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Standard Guide for Testing of Hazardous Materials Packagings¹

This standard is issued under the fixed designation D 4919; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

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~~

1.1 The main focus of this guide is to identify the key information required for United Nations (UN) packaging certification to ensure the selected packaging will be certified to the appropriate level for its intended use. This document also provides guidance for locating relevant sections of the United States Department of Transportation Title 49 Code of Federal Regulations (CFR). Consult with a regulatory specialist whenever needed.

1.2 This guide is intended to assist in determining the appropriate performance tests required to certify packaging designs to the United States Department of Transportation Title 49 Code of Federal Regulations performance oriented packaging standards based on the United Nations Recommendations on the Transport of Dangerous Goods.

1.3 This guide covers the testing for transportation of hazardous materials packagings for net masses not exceeding 400 kg (880 lb) or capacities not exceeding 450 L (119 gal), excepting packagings for infectious substances, radioactive materials, cylinders and other receptacles for gases.

1.4 This guide does not replace domestic or international regulatory requirements for hazardous materials packaging but is strongly recommended to be used in conjunction with those regulations.

1.5 The user of this guide must be trained in accordance with the United States Department of Transportation Title 49 Code of Federal Regulations (49 CFR) as required by 172.700 and should be familiar with other applicable hazardous materials regulations such as; International Civil Aviation Organization (ICAO) Technical Instructions for the Safe Transport of Dangerous Goods by Air, and the International Maritime Dangerous Goods Code (IMDG Code) and carrier rules such as International Air Transport Association (IATA) Dangerous Goods Regulations.

1.6 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.

1.7 *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 requirements prior to use.*

[†]This specification is under the jurisdiction of ASTM Committee D-10 on Packaging and is the direct responsibility of Subcommittee D10.21 on Shipping Container Environment.

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2. Referenced Documents

2.1 ASTM Standards:²

- ~~D685 Practice for Conditioning Paper and Paper Products for Testing~~ 323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)
- ~~D775 Test Method for Drop Test for Loaded Boxes~~² 642 Test Method for Determining Compressive Resistance of Shipping Containers, Components, and Unit Loads
- ~~D959 Method of Drop Test for Filled Bags~~²
- ~~D996 Terminology of Packaging and Distribution Environments~~² 685 Practice for Conditioning Paper and Paper Products for Testing
- ~~D 996 Terminology of Packaging and Distribution Environments~~
- ~~D997 Test Method for Drop Test for Loaded Cylindrical Containers~~² 999 Test Methods for Vibration Testing of Shipping Containers
- ~~D999 Test Methods for Vibration Testing of Shipping Containers~~² 4169 Practice for Performance Testing of Shipping Containers and Systems
- ~~D4169 Practice for Performance Testing of Shipping Containers and Systems~~² 4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing
- ~~D4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing~~² 4359 Test Method for Determining Whether a Material Is a Liquid or a Solid
- ~~D 4577 Test Method for Compression Resistance of a Container Under Constant Load~~
- ~~E4 Practices for Force Verification of Testing Machines~~ D 4991 Test Method for Leakage Testing of Empty Rigid Containers by Vacuum Method
- ~~D 5276 Test Method for Drop Test of Loaded Containers by Free Fall~~
- ~~D 5570 Test Method for Water Resistance of Tape and Adhesives Used as Box Closure~~

2.2 ISO Standard:

ISO 535 Determination of Water Absorption of Paper and Board (Cobb Method)³

2.3 ANSI/ASQC Document: *United Nations 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)

United Nations Recommendations on the Transport of Dangerous Goods⁴

2.4 Regulatory Documents:

International Air Transport Association (IATA) Dangerous Goods Regulations⁵

International Civil Aviation Organization (ICAO) Technical Instructions for the Safe Transport of Dangerous Goods by Air⁶

International Maritime Dangerous Goods Code (IMDG Code)⁷

49 CFR United States Department of Transportation Code of Federal Regulations Title 49, Transportation, Parts 100-199⁸

2.5 United Nations Document:

ST/SG/AC.10/1 Recommendations on the Transport of Dangerous Goods Industry Document:

Steel Shipping Container Institute (SSCI) "UN Test Procedures" for 1A1 and 1A2 Steel Drums⁹

3. Terminology

3.1

3.1 Reference 49 CFR, Section 171.8: *Definitions and Abbreviations.*

3.2 Reference 49 CFR, Part 173, Subpart D: *Definitions Classification, Packing Group Assignment and Exceptions for Hazardous Materials other than Class 1 and Class 7* (for example, definition of *flammable liquid*).

3.3 Reference 49 CFR, Sections 178.503-178.523 for Non-bulk packaging standards (for example, 1A1, 1H2, 4G, etc.).

3.4 Reference 49 CFR, Section 178.601(c): *General Requirements, Definitions.*

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*, Vol 15.09, volume information, refer to the standard's Document Summary page on the ASTM website.

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

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁵ Available from American National Standards Institute, 11 W. 42nd St., 13th Flr, New York, NY 10036.

⁶ Available from United Nations, 1 United Nations Plaza, New York, NY 10017, <http://www.un.org>.

⁷ Available from the Technical Association of the Pulp and Paper Industry, P.O. Box 105113, Atlanta, GA 30348.

⁸ Available from International Air Transport Association (IATA), 800 Place Victoria, P.O. Box 113, Montreal, Quebec H4Z 1M1, Canada, <http://www.iata.org>.

⁹ Available from United Nations, 866 United Nations Plaza, New York, NY 10017.

¹⁰ Available from International Civil Aviation Organization (ICAO), 999 University St., Montreal, Quebec, H3C H57, Canada, <http://www.icao.int>.

¹¹ Available from International Maritime Organization, 4 Albert Embankment, London, Ontario 5E1 7SR, Canada, <http://www.imo.org>.

¹² Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9371 (website: hazmat.dot.gov).

¹³ Available from the Steel Shipping Container Institute (SSCI), 1101 14th Street NW, Washington, DC 20005, <http://www.steelcontainers.com>.

3.5 The terms *hazardous materials* and *dangerous goods* are meant to be interchangeable.

3.6 Reference Terminology D 996.

3.7 Other terms may be found in modal specific regulatory documents listed in 2.4.

3.8 *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 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) (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) (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*.

3.8.1 *Packing Group*—Hazardous Materials are assigned to a Packing Group based on the degree of danger as follows:

3.8.1.1 *Packing Group I*—Substances presenting great danger.

3.8.1.2 *Packing Group II*—Substances presenting medium danger.

3.8.1.3 *Packing Group III*—Substances presenting minor danger.

3.8.2 *Performance Standard*—UN certified Packagings are authorized to transport hazardous materials and are marked to a performance standard as follows:

3.8.2.1 *Performance Standard “X” Packaging* —May be used to transport hazardous materials in Packing Groups I, II, and III.

3.8.2.2 *Performance Standard “Y” Packaging* —May be used to transport hazardous materials in Packing Groups II and III.

3.8.2.3 *Performance Standard “Z” Packaging* —May only be used to transport hazardous materials in Packing Group III.

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 D4169 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:

4.1 The UN performance tests are based on the degree of hazard presented by the proposed hazardous material(s) to be packaged.

4.2 Substances and articles which are hazardous are assigned to a specific packing group as defined in 3.8.1 and may be determined by referencing 49 CFR 172.101 hazardous materials table.

4.3 Only packaging designs that have been successfully tested to the UN performance standards as defined in 3.8.2 may be marked with a UN mark. Hazardous Materials may not be transported in a packaging that does not bear the appropriate UN markings unless otherwise authorized by the applicable competent authority.

4.4 Packages successfully tested to the UN performance standards may or may not withstand the North American distribution environment. To further evaluate the suitability of the package it is strongly recommended that additional tests as detailed in Practice D 4169 or other carrier specified test requirements be conducted.

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. Procedure

5.1 *Introduction*—Hazardous materials must be offered for transportation within the United States in packagings authorized by U.S. DOT 49 CFR. When UN specification packaging is required for shipping hazardous materials, this packaging must first be subjected to and meet the UN performance standards as outlined in 49 CFR. It is recommended the user of this document review key areas of 49 CFR to gain a better understanding of the domestic requirements for package certification. The following are suggested areas to review:

5.1.1 *49 CFR, 173.24, and 173.24a General Requirements for Packagings and Packages*—This section of the regulations contains information on the following: General applicability requirements, Packagings manufactured outside the U.S., Compatibility, Venting of Packagings, Filling Requirements, Vibration Requirements, Filling Limits, Vapor Pressure Determinations and other issues.

5.1.2 *49 CFR, 173.27 General Requirements for Transportation by Aircraft*—This section of the regulations contains information on the following: Pressure capability requirements for packagings transporting liquids, Closure requirements, and requirements for the use of Absorbent Materials.

5.1.3 *49 CFR, 178.601 General Requirements*—This section of the regulations contains information on the following: Design Qualification, Periodic Retesting, Production Testing, and Selective Testing for UN packagings.

5.1.4 *49 CFR, 178.602 Preparation of Packagings and Packages for Testing*—This section of the regulations contains information on filling requirements for liquids and solids packaging certification along with conditioning requirements.

5.2 *Use of UN Certified Packaging*—A UN packaging may be used for different products under the same certification provided the hazardous material and packaging are compatible, the regulations authorize the use of the packaging for the intended hazardous material, and the UN packaging certification is appropriate for the intended product.

5.3 *Key Information for Packaging Certification*—To ensure the selected packaging will be certified to the appropriate level for its intended use the information outlined in 5.3.1-5.3.4 should be obtained and carefully reviewed.

5.3.1 *Packaging Standard*—Determine if the packaging configuration meets the construction and specification requirements of one of the UN standards (for example, Fiberboard Box, Metal Drum, Plastic Drum, etc.) listed in 49 CFR, 178.504–178.523. If the packaging selected does not meet these requirements, approval may be required from the competent authority for UN certification (49 CFR, 178.601(h)).

5.3.2 *Hazardous Material Information*—Determine what products are to be shipped in the selected packaging. Consideration should be given to new or potential products to be shipped. The type of hazardous materials being shipped will determine the appropriate performance tests.

5.3.2.1 *Packing Group*—Packagings must be selected based on the hazards presented in transportation according to the respective Packing Group assignments of the intended hazardous materials as defined in 3.8.1.

NOTE 1—If different products are intended to be shipped in the selected packaging, keep in mind the product presenting the greatest danger may not be the product resulting in the highest specific gravity or heaviest gross mass (for example, a Packing Group I liquid may have a specific gravity of 1.1, and a Packing Group II liquid may have a specific gravity of 1.9). This information is important for determining the appropriate performance tests. The following sections of 49 CFR pertaining to “non-bulk filling limits” provides guidance for the use of UN certified packagings: 49 CFR, 173.24a(b)(1), 173.24a(b)(2), and 173.24a(b)(3). Note, these sections only apply to single and composite packagings and not combination packagings.

5.3.2.2 *Hazardous Material Type (Liquid or Solid)*—Determine if the selected packaging will be used for shipping liquid or solid hazardous materials or both (see Test Method D 4359 for determining whether a material is a liquid or solid). The UN test requirements are different for solids and liquids. If the packaging is intended for shipping both liquids and solids, two separate certification tests may need to be performed. Single and composite packagings tested for liquids may be authorized for solid materials (see 49 CFR 173.24a(b)(3)). Combination packagings require separate testing for liquids and solids. Consult the most recent revision of the hazardous materials regulations to determine certification requirements.

5.3.2.3 *Specific Gravity for Liquids*—Using product Material Safety Data Sheets (MSDS) or other acceptable methods, obtain information on the maximum specific gravity of the liquid product(s) to be shipped in the selected packaging. Testing should be

conducted based on the highest specific gravity product for single and composite packagings and the highest specific gravity product resulting in the heaviest gross mass for combination packagings. This information is needed to determine test levels and authorized gross mass of the packaging.

5.3.2.4 Gross Mass for Solids—Using product MSDS or other acceptable methods, obtain information on the maximum gross mass (based on net fill weight) of the solid product(s) to be shipped in the selected packaging. This information is needed to determine test fill weights and authorized gross mass of the packaging.

5.3.2.5 Vapor Pressure of Liquid Material— For liquid hazardous materials, information on the vapor pressure of the material determined at 50 or 55°C should be obtained using the appropriate ASTM Standard (see Test Method D 323) or other acceptable methods (see 49 CFR, 173.24a(b)(4)). For single and composite packaging this information is required to determine the appropriate hydrostatic test pressure. For inner packagings of a combination packaging intended for shipping liquids by air transportation, this information is required to determine the appropriate pressure differential test requirements.

5.3.3 Mode of Transportation—Determine the intended mode(s) of transportation for the selected packaging. Certain modes of transportation may require additional testing or testing to a more stringent level. (for example, the inner packagings of a combination packaging intended to contain liquids and shipped by air transportation must be capable of passing a pressure differential test (see 49 CFR, 173.27(c)). This capability requirement does not apply if the same package is shipped by surface transportation only.)

5.3.4 Packaging Assembly Functions—Determine how the packaging will be assembled. Information should include:

- 5.3.4.1 Package Description,
- 5.3.4.2 Special closure functions,
- 5.3.4.3 Closure application torque,
- 5.3.4.4 Box sealing method (taped, stitched, glued),
- 5.3.4.5 Inner packaging orientation,
- 5.3.4.6 Cushioning requirements and orientation, and
- 5.3.4.7 Any other requirements to assemble the package as for shipment.

NOTE 2—The form in Table 1 may be used to document key information required for the conduct of the UN certification test.

TABLE 1 Packaging Certification Form—Key Information

Package Description (general information should include; size, shape, material of construction or spec numbers or part numbers to identify packaging and components)	
UN Marking: Record UN marking on previously certified packagings	
Packaging Standard / UN ID Code (5.3.1)	
Packing Group (5.3.2.1)	I, II, III, -6090ffc6fdf7/astm-d4919-032008
Hazardous Material Type (5.3.2.2)	Liquid Solid
Liquid—Specific Gravity (5.3.2.3)	
Solid—Gross Mass (5.3.2.4)	
Vapor Pressure of Liquid at 50 or 55°C (5.3.2.5)	50°C (122°F) 55°C (131°F)
Mode(s) of Transportation (5.3.3)	Air Ground Maritime
Packaging Assembly Functions (5.3.4) (refer to closing instructions supplied by the manufacturer or certifier for previously certified packagings)	Special Closure Functions (for example, Bolt Ring, Lever Lock, Induction Seal, etc.):
	Closure Application Torque(s):
	Box Sealing Method:
	Inner Packaging Orientation:
	Cushioning Requirements:
	Miscellaneous Requirements:

6. Conditioning

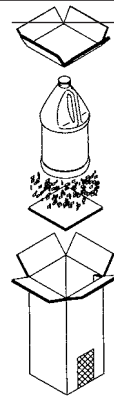
6.1 Standard conditioning shall be at 23 ± 2°C (73 ± 4°F). For packagings fabricated from paper, paperboard, or fiberboard, conditioning shall be in accordance with Practice D685 Test Overview

6.1 Tables 2-5 provide an overview of the required tests based on the hazardous material (liquid or solid) and the packaging type. The tables include the reference sections within this document that provide more detailed information for each UN test and

TABLE 2 Test Overview—Combination Packaging (reference Section 6)^{A,B,C}

NOTE—"X" indicates to conduct the test.

Definition: Combination packagings are a combination of packagings for transport purposes, consisting of one or more inner packagings secured in an outer packaging.					
UN Tests	49 CFR	Section in Document	Liquids	Solids	Required Samples
Drop	178.603	7	X	X	5 for Boxes 6 for Drums
Leakproofness	178.604	8			
Hydrostatic Pressure	178.605	9			
Stacking	178.606	10	X	X	3
Vibration ^D	178.608	11	X	X	3
Pressure Differential	173.27(c)	12	X (Air Transport Only)		3 (Inner Packaging for Liquid)
Cobb Water Absorption	178.516	13	X (4G Fiberboard Box)	X (4G Fiberboard Box)	5 (outer fiberboard material samples)



Combination Packaging Example

^ATesting must be conducted on the complete package assembled as for shipment except for the Pressure Differential and Cobb Water Absorption Tests.

^BDrop test samples and orientations are determined by the shape (type) of outer packaging.

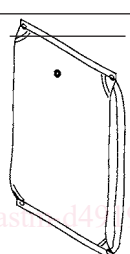
^CTape used for sealing packages should meet water resistant requirements of Test Method D 5570.

^DThe vibration test is a capability requirement and not a "required" test. See 11.2.

TABLE 3 Test Overview—Bag (reference Section 6)^A

NOTE—"X" indicates to conduct the test.

Definition: Bags are flexible packagings made of paper, plastics film, textiles, woven material or other suitable materials.					
UN Tests	49 CFR	Section in Document	Solids	Required Samples	
Drop	178.603	7	X	3	
Leakproofness	178.604	8			
Hydrostatic Pressure	178.605	9			
Stacking	178.606	10			
Vibration ^B	178.608	11	X	3	
Pressure Differential	173.27(c)	12			
Cobb Water Absorption	178.516	13			



Bag Packaging Example

^ATesting must be conducted on the complete package assembled as for shipment.

^BThe vibration test is a capability requirement and not a "required" test. See 11.2.

the corresponding 49 CFR reference. The definition of the packaging type is also included at the top of each table.

7. Drop Test

7.1 The drop test is typically one of the more difficult parts of the UN certification process and it is recommended the drop test be conducted first. The user of this guide should review 49 CFR 178.603 for specific test information such as drop orientations and pass/fail criteria. Drop tests are required for all types of packagings and should be conducted in accordance with Test Method D 5276.

6.2 High temperature conditioning shall be at $40 \pm 2^\circ\text{C}$ ($104 \pm 4^\circ\text{F}$) in accordance with Practice D4332.

6.3 Low temperature conditioning shall be at $-20 \pm 2^\circ\text{C}$, ($-4 \pm 4^\circ\text{F}$), in accordance with Practice D4332.

6.4 The packaging, prepared as for testing, shall be conditioned for at least 7 min/L (qt) or dm^3 (200 min/ft^3) 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.