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Standard Guide for Conducting Internal Pressure Tests on United Nations (UN) Packagings[1]

This standard is issued under the fixed designation D7660; 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.

1. ~~Scope~~ Scope*

1.1 This guide is intended to provide a standardized method and a set of basic instructions for performing internal and hydrostatic pressure testing on packaging ~~designs.~~designs intended for shipping liquids in accordance with the United States Department of Transportation Title 49 Code of Federal Regulations (CFR) and the United Nations Recommendations on the Transport of Dangerous Goods (UN).

1.2 This guide provides information to help clarify various terms used as part of the United Nations (UN) certification process that may assist in determining the applicable test.

1.3 This guide provides the suggested minimum information that should be documented when conducting pressure testing.

1.4 This guide provides information for recommended equipment and fittings for conducting pressure tests.

1.5 This guide is based on the current information contained in 49 CFR, §173.27 and §178.605.

1.6 When testing packaging designs intended for hazardous materials (dangerous goods), the user of this guide shall be trained in accordance with 49 CFR §172.700 and other applicable hazardous materials regulations such as the ICAO Technical Instructions, IMDG Code, and carrier rules such as the IATA Dangerous Goods Regulations.

1.7 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.8 *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.*

1.9 *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]

D4919 Guide for Testing of Hazardous Materials (Dangerous Goods) Packagings

D4991 Test Method for Leakage Testing of Empty Rigid Containers by Vacuum Method

D8134 Guide for Conducting Internal Hydrostatic Pressure Tests on United Nations (UN) IBC Design Types

2.2 *Federal Standard:*[3]

~~49 CFR~~ U.S. Department of Transportation Code of Federal Regulations Title 49, Transportation (49 CFR) Parts 100-185

2.3 *UN Standard:*[4]

~~UN~~ UN United Nations Recommendations on the Transport of Dangerous Goods, Model Regulations (UN Orange Book)

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[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.

[3] Available from Superintendent of Documents, U.S. Government Printing ~~Office Superintendent of Documents,~~ Office, Washington, DC ~~20402–9371, http://phmsa.dot.gov/hazmat.~~ 20402-9371 (website: https://www.phmsa.dot.gov/phmsa-regulations).

[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.~~ 10 Switzerland (website: http:// www.unece.org/trans/danger/danger.htm).

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

2.4 *IATA Standard:*[5]

~~IATA~~ IATA International Air Transport Association (IATA) Dangerous Goods Regulations

2.5 *ICAO Standard:*[6]

~~ICAO~~ ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air

2.6 *IMDG Standard:*[7]

~~IMDG Code~~ International Maritime Dangerous Goods Code (IMDG Code)

3. Terminology

3.1 *Definitions:*

3.1.1 *bar, n*—metric unit of atmospheric pressure equal to 14.50 psi (lb/in.^{2}), 1.02 kg/cm^2 , 29.53 in.-Hg, or 0.9869 atmosphere.

3.1.2 *hydrostatic pressure test, n*—internal pressure test conducted on a container or packaging filled with water and pressurized with water or other suitable means; regulatory reference sections: 49 CFR §178.605, UN 6.1.5.5, IMDG Code 6.1.5.5, ICAO 6.4.5, and IATA 6.3.5.

3.1.2.1 *Discussion*—

This test is required for all single and composite packagings intended for shipping liquid dangerous goods (hazardous materials). For single and composite packagings, the test pressure rating will appear as part of the UN specification marking sequence. This test may also be used to comply with the pressure differential requirements for air transportation (49 CFR §173.27) for inner packagings of combination packagings intended for shipping liquid hazardous materials. For further discussion and clarification, refer to the pressure differential section.

3.1.3 *inches-mercury, in.-Hg, n*—pressure exerted by a 2.54-cm high column of mercury that has a density of 13.5951 g/cm^3 when the acceleration of gravity has the standard value of 9.8 m/s^2; used as a unit in the measurement of atmospheric pressure. One in.-Hg is equal to 3.3864 kPa or 0.491154 psi.

3.1.4 *kilopascal, kPa, n*—unit of pressure in the SI system of international units, the primary, standard system used by the United Nationals (UN) and the U.S. Department of Transportation (DOT) throughout their respective regulations per 49 CFR §171.10.

3.1.4.1 *Discussion*—

To convert kPa to psi, multiply by ~~0.145130~~0.1450377 (95 kPa × ~~0.145130~~0.1450377 = 13.8 psi). For single and composite packagings, the test pressure rating will appear as part of the UN specification marking sequence and shall be shown in kPa.

3.1.5 *leakproofness test, n*—pressure test conducted on an empty container or packaging and pressurized with air or other suitable means; regulatory reference sections: 49 CFR §178.604, UN 6.1.5.4, IMDG Code 6.1.5.4, ICAO 6.4.4, and IATA 6.3.4.

3.1.5.1 *Discussion*—

All packagings intended to contain liquids, except the inner packagings of combination packagings, shall be capable of passing a leakproofness test. Methods to comply are outlined in Appendix B to Part 178 of DOT, 49 CFR.

3.1.5.2 *Discussion*—

The definition for leakproofness is provided in this guide, but the test methods will be addressed in a separate standard.

3.1.6 *packagings, n*—receptacles and any other components or materials necessary for the receptacle to perform its containment function and includes ~~nonbulk~~non-bulk packagings and composite packagings and are: designed to contain a net mass not exceeding 400 kg; designed with a capacity not exceeding 450 L; not intended to transport most gases; not intended to transport infectious substances; not intended to transport most radioactive materials; and not an intermediate bulk container (IBC) as defined in UN Recommendations 6.5.

3.1.7 *pounds per square inch, psi, n*—unit of measure in the English measurement system.

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[5] Available from the International Air Transport Association (IATA), 800 Place ~~Victoria,~~Victoria PO Box ~~113, Montreal, Quebec, H4Z 1M1, Canada, http://www.iata.org.~~113 Montreal - H4Z 1M1 Quebec - Canada (website: http:// www.iata.org).

[6] 6 Available from the International Civil Aviation ~~Organization (ICAO),~~Organization, (ICAO) 999 University ~~St., Montreal, Quebec,~~Street, Montréal, Quebec H3C 5H7, ~~Canada, http://www.icao.org.~~ Canada (website: http:// www.icao.org/).

[7] Available from the International Marine Organization ~~(IMO),~~(IMO, 4 Albert Embankment, London, SE1 ~~7SR, U.K., http://www.imo.org.~~7SR United Kingdom (website: http://www.imo.org/).

3.1.7.1 *Discussion—*

To convert psi to kPa, multiply by 6.89 (13.8 psi × 6.89 = 95 kPa).

3.1.8 *pressure differential test, n*—combination packagings with inner packagings containing liquid hazardous materials shall be capable of meeting the pressure differential requirements for transport by air; regulatory reference sections: 49 CFR §173.27(c), ICAO 4; 1.1.6, and IATA 5.0.2.9.

3.1.8.1 *Discussion—*

The pressure differential is intended to consider both the reduced external pressure as a result of changes in altitude as well as increased internal pressure as a result of the vapor pressure of the hazardous materials in the package. To meet the pressure differential requirement, the following tests may be used:
(*1*) *hydrostatic pressure, n*—The hydrostatic pressure test method should be used for all nonrigid containers and inner packagings. Nonrigid containers are those that expand under pressure such as plastic bottles or vials and thin walled metal containers;
(*2*) *vacuum pressure, n*—The vacuum pressure test is an appropriate method for rigid containers and inner packagings if the required test pressure (pressure differential) is 95 kPa or less. A container is considered rigid if it does not volumetrically expand more than 0.5 % of its nonpressurized volume at ambient temperature when subjected to an internal pressure of 1 atmosphere (100 kPa) as specified in Test Method D4991. Rigid containers are those such as glass bottles and vials, earthenware, and plastic and metal containers with thicker walls that do not significantly expand under pressure.

3.1.8.2 *Discussion—*

The appropriate pressure differential test method shall be validated to confirm the minimum required internal pressure has been met.

3.1.8.3 *Discussion—*

The vacuum pressure method should not be used for "nonrigid" or flexible containers. When a flexible packaging such as a plastic bag is subjected to a vacuum test, the air (fill material) inside the bag will cause the flexible packaging to expand and, subsequently, the internal pressure will decrease. The pressure differential of the test is inversely related to the volume increase of the sample; therefore, large volume increases detract from the severity of the test.

3.1.9 *torr, n*—unit of measure for the pressure exerted by 1 mm of mercury equal to 1/760 th of standard atmospheric pressure; used to measure pressure in vacuum systems.

3.1.9.1 *Discussion—*

The corresponding SI unit is the pascal (Pa). It is a unit of pressure that is equal to approximately 1.316×10^{-3} atmospheres or 133.3 Pa (0.1333 kPa).

4. Significance and Use

4.1 Dangerous goods (hazardous materials) regulations require performance tests to be conducted on packaging designs before being authorized for use. The regulations do not include standardized procedures for conducting performance tests and, because of this, may result in a non-uniform approach and differences in test results between testing facilities.

4.2 The purpose of this guide is to provide guidance and to establish a set of common practices for conducting internal pressure tests on packagings ~~under going~~subjected to UN certification testing or packagings required to meet pressure capability requirements. ~~For more information on the UN certification requirements, refer to Guide D4919.~~

4.3 This guide provides additional information not in the regulations that will facilitate consistent testing. The information and guidance provided here are intended to meet or exceed the minimum regulatory requirements. For more information on the UN certification requirements, refer to Guide D4919. For pressure testing of IBC design types, reference Guide D8134.

5. Equipment

5.1 *Recommended Test Equipment :*
5.1.1 *Appropriate Packaging Closing Equipment (Calibrated as Applicable)*—Closing equipment such as torque wrench, torque meter, lid press, cover/closure crimping tools, and so forth to prepare the packaging as for transport.
5.1.2 *Water Supply Source:*
5.1.2.1 Water supply source system should be designed to minimize water pressure fluctuations during the test.

5.1.2.2 The water source can be building supplied water provided fluctuations in pressure do not occur during the test.

5.1.2.3 ~~Recommended~~ It is recommended to have a separate water supply tank ~~assembly.~~ assembly to enable the use of air pressure over the top of the water supply. Air pressure may be used to pressurize the water supply tank to provide adequate water pressure to the test sample. Refer to Fig. 1~~, Fig. 2, and Fig. 3~~.

5.1.3 Regulator valve to maintain proper water pressure to test containers used to maintain an even pressure throughout the duration of the test.

5.1.4 ~~Manifold~~Pressure station to distribute water from water supply source through the regulator to the test containers. Refer to Fig. 1~~, Fig. 2, and Fig. 3~~.

5.1.5 Hose or hard piping as required.

5.1.6 Pressure gauge(s), psi/kPa, dual marked and calibrated (digital preferred).

5.1.6.1 Gauge to monitor water supply pressure.

5.1.6.2 Gauge(s) to monitor pressure inside test ~~packaging(s).~~container(s).

5.1.6.3 ~~Any~~All gauges used should be calibrated and have an accuracy in the ~~range of ±3 %.~~in the appropriate range.

5.1.7 *Connection Fitting/Valves, Adaptors, Gaskets, and Bushings (or Other Equally Effective Means) as Needed—*

5.1.7.1 Fitting/valve for water inlet to test container.

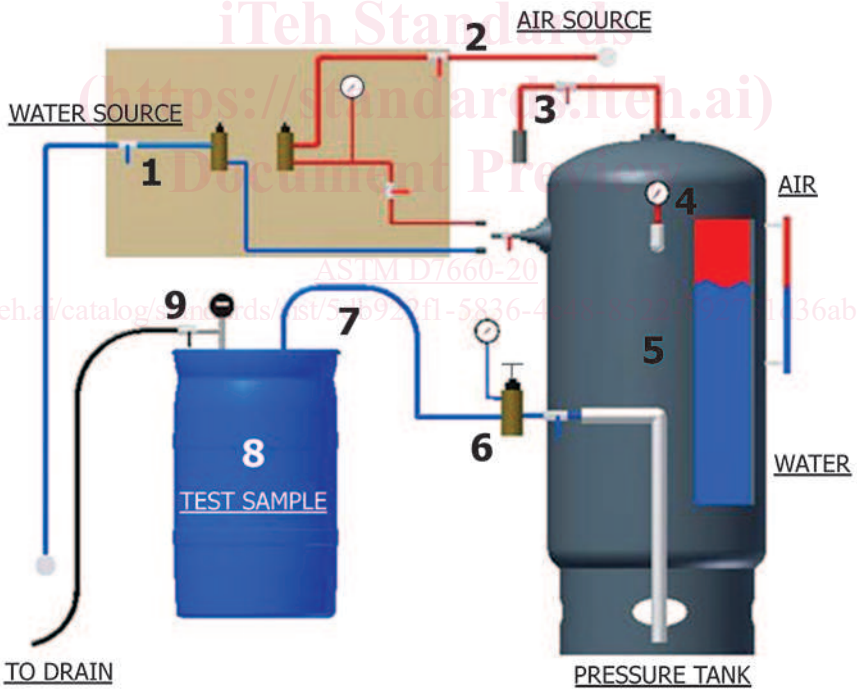
5.1.7.2 Fitting/valve for air release, drainage, and pressure monitoring.

5.1.7.3 Fitting/valve for pressure monitoring (if this is not combined with air release fitting).

NOTE 1—When combining fittings and valves, take care to make sure the assembly does not interfere with the reading on the gauge. A long extension of the fitting may not provide an accurate pressure reading of the test container. Fittings extending above or beyond the test container should be kept as short as possible to maintain accurate values and stable fittings.

5.1.8 Drill and appropriate drill bit.

5.1.9 *Thermometer*—Calibrated 0 to 50°C minimum range.



Component I.D.	Description
1.	Water supply (to pressure tank) with regulator and shut off valve. Hose quick connects to pressure tank when used.
2.	Air supply (to pressure tank) with regulator and shut off valve. Hose quick connects to pressure tank when used.
3.	Tank pressure relief with shut off valve.
4.	Gauge to monitor the pressure inside the tank.
5.	Pressure tank (recommended minimum size of 80 gal) with air over water.
6.	Water supply with regulator and gauge to the test container from the pressure tank.
7.	Water supply hose (¾ in.) with quick connect to attached to test container.
8.	Test container.
9.	T-connection with gauge to monitor pressure in test sample and vent relief for container with hose (½ to ¾ in.). Hose should extend to drain or water recovery container.

NOTE 1—Reference Appendix X1 for pressure station preparation prior to starting the test.

FIG. 1 ~~Larger~~Large Container Internal Hydrostatic Pressure Station ~~Example (Drawing)~~

5.1.10 *Timer with Audible Alarm*—0 to 60 min.

5.2 *Recommended Safety Equipment:*

5.2.1 Safety glasses with side shield.

5.2.2 *Gloves*—fabric, leather, or rubber slip resistant, as appropriate.

6. Sample Size

6.1 *Inner Packagings for Air Transport*—The regulations currently do not have a required sample size specified for the pressure differential test on the inner packaging of a combination packaging, but three specimens are recommended. Reference 49 CFR, § 173.27(c) for additional information.

NOTE 2—The number of test specimens does not invalidate the test results.

6.2 *Packagings (Nonbulk)*—Three specimens are required.

7. Containers

7.1 *Selection:*

7.1.1 Randomly select appropriate specimens to be tested.

7.1.2 Visually inspect specimens to:

7.1.2.1 Verify all closures, plugs, gasket, accessories, and so forth match the closing instructions, and

7.1.2.2 Determine if the container has a properly formed sealing surface (record any blemishes or defects).

7.2 *Preparation:*

7.2.1 *Location of Fittings and Gauges*—Care should be taken not to attach fittings to container embossments or other geometries that could possibly compromise the integrity of the container or invalidate the test. The report should describe in general how many fittings are used and where fittings and gauges are located. Photo documentation is appropriate.

NOTE 3—To reduce the possibility of inconsistent results between test samples, gauges and fittings should be located in the same location.

7.2.1.1 *Single and Composite Packagings*—For all single and composite packaging designs, the pressure gauges and fittings should be located in the highest possible point of the test orientation.

NOTE 4—This may not always be the top head of the container if the container is tested in the horizontal orientation.

7.2.1.2 *Inner Packagings*—It may be difficult to attach fittings to the top head of smaller containers.

(1) Glass Bottles—If the required test pressure is 95 kPa or less, a vacuum pressure test is recommended for all glass bottles or vials. If the required test pressure is more than 95 kPa, the hydrostatic pressure test may be conducted, but care should be taken when fittings are attached. The fittings should be attached to the closure area provided the closure integrity is maintained.

(2) F-style Metal or Aluminum Cans—Attach fittings to the side or bottom of the container and avoid placing them near closures and seams.

(3) Friction-fit Cans (Paint Cans)—Attach fittings to the side or bottom of the container and avoid placing them on the plug or cover or near seams.

(4) Plastic Bottles—Attach fittings to the side or bottom of the container and avoid placing them in the closure or near seams. Try to locate the fitting in an area with uniform wall thickness.

7.2.2 *Container Setup:*

7.2.2.1 Drill an appropriate size hole in the test container for a water inlet fitting and install the fitting and snug tight with a wrench.

7.2.2.2 Drill a second hole of appropriate size in the test container for a pressure-monitoring fitting and install the fitting and snug tight with a wrench.

7.2.2.3 Connect the pressure gauge assembly to this fitting and remember to place it at the highest point of container test orientation.

NOTE 5—If the test container is not large enough or the design does not allow for a secondary fitting to be applied to the container, the person conducting the test shall be able to validate the minimum test pressure was achieved.

7.2.2.4 Connect the water supply line to the water inlet fitting.

7.2.2.5 Slowly open the water supply valve and start filling the test container with water.

7.2.2.6 When the water has reached a level just under the opening, discontinue filling. Dry the sealing area and openings to ensure there is no trapped water in the thread area.

7.2.2.7 Measure and record the temperature of the water inside the test container before sealing the packaging. It is recommended the water temperature be in the range of 12 to 20°C.

7.2.2.8 Insert the closure or plug in the proper opening and secure. Each packaging or inner packaging shall have their fittings, covers, and closures prepared for transportation according to the required closing instructions.

7.2.2.9 Vented closures shall be replaced with nonvented closures of the same specification or the vent shall be sealed. Pressure-relief devices shall be removed and their apertures plugged or shall be rendered inoperative.

7.2.2.10 If samples are prepared by the client or third party, a note should be added to the report to indicate who sealed the containers.

NOTE 6—Some containers can be partially filled before drilling holes into the containers. Regardless of the order of filling and attaching the fittings, all containers should be prepared completely full with water before starting the test. This may be accomplished by tilting the container or venting the container through a fitting while pressurizing the container and allowing the air to be released.

NOTE 7—Care should be taken not to cause damage to any part of the sealing surface or thread areas while filling any container.

8. Rate of Pressurization

8.1 Test pressure should be determined based on the pressures required ~~in~~by the regulations.

8.2 After the container has been sealed (in accordance with the proper closing instructions) and ~~the air has been removed, start pressurizing the container.~~as much air as possible has been removed from the test container, start pressurizing.

8.3 The container shall be ~~pressurized continuously and gradually up~~gradually pressurized to the required test pressure ~~by adding water. The water shall remain on~~ using a continuous supply of water through a regulator. The continuous supply of water should remain open to the test sample throughout the entire test ~~duration. This will~~ duration to allow for the necessary water ~~to be applied to the container through the regulator~~ supply if container expansion occurs.

8.4 The rate of pressurization is dependent on ~~the container, size, and its material of construction.~~ several factors, all of which should be considered when determining the appropriate amount of time required to reach the desired test pressure within a test container. Some of those factors are as follows:

8.4.1 ~~*Inner Packagings—*~~*Package Design—*~~Pressure should be reached within the time of not greater than 2 min.~~The size and shape of the container, the container's material(s) of construction and the degree of expansion/deformation experienced by the container while under pressure.

8.4.2 ~~*Packagings (Nonbulk)—*~~*Test Set-up and Equipment—*~~Pressure should be reached within the time of not less than 2 min and not greater than 5 min.~~The flow rate of water into the test container, pressure difference between the pressure tank and the test container, and having the equipment sized and configured appropriately. The following table provides recommended times to achieve 100 kPa test pressure:

Package Capacity, gal	Rigid Package, minutes	Elastic (Flexible) Package, minutes
up to 5	≤2	≤ 2
≥5 to 25	≤3	≤ 3
≥26 to 55	2-4	2-5
≥56 to 85	2-5	3-6
≥86 to 119	3-6	4-8

8.5 For all design types, record the elapsed time to reach the required test pressure. If your pressure station incorporates a flow meter, the rate of flow (litres/second) should be documented.

8.6 Larger containers (such as drums and jerricans) may need to be secured with rope, straps, or shims to prevent them from tipping over as they expand during the test.

8.7 If more than one ~~specimen~~container is to be tested at the same time (simultaneously), a method shall be in place to confirm all ~~specimens~~containers are receiving the minimum required test pressure. This may be accomplished by having a pressure gauge on each ~~specimen~~container or attaching a valve with shutoff and periodically attaching a pressure gauge to check each test container.

NOTE 8—After the inner packaging or packaging has been closed and sealed for transport, the pressure test should be started within 15 min. If the time exceeds 15 min, it is permissible to reseal all closures and fittings. If the test is conducted after 15 min and the closures and fittings are not resealed, a note should be made in the report.

9. Test Duration

9.1 The test duration shall be conducted at the minimum times as required by the applicable regulations.

9.2 The test time begins when the specimen stabilizes at the minimum required test pressure.

9.3 The test pressure in the inner packaging or packagings shall be held continuously and evenly for the appropriate required test period. The test pressure shall remain at or slightly above the required level throughout the test duration.

9.3.1 *Packagings (Nonbulk)*—Reference 49 CFR §178.605, UN 6.1.5.5, IMDG Code 6.1.5.5, ICAO 6.4.5, and IATA 6.3.5.

9.3.2 *Plastic Packagings*—Shall be subjected to the test for not less than 30 min.

9.3.3 *Metal and Other than Plastic Packagings*—Shall be subjected to the test for not less than 5 min.

9.4 *Inner Packagings:*

9.4.1 The regulations currently do not have a required time frame specified for conducting the pressure differential test on the inner packaging of a combination packaging.

9.4.2 It is recommended to use the test duration specified for testing packagings as detailed in this guide, which is 30 min for plastic and 5 min for other than plastic.