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RSPA-1996-12678-1

The U.S. Dept. of Transportation
Office of Hazardous Materials Standards
400 Seventh St., Southwest, Room No. 8430
Washington, D.C. 20590
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RE: Petition for rule making affecting subsection (i.e., paragraph) 178.606(d) which is found in Subpart M of Part 178 in Title 49 of the Code of Federal Regulations, relating to the performance testing of non-bulk packagings.

Dear Ladies and Gentlemen:

My telephone conversations with Eileen Martin and Bill Gramer earlier today concerning the pass/fail or acceptance criterion for both the initial design qualification (i.e., the three meter high stack simulation) and the alternative periodic design requalification (i.e., the dynamic compression) stacking tests, have prompted me to summarize my concerns in writing and to recommend that RSPA undertake a rule making action in order to provide the clarification that I feel is necessary to ensure that all performance-oriented non-bulk packagings are evaluated using the same acceptance criterion for compliance with the required stacking test that is discussed in 49 CFR 178.606. Please recognize, that the types of single non-bulk packagings that I am mainly referring to throughout the remainder of this letter, are removable head pails, drums, or jerricans which are intended for use in transporting aqueous ladings.

To begin with, Eileen and Bill both confirmed that I have been correctly interpreting the tail end of the last sentence in paragraph 178.606(f) which states that "in no case may the maximum deflection exceed one inch." Previous conversations that I have had with some DOT-accredited third party packaging certification agencies and packaging manufacturers had caused me to doubt whether or not I was interpreting and understood paragraph 178.606(f) correctly to state that the maximum one inch deflection only pertains to the dynamic compression test, and that it is not to be used as part of the acceptance criterion while assessing a packaging's performance while conducting the three meter high stack simulation.

However, I received two conflicting responses and different opinions when I asked both of these individuals a second question relating to whether or not liquid-filled containers need to be placed on their sides and observed for leakage immediately after the required loads are removed when conducting the three meter high stack simulation. Eileen seemed to share my interpretation of the language "no test sample may leak," thinking that it meant that a container should not leak when it is placed on its side and checked for leakage immediately after the required load is removed; whereas, Bill stated that paragraph 178.606(f) was written in such a way that a container should be considered to have passed the test if it does not leak while remaining in an upright position anytime during or after the stacking test is performed. Paragraph 178.606(f) presently reads as follows:

> "*Criteria for passing the test.* No test sample may leak. In composite packagings or combination packagings, there must be no leakage of the filling substance from the inner receptacle, or inner packaging. No test sample may show any deterioration which could adversely affect transportation safety or any distortion likely to reduce its strength, cause instability in stacks of packages, or cause damage to inner packagings likely to reduce safety in transportation. For the dynamic compression test, a container passes the test if, after application of the required load, there is no buckling of the sidewalls sufficient to cause damage to its expected contents; in no case may the maximum deflection exceed one inch."

49 CFR 178.606(f) does not specify that no test sample may leak immediately after the required load is removed and the container is placed on its side upon the conclusion of the three meter high stack simulation. Which has led me to question, what was RSPA's original intent when it adopted performance-oriented packaging standards, and how does it view this issue today? Additionally, I was wondering if RSPA is aware of any attempts made by the Technical Committee 261/Subcommittee 1/Working Group 6 (i.e., TC261/SC1/WG6) of the European Standards Organization (CEN) to clarify the pass/fail criterion relating to the performance testing of dangerous goods packagings in accordance with the guidelines that are found in paragraph 9.7.6.3 in Chapter 9 of the UN Recommendations on the Transport of Dangerous Goods, which reads almost identical to 49 CFR 178.606(f)?

I personally feel that placing containers on theirs side immediately after the required static load is removed upon the conclusion of the three meter high stacking simulation test, should be part of the pass/fail or acceptance criterion that applies to all non-bulk packagings, including composite and combination packagings, that are intended to contain liquid hazardous materials. Likewise, I believe that it is irrelevant whether its a metal, plastic, or fibre open head drum or pail that we are concerned with, or a composite packaging utilizing any of the preceding as containers as the outer packaging; because I contend that virtually all removable head containers which utilize a tubular or sponge-type elastomeric sealing gasket (most commonly a thermoset rubber) or a dispensed-in-place foamed urethane or hot melt sealing gasket in their primary closures (i.e., the seal that occurs between the body and the cover) in order to prevent the container from leaking when it is used to transport aqueous ladings, should be subjected to the stacking test for a duration of twenty-eight days at an elevated temperature as part of the initial design qualification test in order to ensure that their gasketed closures are designed and constructed so the containers will not leak as a result of any permanent or prolonged intermittent compression set (i.e., collapsation or flattening of the

sealing gasket which renders it ineffective at preventing leakage) that may occur during conditions which are commonly encountered in the distribution and transportation environment. The simple fact that 1H2, 3H2, 6HH1, and 6HH2-type packagings which are intended for use in transporting liquids must withstand a static load that is equivalent to the combined weight of identical filled containers that would be stacked on them if a ten foot (i.e., three meter) tall column stack was simulated, for period of twenty-eight days in an environment where the temperature remains at least 104 degrees Fahrenheit (40 degrees Centigrade) makes their gasketed closures more prone to leaking if they are laid on their sides immediately after the required loads are removed; than for example, 1A2-type removable head steel pails and drums which are only required to support a comparable load for a duration of 24 hours at standard laboratory temperature (i.e., 73 +/- 4 F or 23 +/- 2 C). I personally feel that part of the purpose of conducting the stacking test on packagings which are intended for use in transporting liquids and which are to be warehoused and transported at slightly elevated temperatures for reasonable lengths of time, should be to assess whether or not the sealability of the packaging's closures will be adversely affected by the range of temperatures which are likely to be encountered in the distribution environment and the by length of time that the packagings would need to support a load that is equal to or greater than the combined weight of identical filled packagings that would be placed on them in a three meter high column stack

Furthermore, I wanted to advise RSPA that some DOT-accredited third party packaging certification agencies and packaging manufacturers whom elect to test and self-certify their own containers, will wait anywhere from a few minutes to several hours before placing the containers on their sides and observing them for leakage once the required load has been removed; whereas yet others, are not in the practice of turning the containers on their sides and checking for leakage because the first sentence in section 178.606(f) simply states that "no test sample may leak," which can be interpreted to mean that the packaging may not leak while remaining in an upright position anytime during or after the stacking test is performed. This compels me to ask RSPA for clarification, concerning how much time should be provided from the moment that the load is removed until the container is laid on its side and observed for leakage? Gasketed closures, particularly those of removable head pails, drums, and jerricans which are intended for use in transporting liquids, will commonly leak if the containers are placed on their sides and inspected for leakage immediately after the appropriate loads has been removed, because the sealing gaskets within the containers' primary closure have not been given adequate time to recover (i.e., to retain their original shape and develop sufficient sealing pressures in order to prevent the container from leaking, after having been placed under a static compression load for a period of time) and reseal themselves. Nevertheless, I tend to question whether giving a gasketed closure any length of time to recover and reseal is an adequate simulation of actual container handling and stacking conditions that are experienced in the real world. For instance, what would happen if a pail or drum tipped over and leaked while someone was breaking apart palletized stacks of filled containers because the gasketed closures were given ample time to fully recover and reseal themselves before they were observed for leakage upon conclusion of the stacking test; and worse yet, if they were deemed to have passed stacking test because they did not leak while standing in the normal upright position? Often times, it is possible a pail or drum manufacturer to use a thinner, less-dense, less resilient, or lesser quantity of gasketing material

which normally results in a less costly sealing gasket that is installed in the covers of removable head containers, because the less expensive gasket will provide a leakproof seal when the drop, leakproofness, hydrostatic, and vibration tests are conducted; but is not adequate to prevent the containers from leaking when they are placed on their side immediately after the required load is removed.

In conclusion, I feel that the somewhat ambiguous language of paragraph 178.606(f) has resulted in many different interpretations and therefore, procedural differences concerning the way which many DOT-accredited third party packaging certification agencies and packaging manufacturers have and may continue evaluate a packaging's ability to endure the stacking tests which are discussed in 49 CFR 178.606; and I tend to question whether a uniform level of transport safety can be maintained due to such inconsistencies. Please do not hesitate to telephone me at (714) 582-6289, if you wish to discuss these matters in greater depth.

Sincerely,

Bobby Roper

Enclosure - a copy of ASTM D4919-89

cc: Eileen Martin
Bill Gramer

Designation: D 4919 – 89ε1

Standard Specification for Testing of Hazardous Materials Packagings[1]

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

ε1 NOTE—The approval date was editorially corrected in December 1989.

1. Scope

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

1.2 The following safety hazards caveat pertains only to the test method portions, Sections 8–14, of this specification. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* See also A1.2.

2. Referenced Documents

2.1 *ASTM Standards:*

D 685 Method of Conditioning Paper and Paper Products for Testing[2]

D 775 Test Method for Drop Test for Loaded Boxes[2]

D 959 Method of Drop Test for Filled Bags[2]

D 996 Terminology of Packaging and Distribution Environments[2]

D 997 Test Method for Drop Test for Loaded Cylindrical Containers[2]

D 999 Methods for Vibration Testing of Shipping Containers[2]

D 4169 Practice for Performance Testing of Shipping Containers and Systems[2]

D 4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing[2]

D 4577 Test Method for Compression Resistance of a Container Under Constant Load[2]

E 4 Practices for Load Verification of Testing Machines[3]

2.2 *ISO Standard:*

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

2.3 *ANSI/ASQC Document:*

ANSI/ASQC Z-1.15 Generic Guidelines for Quality Systems[4]

2.4 *TAPPI Standard:*

TAPPI T 441 Water Absorptiveness of Sized (Nonbibulous) Paper and Paperboard (Cobb Test)[5]

2.5 *United Nations Document:*

ST/SG/AC.10/1 Recommendations on the Transport of Dangerous Goods[6]

3. Terminology

3.1 *Descriptions of Terms Specific to This Standard:*

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

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

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

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

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

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

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

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

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

3.1.9 *inner receptacles*—receptacles which require an outer packaging in order to perform their containment function.

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

Current edition approved Nov. 10, 1989. Published December 1989.

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

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

[4] Available from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

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

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

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

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

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

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

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

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

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

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

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

4. Significance and Use

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

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

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

Packing Group I Substances presenting great danger
Packing Group II Substances presenting medium danger
Packing Group III Substances presenting minor danger

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

5. Test Specimens

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

6. Filling and Closure Procedures

6.1 *Liquids:*

6.1.1 Packagings intended for the containment of liquids shall be filled to 98 % of their maximum capacity with water at 23 ± 2°C (73 ± 4°F) for subsequent testing at normal and high temperatures unless otherwise specified.

6.1.2 Plastic packagings, with the exception of bags and expanded polystyrene boxes, intended for the containment of liquids shall be filled with a solution which remains liquid at −18°C (0°F) and has a minimum density of 1 g per cm^3 (specific gravity at least 1) for testing at low temperatures.

6.2 *Solids:*

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

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

7. Conditioning

7.1 Standard conditioning shall be at 23 ± 2°C (73 ± 4°F). For packagings fabricated from paper, paperboard, or fiberboard, conditioning shall be in accordance with Method D 685.

7.2 High temperature conditioning shall be at 40 ± 2°C (104 ± 4°F) in accordance with Practice D 4332.

7.3 Low temperature conditioning shall be at −20 ± 2°C, (−4 ± 4°F), in accordance with Practice D 4332.

7.4 The packaging, prepared as for testing, shall be conditioned for at least 7 min/L (qt) or/dm^3 (200 min/ft^3) of maximum capacity or 24 h whichever is longer. Longer times shall be used if necessary to ensure that packagings and contents reach equilibrium with the conditioning atmosphere and are maintained in that condition for a minimum of four hours.

8. Compatibility Test

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

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

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

8.4 *Criteria for Passing Test*—The packages shall show no evidence of stress cracking or crazing, oxidation, embrittlement, vapor pressure build-up, collapse of walls, seepage, or other defect likely to cause or indicate premature failure. The packaging shall pass the tests specified in 8.3.

9. Drop Test

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

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

9.3 *Test Preparation*—The packagings shall be filled and closed with the procedures specified in Section 6.

9.4 *Drop Height:*

9.4.1 For solids and liquids, if the test is performed with the solid or liquid to be carried, or with another substance having essentially the same physical characteristics, or for liquids if the test is performed with water and the intended liquid contents have a density not exceeding 1.2 g/cm^3 (specific gravity not exceeding 1.2), the drop height shall be as specified below:

	Packing Group I	Packing Group II	Packing Group III
Drop Height	1.8 m (70. 9 in.)	1.2 m (47.2 in.)	0.8 m (31.5 in.)

9.4.2 Where packagings are filled with water and the density of the intended liquid contents is more than 1.2 g/cm^3 (specific gravity more than 1.2), to obtain the drop height in meters, multiply the relative density (specific gravity) by 1.5 for Packing Group I products, by 1.0 for Packing Group II products or by 0.67 for Packing Group III products. Round up the drop height to the first decimal. See below:

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

9.5 *Test Procedure:*

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

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

9.5.3 *Fiberboard Drums*—Test six drums, conditioned in accordance with 7.1. Drop test three packages, one drop each, diagonally on the chime or, if the packaging has no chime, on a circumferential seam or edge. Drop test three additional packages, one drop each, on the weakest part not tested by the first drop, for example a closure. Perform drop tests in accordance with Test Method D 997 without the beam hazard.

9.5.4 *Plastic Drums, Plastic Jerricans, Plastic Composite Packagings*—Test six packages conditioned in accordance with 7.3. Drop test three packages, one drop each, diagonally on the chime or, if the packaging has no chime, on a circumferential seam or edge. Drop test three additional packages, one drop each, on the weakest part not tested by the first drop, for example a closure. Perform drop tests in accordance with Test Method D 997 without beam hazard if cylindrical in shape, or Test Method D 775 if rectangular in shape.

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

9.5.6 *Fiberboard Boxes*—Test five boxes, one for each drop, conditioned in accordance with 7.1. Drop individual boxes flat on bottom, top, one long side, one short side. Drop box diagonally on the manufacturer's joint bottom corner (5-2-3 corner). Perform drop tests in accordance with Test Method D 775.

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

9.5.8 *Paper Bags*—Test three bags, conditioned in accordance with 7.1, two drops per bag. First drop bags flat on face, followed by drop on end (valve end if applicable). Perform drop tests in accordance with Method D 959, without beam hazard.

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

9.5.10 *Composite Packagings, Plastic Receptacle with Outer Plywood Box*—Test five packages conditioned in accordance with 7.3. Perform tests specified in 9.5.5.

9.5.11 *Composite Packagings Plastic Receptacle with Outer Fiber Drum*—Test six packages, one drop per package. Perform tests specified in 9.5.3 except that conditioning shall be in accordance with 7.3.

9.5.12 *Composite Packagings Plastic Receptacle with Outer Fiber Box*—Test five packages, one drop per package. Perform tests specified in 9.5.6, except that conditioning shall be in accordance with 7.3.

9.5.13 *Composite Packagings Plastic Receptacle with Outer Steel Drum*—Test six packages, one drop per package. Perform tests specified in 9.5.2 except that conditioning shall be in accordance with 7.3.

9.5.14 *Combination Packagings*—Test packages as specified for the outer packaging, except that combination packagings with inner plastic packagings other than bags and expanded polystyrene boxes shall be conditioned in accordance with 7.3.

9.6 *Criteria for Passing Test:*

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

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

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

10. Stacking Test

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

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

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

10.4 *Test Preparation:*

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

10.4.2 Condition plastic drums, plastic jerricans, and plastic boxes intended for liquids and composite packagings consisting of plastic receptacles for liquids contained in outer plastic drums or plastic boxes in accordance with Practice D 4332 at 40 ± 2°C (104 ± 4°F) and test under those conditions.

10.4.3 Condition packages fabricated from fiberboard, paperboard, or paper including composite packagings with outer fiberboard packagings to 23 ± 1°C (73.4 ± 2°F) and 50 ± 2 % relative humidity, in accordance with Method D 685 or Practice D 4332 as applicable (see Section 7) and test under those conditions.

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

10.5 *Test Procedures:*

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

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

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

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

where:
w = gross weight of package (as shipped), in pounds,
h = height of package, in inches, and
F = force, in pounds.
Where a constant load is used, the mass of the constant load shall be not less than as calculated using the following formula:

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

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

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

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

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

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

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

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

11. Hydrostatic Test

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

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

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

11.3 Metal packagings and composite packagings (glass, porcelain, or stoneware) including their closures shall be subjected to the test pressure for 5 min.

11.4 Plastic packagings and composite packagings (plastic material) including their closures shall be subjected to the test pressure for 30 min.

11.5 The hydraulic pressure (gage), as determined by any one of the following methods, shall be:

(a) not less than the total gage pressure measured in the packaging (that is, the vapor pressure of the filling substance and the partial pressure of the air or other inert gases, minus 100 kPa) (14.5 psi) at 55°C (131°F)), multiplied by a safety factor of 1.5. This total gage pressure shall be determined on the basis of a maximum degree of filling such that the packaging shall not become liquid full at 55°C (131°F) and a filling temperature of 15°C (50°F);

(b) not less than 1.75 times the vapor pressure at 50°C (122°F) of the substance to be transported, minus 100 kPa (14.5 psi) with a minimum test pressure of 100 kPa (14.5 psi);

(c) not less than 1.5 times the vapor pressure at 55°C (131°F) of the substance to be transported, minus 100 kPa (14.5 psi) with a minimum test pressure of 100 kPa (14.5 psi).

11.6 In addition, packagings intended to contain substances of Packing Group I shall be tested at least to a minimum test pressure of 250 kPa (36.3 psi) (gage) for a test period of 5 or 30 min depending upon the material of construction of the packaging, in accordance with 11.3 or 11.4.

11.7 Alternative means of pressure testing, such as a vacuum chamber, may be used where applicable.

11.8 *Criteria for Passing the Test*—There shall be no leakage as evidenced by visible liquid on any external surface of the packaging or on the paper that was placed on the floor.

12. Leak Resistance Test

12.1 The leak resistance test shall be performed as a pre-production test on all types of packagings intended to contain liquids prior to production for use. For the pre-production test three samples per design type and manufacture shall be tested.

12.2 The leak resistance test shall be performed on each production packagings intended to contain liquids prior to first use and, after reconditioning, prior to reuse. For the production leak resistance test, the packagings need not have their own closures fitted.

12.3 Unless otherwise specified, the leakage test is not required for the inner packagings of combination packagings.

12.4 The leak resistance test shall be conducted in accordance with Annex A3.

12.5 The air pressure (gage) to be applied shall be:

Packing Group I	Packing Group II	Packing Group III
Not less than 30 kPa (4.4 psi)	Not less than 20 kPa (2.9 psi)	Not less than 20 kPa (2.9 psi)

12.6 *Criteria for Passing Test*—There shall be no evidence of leakage which is indicated by formation of air bubbles.

13. Water Resistance Test

13.1 The water resistance test shall be performed on all types of outer fiberboard boxes prior to initial use and, where specified, at periodic intervals.

13.2 Condition the fiberboard in accordance with Method D 685.

13.3 Perform the test on the specimens as specified in ISO 535 or TAPPI T 441.

13.3.1 The flutes in the test specimen may be crushed with a heavy roller or other suitable means to flatten them so a good ring seal can be achieved.

13.3.2 Expose the test material to the water for 30 min.

13.4 *Criteria for Passing*—The water absorption shall not exceed 155 g/m^2 (0.508 oz/ft^2).

14. Cooperage Test

14.1 The cooperage test shall be performed on bung type wooden barrels prior to initial use and, where specified, at periodic intervals.

14.2 Perform the cooperage test in accordance with Annex A4.

14.3 The increase in the cross section diameter, expressed as a percentage of the original diameter, shall not exceed 10 %.

15. Recommendations

15.1 It is recommended that for transportation of hazardous materials in packages in Canada and the United States that the additional tests as described in Appendix X1 be carried out.

16. Report

16.1 The report shall include the following:

16.1.1 Identification of the packagings using exploded view drawings or cross-sectional drawings, including detailed data on material construction of inner packagings and cushionings of combination packagings, inner receptacles of composite packagings, and data on closures.

16.1.2 Identification of contents as tested, including net and gross masses.

16.1.3 The degree of severity of the test: Packing Group I, Packing Group II, or Packing Group III.

16.1.4 Method of conditioning, if any, prior to each test, and whether the conditioning atmosphere was maintained during the test.

16.1.5 For compatibility test, the specific hazardous material tested, including concentration, the temperature and the duration of the test, the condition of the packaging prior to performance of the drop tests, the stacking test, and where applicable, the leak resistance pre-production and hydrostatic tests, and the results of these tests.

16.1.6 For drop tests, the orientation of each drop, the height of each drop, details of observed damage, and whether the packaging met the criteria for passing the test.

16.1.7 For the stacking test, the duration of the test, the force in newtons, whether a compression testing machine or a constant load tester was used, and whether the criteria for passing the test were met. When determined, the deflection shall be reported.

16.1.8 For the hydrostatic test, whether a vented closure was replaced or sealed, the test pressure, time of maintenance of the test pressure, the test pressure at failure where applicable, and whether the packaging met the criteria for passing the test. For Packing Group I packaging, whether the

actual closure was used in performing the test required in 11.4.6.

16.1.9 For the leak resistance pre-production test, whether a vented closure was replaced or sealed, the test pressure and whether the packaging met the criteria for passing the test.

16.1.10 For the leak resistance production test no test report is required.

16.1.11 For the water resistance test, the water absorption measured in grams per square meter (ounces per square foot).

16.1.12 For the cooperage test, the age of the barrel since manufacture in days, the diameter of the cross section of the barrel at the location of the head before the test, and after the test, the time to measurement after removal of the last hoop, the diameter measured after the test.

16.1.13 A statement to the effect that all tests were made in full compliance with the requirements of this standard, or noting any variations and detailing them.

16.1.14 The name and address of the testing agency, the date, and the signature of a responsible officer of the testing agency.

17. Precision and Bias

17.1 The precision and bias of this test method is dependent on those of the various test methods used and have not been expressly determined.

ANNEX

(Mandatory Information)

A1. Compatibility Test

A1.1 *Scope:*

A1.1.1 This test method determines the compatibility of a receptacle to the intended contents.

A1.1.2 *This test method involves hazardous materials. The method does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

A1.2 *Significance and Use*—This test method is used to determine permeability and compatibility of receptacles by filling packagings to rated capacity with the specific hazardous material and storing them at room temperature for at least 180 days, or as defined in A1.4.6.

A1.3 *Apparatus:*

A1.3.1 *A suitable storage area*, capable of maintaining the required minimum temperature, is required.

A1.3.2 The storage area must be suitable for storage of the particular hazardous materials involved.

A1.4 *Procedure:*

A1.4.1 Fill sufficient test packagings to perform the drop tests, stacking tests, leak resistance tests and, where applicable, the hydrostatic tests.

A1.4.2 Fill packagings with each of the actual substances and at the actual concentrations to be carried, and close with the procedures in Section 6.

A1.4.3 Weigh each package and record the initial gross mass.

A1.4.4 Inner packages must be placed in outer packagings.

A1.4.5 The packaging shall be subjected to a superimposed load as specified in Section 10.

A1.4.6 Store the test packages at room temperature, not less than 18°C (64°F) for at least 180 days, or at not less than 50°C (122°F) for 28 days, or at not less than 60°C (140°F) for 14 days. Any substance likely to become unstable at elevated temperatures shall be stored at not over 18°C (64°F) for 180 days. Appropriate precautions must be taken to ensure that filled packages are stored in a safe manner.

A1.4.7 At the end of the test period, weigh each package and record the gross mass after storage. Calculate the percentage gross mass loss or gain as a percentage of the original gross mass.

A1.4.8 Empty and rinse each package and examine the exterior and interior of each package for evidence of leakage or damage.

A1.5 *Precision and Bias*—The precision and bias of this test method have not been determined.

A2. Hydrostatic Test

A2.1 *Scope*—This test method determines the ability of a packaging to withstand internal positive pressure.

A2.2 *Significance and Use:*

A2.2.1 This test method is used to determine the ability of a packaging to withstand a positive internal pressure by subjecting the packaging to a hydrostatic pressure and observing for any leakage while under pressure.

A2.2.2 This test method is conducted on all packagings intended to contain liquids, except inner packagings of combination packagings which do not require testing unless otherwise specified. This test method consists of pressurizing three packagings hydrostatically to the specified pressure. While at this pressure, the packagings are inspected for leakage.

A2.3 *Apparatus:*

A2.3.1 *A pressure gage*, of laboratory precision quality (± 0.25 % full scale accuracy) with graduations not exceeding 5 kPa (0.5 psi).

A2.3.2 *Equipment*, to provide regulated hydrostatic pressure.

A2.3.3 *Fittings and plumbing*, required to hydrostatically pressurize the packagings.

A2.3.4 *Light-Colored Absorbent Paper.*

A2.3.5 *Water*, or other suitable liquid as the hydrostatic test liquid.

A2.4 *Conditioning*—This test method is performed while the packagings are at ambient temperature, except that packagings fabricated in part of fiberboard shall be prepared in accordance with A2.5, then conditioned as specified in 7.1 and tested without delay.

A2.5 *Test Preparation:*

A2.5.1 Vented closures shall be replaced with non-vented closures, or the vents shall be sealed.

A2.5.2 Install an appropriate fitting in the packagings in such a manner as not to affect the performance of the packaging.

A2.5.3 Completely fill the packaging, eliminating all air pockets, with water.

A2.5.4 Close the packagings as specified in Section 6 and connect the hydrostatic pressure supply to the test fitting in the packaging, making sure the system is completely filled with water.

A2.5.5 Completely dry all external surfaces of the packaging.

A2.5.6 Position the packaging in the center of a sheet of absorbent paper previously placed on the floor. The paper should be dry and extend at least 300 mm (12 in.) in all directions beyond the base of the package.

A2.6 *Test Procedure:*

A2.6.1 The manner in which the packagings are supported shall not invalidate the test.

A2.6.2 Hydrostatically pressurize the packagings at a rate of 25 kPa/min (3.6 psi/min) to the specified pressure and maintain for the specified time.

A2.6.3 At the end of the specified time and before the pressure is released, carefully inspect the packaging for evidence of leakage.

A2.6.4 Release the pressure and carefully inspect the paper and the bottom of the packaging for evidence of leakage.

A2.7 *Precision and Bias*—The precision and bias of this test method have not been determined.

A3. Leak Resistance Test

A3.1 *Scope*—This test method determines the resistance to leakage of a receptacle.

A3.2 *Significance and Use*—This test method is used to determine the leak resistance of a receptacle by subjecting it to a low positive internal air pressure and, by immersion or other means, detecting any leaks. It is used as a pre-production test and as a production test on all production packagings intended to contain liquids prior to first use and, after reconditioning, prior to reuse. Unless otherwise specified, this test is not required for the inner packagings of combination packagings.

A3.3 *Apparatus:*

A3.3.1 *A pressure gage*, of laboratory precision quality (± 0.25 % full-scale accuracy) with graduations not exceeding 5 kPa (0.5 psi).

A3.3.2 *Equipment*, to provide regulated air pressure.

A3.3.3 *A tank*, large enough to immerse the receptacle under test and which permits examination of all surfaces and seams of the receptacle while it is under constant air pressure to detect leakage by formation of bubbles.

A3.3.4 Any other apparatus capable of detecting the same threshold rate of leakage as is detected by the immersion method may be used.

A3.4 *Procedure (Pre-Production Tests):*

A3.4.1 Vented closure shall be replaced with non-vented closures or the vents shall be sealed.

A3.4.2 The packagings including their closures shall be restrained under water while the specified internal air pressure is applied. The method of restraint shall not affect the results of the test. Other methods at least equally effective may be used.

A3.4.3 The packagings shall be carefully examined for leakage as evidenced by a stream of bubbles.

A3.5 *Procedure (Production Tests):*

A3.5.1 Vented closures shall be replaced with non-vented closures or the vents shall be sealed.

A3.5.2 For the production leak resistance test the packagings need not have their own closures fitted.

A3.5.3 The packagings including their closures shall be restrained under water while the specified internal air pressure is applied.

A3.6 *Precision and Bias*—The precision and bias of this test method have not been determined.

A4. Cooperage Test

A4.1 *Scope*—This test method determines the stability of the cooperage of a wooden barrel.

A4.2 *Significance and Use*—This test method is used to determine the stability of the cooperage of a bung type wooden barrel by removing the hoops of the barrel above the bilge and measuring the tendency of the staves to straighten.

A4.3 *Apparatus—A flexible tape measure* or *ruler.*

A4.4 *Procedure:*

A4.4.1 Store the barrel for at least 48 h at ambient temperature and humidity prior to making initial measurements.

A4.4.2 Measure and record the diameter of the cross section of the barrel at the location of the head, to the nearest millimeter (0.04 in.).

A4.4.3 Remove all hoops above the bilge, starting with the hoop closest to the bilge, and progressing towards the head.

A4.4.4 Measure and record the diameter of the cross section of the barrel at the location of the head to the nearest

millimeter (0.04 in.), at least 5 but not more than 10 min after removal of the last hoop.

A4.5 *Precision and Bias*—The precision and bias of this test method have not been determined.

APPENDIX

(Nonmandatory Information)

X1. Other Test Procedures

X1.1 The procedures described in the text of the standard are to be considered a minimum requirement for adequate testing of packaging for hazardous materials. Additional test procedures should be conducted to evaluate the packaging as is suggested by shipping experience, improved packaging technology, and good engineering practice.

X1.2 A vibration test using an appropriate method in accordance with Methods D 999 is strongly recommended.

X2. Quality Assurance

X2.1 The test procedures described in this document are intended to be part of a more comprehensive quality assurance program for the packaging of hazardous substances. It is recommended that ANSI/ASQC Z-1.15 be consulted for basic guidance. This includes the consideration of subjects such as the inspection and control of raw materials and of packaging components, the periodic inspection and test of completed packaging based on sound statistical practice, and the monitoring of field performance.

X2.2 When this standard is referenced as part of a contract or purchase order or is referenced by a regulatory agency, quality assurance provisions such as an acceptance sampling plan or more detailed material and component descriptions may be included. Other provisions for a package to retain a "qualified" status may also be considered.

X3. Stacking Height

X3.1 The forces calculated for the stacking test are a minimum, based on top loading of similar packages. The package may be top loaded with heavier cargo. Consideration should be given to using a stacking force based on actual shipping experience.