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Standard Guide for Testing of Hazardous Materials (Dangerous Goods) Packagings¹

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

1. Scope*

1.1 This guide identifies 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 and 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 provides assistance 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 (dangerous goods) 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 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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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, health, and environmental practices and determine the applicability of regulatory limitations 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

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
- D8135** Guide for Selection of Substitute, Non-hazardous, Particulate Solid Filling Substances for Packagings Subjected to the United Nations Performance Tests
- D8409** Guide for Conducting Stacking Tests on UN Packagings Using Guided or Unguided Loads
- 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, Model Regulations (UN Orange Book)⁴
- 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 *Industry Document:*
Industrial Steel Drum Institute (ISDI) and Reusable Industrial Packaging Association (RIPA) Hazardous Materials Packaging Testing Procedures for Steel Drums⁹

3. Terminology

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

³ Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <https://www.iso.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.org>.

⁷ Available from International Marine Organization, 4 Albert Embankment, London, SE1 7SR UK, <http://www.imo.org>.

⁸ Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9371 (www.phmsa.dot.gov/phmsa-regulations).

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

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 have the UN specification mark applied to the outer packaging. Hazardous Materials may not be transported in a packaging that does not bear the appropriate UN specification 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 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 selecting solids fill materials for package testing the user of this guide should consult Guide **D8135** for guidance on the selection of the proper solids fill material for the test specimens.

5.1.4.3 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 °C 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.

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 (x)	II (Y)	III (Z)
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 °C 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 packaging)	Special Closure Functions (for example, Bolt Ring, Lever Lock, Induction Seal, etc.):			
	Closure Application Torque(s):			
	Box Sealing Method: ⁴			
	Inner Packaging Orientation:			
	Cushioning Requirements:			
	Miscellaneous Requirements:			

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

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.

6. Test Overview

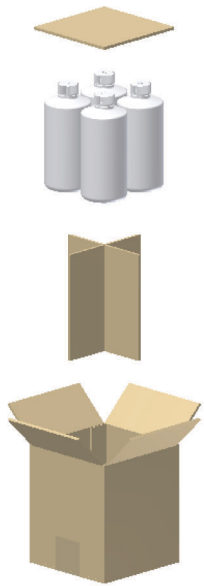
6.1 Design Qualification testing procedures are intended, as explicitly stated in the HMR, to be the minimum performance capability levels for packaging manufactured to transport

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.

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

NOTE 1—“X” indicates to conduct the test.

UN Tests	49 CFR	Section in Document	Liquids	Solids	Required Samples	 <p>Combination Packaging Example</p>
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)	


^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.

UN Tests	49 CFR	Section in Document	Solids	Required Samples	 <p>Bag Packaging Example</p>
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			


^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.

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
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			



Single Packaging Example

^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
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)



Composite Packaging Example

^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. 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.

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			Ambient	23°C and 50 % RH	-18 °C
Plastic	Fiberboard	Other	Plastic	Other				
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 ^{B,F}	
		X ^D	N/A single packaging					
		X ^D	X				X ^F	
		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 °C ± 2 °C and 50 % ± 2 % RH are preferred conditions; two other options are 20 °C ± 2 °C and 65 % ± 2 % RH, or 27 °C ± 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			Ambient	23°C and 50 % RH	-18°C
Plastic	Fiberboard	Other	Plastic	Other				
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 °C ± 2 °C and 50 % ± 2 % RH are preferred conditions; two other options are 20 °C ± 2 °C and 65 % ± 2 % RH, or 27 °C ± 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.

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:

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.

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.

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.)

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