's joint bottom corner (5-2-3 corner). Perform drop tests in accordance with Test Method D 775.

9.5.7 *Textile Bags*—Test three bags, two drops per bag. No conditioning is required. First drop bags flat on face, followed by drop on end (valve end if applicable). Perform drop tests in accordance with Method D 959, without beam hazard.

9.5.8 *Paper Bags*—Test three bags, conditioned in accordance with 6.1, two drops per bag. First drop bags flat on face, followed by drop on end (valve end if applicable). Perform drop tests in accordance with Method D 959, without beam hazard.

9.5.9 *Plastic Fabric Bags and Plastic Film Bags*—Test three bags, three drops per bag. No conditioning is required. First drop bags flat on face, followed by flat drop on side, followed by drop on end. Perform drop tests in accordance with Method D 959, without beam hazard.

9.5.10 *Composite Packagings, Plastic Receptacle with Outer Plywood Box*—Test five packages conditioned in accordance with 6.3. Perform tests specified in 9.5.5.

9.5.11 *Composite Packagings Plastic Receptacle with Outer Fiber Drum*—Test six packages, one drop per package. Perform tests specified in 9.5.3 except that conditioning shall be in accordance with 6.3.

9.5.12 *Composite Packagings Plastic Receptacle with Outer Fiber Box*—Test five packages, one drop per package. Perform tests specified in 9.5.6, except that conditioning shall be in accordance with 6.3.

9.5.13 *Composite Packagings Plastic Receptacle with Outer Steel Drum*—Test six packages, one drop per package. Perform tests specified in 9.5.2 except that conditioning shall be in accordance with 6.3.

9.5.14 *Combination Packagings*—Test packages as specified for the outer packaging, except that combination packagings with inner plastic packagings other than bags and expanded polystyrene boxes shall be conditioned in accordance with 6.3.

9.6 Criteria for Passing Test:

9.6.1 When equilibrium has been reached between the internal and external pressures, and the package is rotated through all planes, there shall be no leakage of the filling

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substance. A slight discharge from the closure(s) upon impact shall not be considered to be a failure provided that no further leakage occurs.

9.6.2 There shall be no release of any of the inner packages from the outer packaging, but minor exposure of the inner packages which does not permit their withdrawal is acceptable. Inner packages shall be examined for leakage. There shall be no leakage of the filling substance from inner packages.

10. Stacking Test

10.1 The stacking test shall be performed on all types of packagings, other than bags, prior to initial use and, where specified, at periodic intervals.

10.2 The stacking test shall conform to Test Method D 4577, or be performed with the actual stacked load. If a compression testing machine is used, it shall be capable of applying a constant force to an accuracy of $\pm 1\%$ when determined in accordance with Practices E 4.

10.3 Subject three separate packages to the stacking test by applying a force equivalent to the total actual weight of identical packages which might be stacked on a package during transport. The force should be calculated on the basis of the actual mass of the packages shipped. (See X4.) The force shall be applied to the top of the package in the same manner as applied by the actual loaded package. Unless otherwise specified a stacking height of at least three meters (118 in.) shall be used in calculating the load (see 10.5.1).

10.4 Test Preparation:

10.4.1 Fill and close the packaging with the procedures specified in Section 6.

10.4.2 Condition plastic drums, plastic jerricans, and plastic boxes intended for liquids and composite packagings consisting of plastic receptacles for liquids contained in outer plastic drums or plastic boxes in accordance with Practice D 4332 at $40 \pm 2^\circ\text{C}$ ($104 \pm 4^\circ\text{F}$) and test under those conditions.

10.4.3 Condition packages fabricated from fiberboard, paperboard, or paper including composite packagings with outer fiberboard packagings to $23 \pm 1^\circ\text{C}$ ($73.4 \pm 2^\circ\text{F}$) and $50 \pm 2\%$ relative humidity, in accordance with Method D 685 or Practice D 4332 as applicable (see Section 6) and test under those conditions.

10.4.4 Packagings other than those covered in 10.4.2 and 10.4.3 require no conditioning prior to the stacking test.

10.5 Test Procedures:

10.5.1 The test sample shall be subjected to a force applied evenly on the top surface of the test specimen. The force to be applied shall be not less than as calculated using the following formula:

$$F = \frac{9.8 m (3000-h)}{h} \quad (1)$$

where:

m = gross mass of package (as shipped), in kilograms,
 h = height of package, in millimeters, and
 F = force, in newtons.

or:

$$F = \frac{w (118-h)}{h} \quad (2)$$

where:

w = gross weight of package (as shipped), in pounds,
 h = height of package, in inches, and
 F = force, in pounds.

Where a constant load is used, the mass of the constant load shall be not less than as calculated using the following formula:

$$M = \frac{m (3000-h)}{h} \quad (3)$$

where:

m = gross mass of package (as shipped), in kilograms,
 h = height of package, in millimeters, and
 M = constant load mass, in kilograms.

or:

$$W = \frac{w (118-h)}{h} \quad (4)$$

where:

w = gross weight of package (as shipped), in pounds,
 h = height of package, in inches, and
 W = constant load weight, in pounds.

10.5.2 For packagings other than plastic drums and plastic jerricans intended for liquids and composite packagings consisting of plastic receptacles for liquids contained in outer plastic drums, the force or constant load shall be applied for a period of 24 h.

10.5.3 For plastic drums and plastic jerricans intended for liquids and composite packagings consisting of plastic receptacles for liquids contained in outer plastic drums or solid plastic boxes, the force or constant load shall be applied for a period of 28 days at $40 \pm 2^\circ\text{C}$ ($104 \pm 4^\circ\text{F}$). Upon removal of the force or constant load, examine the package for evidence of leakage, spillage, and damage.

NOTE 1—It may be desirable to measure the deflection during the test and prior to removal of the load.

10.6 *Criteria for Passing Test*—No test sample shall leak. There shall be no leakage of the filling substance from the inner receptacle of composite packagings or from inner packages of combination packagings. The packages shall show no deformation likely to reduce their strength or integrity or to cause instability in 3 m (118 in) stacks of packages. Sufficient stacking balance has been obtained when, after the stacking test—in the case of plastic packagings, after cooling to ambient temperature—two filled packages of the same type placed on the filled test sample maintain their position for a minimum of 1 h.

11. Hydrostatic Test

11.1 The hydrostatic test shall be performed on all types of packagings intended for the transportation of liquids, except inner packagings of combination packagings which are not required to be tested unless otherwise specified, prior to initial use and, where specified, at periodic intervals.

NOTE 2—Special requirements for air transport may not be covered in their entirety by this test.

11.2 Perform the hydrostatic test in accordance with Annex A2. Three samples per design type and manufacture shall be tested.