Designation: D4919 – 17

Standard Guide for Testing of Hazardous Materials (Dangerous Goods) Packagings[1]

This standard is issued under the fixed designation D4919; 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 U.S. Department of Defense.

1. Scope*

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.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)

D642 Test Method for Determining Compressive Resistance of Shipping Containers, Components, and Unit Loads

D685 Practice for Conditioning Paper and Paper Products for Testing

D996 Terminology of Packaging and Distribution Environments

D999 Test Methods for Vibration Testing of Shipping Containers

D4169 Practice for Performance Testing of Shipping Containers and Systems

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

D4359 Test Method for Determining Whether a Material Is a Liquid or a Solid

D4577 Test Method for Compression Resistance of a Container Under Constant Load

[1] This guide is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.22 on Hazardous Materials.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

D4991 Test Method for Leakage Testing of Empty Rigid Containers by Vacuum Method
D5276 Test Method for Drop Test of Loaded Containers by Free Fall
D5570 Test Method for Water Resistance of Tape and Adhesives Used as Box Closure
D7660 Guide for Conducting Internal Pressure Tests on United Nations (UN) Packagings
D7790 Guide for Preparation of Plastic Packagings Containing Liquids for United Nations (UN) Drop Testing
D7887 Guide for Selection of Substitute, Non-hazardous, Liquid Filling Substances for Packagings Subjected to the United Nations Performance Tests

2.2 *ISO Standard:*
ISO 535 Determination of Water Absorption of Paper and Board (Cobb Method)[3]

2.3 *United Nations Document:*
United Nations Recommendations on the Transport of Dangerous Goods[4]

2.4 *Regulatory Documents:*
International Air Transport Association (IATA) Dangerous Goods Regulations[5]
International Civil Aviation Organization (ICAO) Technical Instructions for the Safe Transport of Dangerous Goods by Air[6]
International Maritime Dangerous Goods Code (IMDG Code)[7]
49 CFR United States Department of Transportation Code of Federal Regulations Title 49, Transportation, Parts 100-199[8]

2.5 *Industry Document:*
Industrial Steel Drum Institute (ISDI) and Reusable Industrial Packaging Association (RIPA) Hazardous Materials Packaging Testing Procedures for Steel Drums[9]

3. Terminology

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*.

3.5 The terms *hazardous materials* and *dangerous goods* are considered synonymous.

3.6 Reference Terminology D996.

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:*
3.8.1 *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 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 D4169 or other carrier specified test requirements be conducted.

5. 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

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[4] Available from the UN Economic Commission for Europe, Information Service, Palais des Nations, CH-1211 Geneva 10, Switzerland, http://www.unece.org/trans/danger/danger.htm.
[5] Available from International Air Transport Association (IATA), 800 Place Victoria, P.O. Box 113, Montreal, Quebec H4Z 1M1, Canada, http://www.iata.org.
[6] Available from International Civil Aviation Organization (ICAO), 999 University St., Montreal, Quebec, H3C H57, Canada, http://www.icao.int.
[7] Available from International Marine Organization, 4 Albert Embankment, London, Ontario 5E1 7SR, Canada, http://www.imo.org.
[8] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9371 (website: hazmat.dot.gov).
[9] Available from the Industrial Steel Drum Institute (ISDI), P.O. Box 790, Severna Park, MN 21146-0790. www.whysteeldrums.org; and Reusable Industrial Packaging Association (RIPA), 51 Monroe Street Suite 812, Rockville, MD 20850, Tel. 301.577.3786, www.reusablepackaging.org

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.

5.1.4.1 When selecting liquid fill materials for package testing the user of this guide should consult Guide D7887 for guidance on the selection of the proper liquid fill material for the test specimens.

5.1.4.2 When preparing packages for testing the user of this guide should consult Practice D4332 and Guide D7790 for guidance on package conditioning prior to testing.

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 D4359 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 D323) 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.)

TABLE 1 Design Qualification Packaging/Test Parameters—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
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:[A]
	Inner Packaging Orientation:
	Cushioning Requirements:
	Miscellaneous Requirements:

[A] Tape used for sealing packages should meet water resistant requirements of Test Method D5570 [See: 49 CFR 178.516(b)(4)].

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.

6. Test Overview

6.1 Design Qualification testing procedures are intended, as explicitly stated in the HMR, to be the minimum performance capability levels for packaging manufactured to transport Hazardous Materials under conditions normally incident to transportation. [See: 49 CFR §178.601(a)]. The HMR tests are designed to be gross package capability evaluations that can be performed in a similar manner in all parts of the world, but under circumstances with some variance in test facility capabilities. This is an intentional feature of the test designs and protocols. The focus of HMR testing is not the determination of quantifiable, comparison data to allow for analytical evaluation. In package testing, "Conditioning" of the packages or packaging materials prior to testing is known to affect accuracy, repeatability and precision of results over sample sets. The conditioning requirements of the testing procedures in the HMR are not reflective of what is understood as best practices for determining analytical test results. It is recommended that facilities performing the HMR tests consult the guidance on conditioning in the relevant ASTM documents for any particular packaging material as applicable. The following standards are commonly used for conditioning: Practice D4332 and Practice D685.

6.2 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 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 D5276.

7.2 *Drop Test Conditioning Requirements*—Tables 6 and 7 provide an overview of the required drop test conditioning for the various packaging types and should be conducted in accordance with Practice D4332, Practice D685, and Guide D7790. [See: 6.1 above].

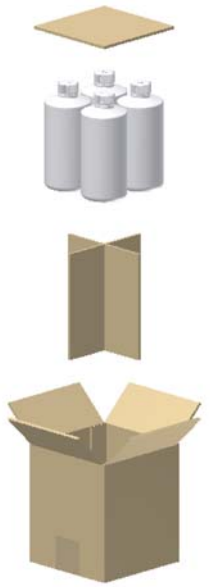
7.3 *Drop Height Determination:*

TABLE 2 Test Overview—Combination Packaging (reference Section 6)

NOTE 1—"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[A,B]	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[A,C]	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

[A] Testing must be conducted on the complete package assembled as for shipment except for the Pressure Differential and Cobb Water Absorption Tests.
[B] Drop test samples and orientations are determined by the shape (type) of outer packaging.
[C] The vibration test is a capability requirement and not a "required" test. See 11.2.

TABLE 3 Test Overview—Bag (reference Section 6)

NOTE 1—"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[A]	3
Leakproofness	178.604	8		
Hydrostatic Pressure	178.605	9		
Stacking	178.606	10		
Vibration[B]	178.608	11	X[A]	3
Pressure Differential	173.27(c)	12		
Cobb Water Absorption	178.516	13		

Bag Packaging Example

[A] Testing must be conducted on the complete package assembled as for shipment.
[B] The vibration test is a capability requirement and not a "required" test. See 11.2.

7.3.1 For solids and liquids, if the test is performed with the solid or liquid to be carried or with another substance essentially having the same characteristics, the drop height shall not be less than that specified in Table 8.

TABLE 4 Test Overview—Single Packaging (reference Section 6)[A]

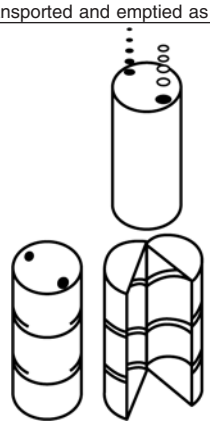
NOTE 1—"X" indicates to conduct the test.

Definition: Non-bulk packaging other than a combination packaging "Stand Alone Packaging."						
UN Tests	49 CFR	Section in Document	Liquids	Solids	Required Samples	 Single Packaging Example
Drop	178.603	7	X	X[B]	5 for Boxes 6 for Drums or Jerricans	
Leakproofness	178.604	8	X		3	
Hydrostatic Pressure	178.605	9	X		3	
Stacking	178.606	10	X	X	3	
Vibration[C]	178.608	11	X	X	3	
Pressure Differential	173.27(c)	12				
Cobb Water Absorption	178.516	13				

[A] Testing must be conducted on the complete package assembled as for shipment.
[B] Drop test samples and orientations are determined by the shape (type) of packaging (see 7.1).
[C] The vibration test is a capability requirement and not a "required" test. See 11.2.

TABLE 5 Test Overview—Composite Packaging (reference Section 6)[A]

NOTE 1—"X" indicates to conduct the test.

Definition: Composite packagings are 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.						
UN Tests	49 CFR	Section in Document	Liquids	Solids	Required Samples	 Composite Packaging Example
Drop	178.603	7	X	X[B]	5 for Boxes 6 for Drums	
Leakproofness	178.604	8	X		3	
Hydrostatic Pressure	178.605	9	X		3	
Stacking	178.606	10	X	X	3	
Vibration[C]	178.608	11	X	X	3	
Pressure Differential	173.27(c)	12				
Cobb Water Absorption	178.516	13	X (6HG2 Packaging Only)	X (6HG2 Packaging Only)	5 (outer fiberboard material samples)	

[A] Testing must be conducted on the complete package assembled as for shipment.
[B] Drop test samples and orientations are determined by the shape (type) of packaging (see 7.1).
[C] The vibration test is a capability requirement and not a "required" test. See 11.2.

7.3.2 For liquids if the test is performed with water or water/antifreeze solution and the substance to be transported has a specific gravity not exceeding 1.2, the drop height shall not be less than that specified in Table 9.

7.3.3 For liquids if the test is performed with water or water/antifreeze solution and the substance to be transported has a specific gravity exceeding 1.2, the drop height shall be calculated on the basis of the specific gravity of the substance to be carried, rounded up to the first decimal (for example, 1.21 should be rounded up to 1.3) (see 49 CFR 178.603(e)(2)(ii)). The drop height shall not be less than that specified in Tables 10-12.

NOTE 3—If the specific gravity exceeds 2.2, calculate the drop height

TABLE 6 Drop Test Conditioning Requirements (Single and Composite Packaging) (reference Section 7)

NOTE 1—"X" indicates materials of construction and required pre-conditioning.

Material of Construction for:					→ → → → First determine the material of construction for the packaging type and then move across the row to determine the required pre-conditioning → → → →	Required Pre-Conditioning for Complete Packaging		
Single or Outer Packaging			Inner Receptacle for Composite					
Plastic	Fiberboard	Other	Plastic	Other		Ambient	23°C and 50 % RH	−18°C
X			N/A single packaging					X[A,F]
X			X					X[A,F]
X				X				X[A,F]
	X		N/A single packaging				X[C,E]	
	X		X					X[B,F]
	X			X			X[C,E]	
		X[D]	N/A single packaging			X		
		X[D]	X					X[F]
		X[D]		X		X		

[A] −18°C pre-conditioning is not required for boxes made of expanded polystyrene (4H1).
[B] −18°C pre-conditioning is not required for combination packagings with plastic bags intended to contain solids or Articles.
[C] 23 ± 2°C and 50 ± 2% RH are preferred conditions; two other options are 20 ± 2°C and 65 ± 2% RH, or 27 ± 2°C and 65 ± 2% RH.
[D] "Other" includes materials such as Steel, Aluminum, Monel, Nickle, Glass, Porcelain, Stoneware.
[E] See ASTM D4332 Standard Practice for Conditioning Containers, Packages, or Packaging Components for Testing.
[F] See ASTM D7790 Standard Guide for Preparation of Plastic Packagings Containing Liquids for United Nations (UN) Drop Testing.

TABLE 7 Drop Test Conditioning Requirements (Combination Packaging) (reference Section 7)[A]

NOTE 1—"X" indicates materials of construction and required pre-conditioning.

Material of Construction for:					→ → → → First determine the material of construction for the inner and outer packaging and then move across the row to determine the required pre-conditioning → → → →	Required Pre-Conditioning for Complete Packaging		
Outer Packaging			Inner Packaging					
Plastic	Fiberboard	Other	Plastic	Other		Ambient	23°C and 50 % RH	−18°C
X			X					X[A,B,F]
X				X[D]				X[A,F]
	X		X					X[B,F]
	X			X[D]			X[C,E]	
		X[D]	X					X[B,F]
		X[D]		X[D]		X		

[A] −18°C pre-conditioning is not required for boxes made of expanded polystyrene (4H1).
[B] −18°C pre-conditioning is not required for combination packagings with plastic bags intended to contain solids or Articles.
[C] 23 ± 2°C and 50 ± 2% RH are preferred conditions; two other options are 20 ± 2°C and 65 ± 2% RH, or 27 ± 2°C and 65 ± 2% RH.
[D] "Other" includes materials such as Steel, Aluminum, Monel, Nickle, Glass, Porcelain, Stoneware.
[E] See ASTM D4332 Standard Practice for Conditioning Containers, Packages, or Packaging Components for Testing.
[F] See ASTM D7790 Standard Guide for Preparation of Plastic Packagings Containing Liquids for United Nations (UN) Drop Testing.

TABLE 8 Drop Height Determination (reference Section 7.3.1)[A]

Packing Group I	Packing Group II	Packing Group III
1.80 m (70.9 in.)	1.20 m (47.2 in.)	0.80 m (31.7 in.)

[A] Packagings tested for solids must be tested in accordance with this method [See: 49 CFR 178.601(e)(1)]. Packagings tested with solids may not utilize the corrected drop height method outlined in 7.3.3 [49 CFR 178.603(e)(2)(ii)].

TABLE 9 Drop Height Determination (reference Section 7.3.2)

Packing Group I	Packing Group II	Packing Group III
1.80 m (70.9 in.)	1.20 m (47.2 in.)	0.80 m (31.7 in.)

based on the formulas shown in Tables 10-12 for each Packing Group.

NOTE 4—The format of 49 CFR 178.603 indicates conversions from meters to feet (for example, 1.8 m equals 5.9 ft). Tables 10-12 convert meters to inches since this is the most common method and a more accurate method of measuring drop heights for package testing in the U.S. Since most drop test measuring devices and drop testers used for UN certification testing are not capable of measuring to the nearest tenth of an inch, Column IV indicates a more practical drop height based on the calculated drop height rounded up to the nearest inch.

TABLE 10 Drop Height Determination: Packing Group I (X) (Meters = 1.50 × S.G.) (reference Section 7.3.3)

Column I S.G.[A]	Column II Meters[B]	Column III In. (Calculated Min)[C]	Column IV In. (Rounded Up)[D]
2.2	3.30	129.9	130
2.1	3.15	124.0	124
2.0	3.00	118.1	119
1.9	2.85	112.2	113
1.8	2.70	106.3	107
1.7	2.55	100.4	101
1.6	2.40	94.5	95
1.5	2.25	88.6	89
1.4	2.10	82.7	83
1.3	1.95	76.8	77
1.2	1.80	70.9	71

[A] Column I: Maximum Specific Gravity of Liquid Hazardous Material to be transported (rounded up to the first decimal).
[B] Column II: Required drop height in meters (Column I × factor of 1.5 for P.G. I, 1.0 for P.G. II or 0.67 for P.G. III).
[C] Column III: Calculated minimum drop height in inches rounded to the nearest tenth of an inch (column II divided by 0.0254).
[D] Column IV: Practical drop height: Calculated minimum drop height (column III) rounded up to the nearest inch.

TABLE 11 Drop Height Determination: Packing Group II (Y) (Meters = 1.00 × S.G.) (reference Section 7.3.3)

Column I S.G.[A]	Column II Meters[B]	Column III In. (Calculated Min)[C]	Column IV In. (Rounded Up)[D]
2.2	2.20	86.6	87
2.1	2.10	82.7	83
2.0	2.00	78.7	79
1.9	1.90	74.8	75
1.8	1.80	70.9	71
1.7	1.70	66.9	67
1.6	1.60	63.0	63
1.5	1.50	59.1	60
1.4	1.40	55.1	56
1.3	1.30	51.2	52
1.2	1.20	47.2	48

[A] Column I: Maximum Specific Gravity of Liquid Hazardous Material to be transported (rounded up to the first decimal).
[B] Column II: Required drop height in meters (Column I × factor of 1.5 for P.G. I, 1.0 for P.G. II or 0.67 for P.G. III).
[C] Column III: Calculated minimum drop height in inches rounded to the nearest tenth of an inch (column II divided by 0.0254).
[D] Column IV: Practical drop height: Calculated minimum drop height (column III) rounded up to the nearest inch.

TABLE 12 Drop Height Determination: Packing Group III (Z) (Meters = 0.67 × S.G.) (reference Section 7.3.3)

Column I S.G.[A]	Column II Meters[B]	Column III In. (Calculated Min)[C]	Column IV In. (Rounded Up)[D]
2.2	1.47	58.0	58
2.1	1.41	55.4	56
2.0	1.34	52.8	53
1.9	1.27	50.1	51
1.8	1.21	47.5	48
1.7	1.14	44.8	45
1.6	1.07	42.2	43
1.5	1.01	39.6	40
1.4	0.94	36.9	37
1.3	0.87	34.3	35
1.2	0.80	31.7	32

[A] Column I: Maximum Specific Gravity of Liquid Hazardous Material to be transported (rounded up to the first decimal).
[B] Column II: Required drop height in meters (Column I × factor of 1.5 for P.G. I, 1.0 for P.G. II or 0.67 for P.G. III).
[C] Column III: Calculated minimum drop height in inches rounded to the nearest tenth of an inch (column II divided by 0.0254).
[D] Column IV: Practical drop height: Calculated minimum drop height (column III) rounded up to the nearest inch.

8. Leakproofness Test

8.1 The user of this guide should review 49 CFR, 178.604 for specific test information, pass/ fail criteria and requirements for design qualification, periodic retest, and production testing. The leakproofness test must be performed with compressed air or other suitable gases on all packagings intended to contain liquids. Alternate methods of leakproofness testing are listed in Appendix B to Part 178 of 49 CFR.

8.2 For design qualification and periodic retests the leakproofness test must be performed on packagings with closures in place. Vented closures must be sealed or replaced with similar non-vented closures. The test is a 5-min pressure test when using the immersion test method. Other approved methods may be used as specified in Appendix B to part 178.

8.3 The required test pressure is related to the Packing Group of the Material. Packing Group I is 30 kPa and Packing Groups II and III are 20 kPa.

8.4 The regulations require a production leakproofness test on every packaging intended to contain liquids before the first use of the package. For production testing, packagings need not have their closures in place. Leakproofness tests are also required prior to each reuse unless otherwise specified. (see 49 CFR 173.28(b)).

8.5 The leakproofness test (including the production test) does not apply to inner packagings of a combination packaging. (For example, a glass bottle for liquids placed inside a corrugated box.)

8.6 A laboratory precision gauge should be used such that individual measurement results including errors in reading and calibration shall not exceed ±3 %.

9. Hydrostatic Pressure Test

9.1 The user of this guide should review 49 CFR, 178.605 for specific test information, pass/ fail criteria and requirements for design qualification and periodic retest and reference Guide D7660 for guidance on conducting the internal pressure test. The hydrostatic pressure test must be performed on all single/ composite packagings intended to contain liquids.

9.2 The hydrostatic pressure test is conducted on a packaging filled with water and pressurized using an appropriate method (typically water pressure). The pressure should be applied continuously and gradually up to the required test pressure. The hydrostatic pressure test is a 30-min test for all plastic packagings and a 5-min test for all packaging materials other than plastic.

9.3 The regulations offer three options for determining the hydrostatic test pressure requirement (49 CFR 178.605(d)). The first option is based on gage pressure of the product in the packaging. The next two options are based on the vapor pressure of the hazardous material at 50 or 55°C. Examples of vapor pressure determination for packagings and materials are available in several International Regulations. [For examples see: UN Orange Book, 4.1.1.10; ICAO Table 4.4.7(c); IMDG 4.1.1.10; IATA 5.0.2.9, Table 5.0(a)]. Single and composite packagings marked to Performance Standard X (intended to contain liquid hazardous materials of Packing Group I) must be tested to a minimum test pressure of 250 kPa.

9.4 The hydrostatic pressure test is not required for inner packagings of a combination packaging.

NOTE 5—The hydrostatic pressure tests may be used to meet the pressure differential capability requirements of inner packagings of a combination packagings intended for liquids shipped by air transportation (see 49 CFR 173.27(c)).

9.5 A laboratory precision gage should be used such that individual measurement results including errors in reading and calibration shall not exceed ±3 %.

10. Stack Test

10.1 The user of this guide should review 49 CFR 178.606 for specific test information, calculation requirements, and pass/fail criteria and requirements for design qualification and periodic retesting. Stack tests are required for all types of packagings except bags and should be conducted in accordance with Test Method D4577 or Test Method D642 (for Periodic retest only).

TABLE 13 Stack Test Conditioning Requirements (Design Qualification) (reference Section 10)[A]

Packaging Type	Test Condition	Test Duration
Plastic Single Packagings for Liquids	40°C (104°F)	28 days
Composite Packagings with Plastic Outer for Liquids	40°C (104°F)	28 days
Plastic Single and Composite Packagings for Solids	Ambient	24 h
Single and Composite Packaging with Fiberboard Outer	Per 49 CFR 178.602(d)[B]	24 h
Combination Packaging with Fiberboard Outer	Per 49 CFR 178.602(d)[B]	24 h
Non-Plastic and Non Fiberboard Packagings	Ambient	24 h

[A] For periodic retest the stack test may be performed at ambient conditions and the dynamic compression test option may be used. See 49 CFR, 178.606(c)(2)(ii).
[B] Preferred: 50 percent ±2 percent relative humidity, and at a temperature of 23°C ± 2°C (73°F ± 4°F). Note that 178.602(d)(2) allows for alternate conditions.

10.2 *Stack Test Conditioning and Duration Requirements*—Table 13 provides an overview of the required stack test conditioning for the various packaging types and should be conducted in accordance with Practice D4332, Practice D685 and Guide D7790 [See: 6.1 above].

11. Vibration Test

11.1 The user of this guide should review 49 CFR 178.608 for specific test information and pass/fail criteria. The one-hour vibration test is a capability test for all types of packagings and should be conducted in accordance with Test Methods D999.

11.2 The vibration test is a unique capability requirement for U.S. certified packagings and is not part of the UN Recommendations. Capability requirements may be met by; conducting the vibration test, previous successful shipping history, or other equally effective means of determining capability. It is strongly recommended to conduct the vibration test to establish the capability of meeting the requirements of the regulations. (see 49 CFR 173.24a(a)(5)).

12. Pressure Differential Test

12.1 The user of this document should review 49 CFR 173.27(c) for the pressure test requirements for packages shipped by air transportation. The pressure differential test may be performed by conducting the hydrostatic pressure test outlined in 49 CFR, 178.605, or by conducting a vacuum pressure test on rigid containers as outlined in Test Method D4991. Plastic packagings must be subjected to the test for at least 30 min and other materials for at least 5 min. Conduct the pressure test in accordance with D7660 Standard Guide for Conducting Internal Pressure Tests on United Nations (UN) Packagings.

12.2 Inner packagings of a combination packaging which contain liquid and are intended for air transportation must be capable of meeting a pressure differential test. This requirement does not apply to inner packagings for liquids shipped by surface transportation only.

12.3 As a point of clarification: Single and composite packagings intended for shipping liquid hazardous materials (surface or air transportation) must be subjected to the internal hydrostatic pressure test specified in 49 CFR, 178.605. In addition, the pressure rating (in kPa) is indicated in the UN marking. The UN marking for a combination packaging does not indicate whether the inner packaging has been pressure tested and approved for air transportation. This information must be obtained from the certification report.

12.4 Single and Composite packagings intended for liquid hazardous materials and shipped by air transportation must be marked to a minimum test pressure as specified in 49 CFR 173.27(c)(2)(ii).

13. Cobb Water Absorption Test

13.1 The cobb water test is a construction requirement for corrugated boxes as stated in 49 CFR, 178.516 and should be conducted in accordance with ISO 535. The 30-min test determines the water resistance of the outer surface of a corrugated box. The water absorption cannot be greater than 155 g/m^2.

14. Test Report

14.1 Following each design qualification test and periodic retest on a packaging, a test report must be prepared. The user of this guide should refer to 49 CFR, 178.601(l) for the record retention requirements and the minimum requirements for a test report.

14.2 The report should contain sufficient information to be able to identify the packaging and all components used in the certification test. (for example,; dimensions, materials of construction, thickness, method of fabrication, closure information, packaging sealing method and any other pertinent information to accurately describe the packaging design) This may be accomplished by including assembly view and individual component drawings, photographs, specification numbers or part numbers of all packaging components and should include the information in Table 1.

15. UN Markings

15.1 Once the packaging has successfully passed the applicable UN performance tests, the packaging must be marked with the appropriate UN markings. Refer to 49 CFR 178.3 and 178.503 to review the requirements for marking of packages.

16. Keywords

16.1 dangerous goods; hazardous materials; packaging; packing group

SUMMARY OF CHANGES

Committee D10 has identified the location of selected changes to this standard since the last issue (D4919 – 03(2008)) that may impact the use of this standard. (Approved April 1, 2017.)

(1) 2.1—Added recently completed relevant Guides D7660, D7887, and D7790.
(2) 2.5—Revised industry organization information.
(3) Section 3—Added minor editorial corrections.
(4) 5.1.4—Incorporated additional ASTM guidance documents.
(5) Table 2—New example drawing, superscripts moved to appropriate entries.
(6) Table 3—New example drawing, superscripts moved to appropriate entries.
(7) Table 4—New example drawing, superscripts moved to appropriate entries.
(8) Table 5—Superscripts moved to appropriate entries.
(9) Table 6—Superscripts moved to appropriate entries; references to new guidelines inserted in footnotes.
(10) Table 7—Superscripts moved to appropriate entries; references to new guidelines inserted in footnotes.
(11) Table 8—Revised footnote.
(12) Section 9—Additional information added.
(13) Section 10—Modified conditioning language for fiberboard packaging entries.
(14) Section 12—Added reference to Guide D7660 for test guidance.
(15) Section 6—Added new 6.1 to address concerns about conditioning requirements under the regulations related to ASTM common practices.
(16) 7.2—Reference to 6.1 added.
(17) 10.2—Reference to 6.1 added.
(18) Table 1—Renamed to reflect test information requirements without use of the word “certification.”
(19) 6.1—Clarified conditioning requirements for package testing when differences exist between the HMR and best practices at reference test facilities (resolution of negative votes).
(20) Table 1—Title clarification added (resolution of negative vote).
(21) Various Tables—Reformatted to allow for printing and viewing (comments).
(22) 7.2—Added conditioning language clarification.
(23) 10.2—Added conditioning language clarification.