



Standard Test Method for Environmental Stress Crack Resistance of Plastic Injection Molded Open Head Pails¹

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1. Scope

1.1 This test method provides procedures for an indication of the environmental stress crack resistance of plastic injection molded open head pails, covers, and components as a summation of the effects of container design, resin, manufacturing conditions, field performance, and other factors.

1.2 This test method may be used to evaluate a container's resistance to mechanical failure by cracking when in the presence of chemical and physical stresses.

1.3 Two procedures are provided as follows:

1.3.1 *Procedure A, Specified Stress-Crack Resistance Test Method*—This procedure is particularly useful for quality control since the conditions of the test are specified.

1.3.2 *Procedure B, User Selected Stress-Crack Resistance Test Method*—This procedure allows individual selection of test levels and is particularly useful as a design and development tool.

1.4 These procedures are not designed to test the ability of the cover gasketing material or closure to retain the test reagent. Loss or leakage of the reagent through these openings does not constitute container failure. However, this may indicate an internal pressure loss that might affect test results.

1.5 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.

1.6 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific warning statements are given in [6.2](#), [10.2.3](#), [10.2.4](#), [10.2.6](#), and [10.2.8](#).

¹ This test method is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.21 on Shipping Containers and Systems - Application of Performance Test Methods.

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2. Referenced Documents

2.1 *ASTM Standards*:²

D996 Terminology of Packaging and Distribution Environments

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

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

3. Terminology

3.1 *Definitions*—Reference Terminology D996 for definitions applicable to this test method.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *environmental stress crack*—an external or internal crack that develops when a container is exposed to chemical or physical stresses, or both.

3.2.2 *stress crack failure*—any environmental stress crack that causes a loss or leakage of the test reagent shall be interpreted as container failure.

4. Summary of Test Method

4.1 The environmental stress-crack resistance is determined by subjecting an injection molded open head pail and cover that is filled and sealed with a stress-crack reagent to a mechanical top load at elevated temperatures. The recommended minimum test duration shall be 14 days, or as specified by the user. The time to stress-crack failure is observed.

4.1.1 Procedure A exposes a minimum of three containers to specified levels of chemical and physical stresses.

4.1.2 Procedure B exposes containers to varying chemical and physical stresses based on the user's knowledge and objectives.

5. Significance and Use

5.1 These procedures provide an indication of the environmental stress-crack resistance of injection molded open head

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.

pails, covers, and components from a selected group or lot. Provided the thermal history of each container is constant, this test method may be used for determining the applicability of various plastic resins and mold designs for injection molding of open head pails and covers.

5.2 The environmental stress-crack that occurs is indicative of what results when a container is exposed to agents such as soaps, organics, or any surface active solutions while under environmental conditions of stress.

5.3 Environmental stress-cracking is a mechanism of chemical attack that is highly dependent upon the test reagent, resin, container manufacturing or processing history, exposure temperature, applied stress, and other factors. The combination of these factors may result in eventual stress-crack failure.

5.4 Procedure A minimizes the potential for test variability by providing the user with rigidly defined test conditions. This test method may be used for production quality control of injection molded open head containers.

5.5 Procedure B allows the user to select and evaluate extreme individual elements or the interaction of several test levels on container performance. These conditions are established based on laboratory experience and available knowledge of the distribution environment. This test method may be used for identifying critical stresses which could aid in container design or help in minimizing the occurrence of these stresses during distribution.

5.6 This test method is intended only as a pass/fail procedure in accordance with the user's specification, or as agreed upon between the user and the supplier. It is not intended as a predictor or indicator of field performance regarding time to failure.

6. Apparatus

6.1 *Environmental Chamber*—The environmental chamber should be capable of maintaining a temperature control of $\pm 2.5^\circ\text{F}$ ($\pm 1.4^\circ\text{C}$) of set point. For best circulation and a constant temperature throughout, a forced air system is recommended.

6.2 *Top Load*—Requires a pail identical to the test pail be filled to rated capacity or weight and then nested above the test pail. Free weights are then placed above in amounts necessary to equal the specified top load. A calibrated pneumatic or hydraulic cylinder may be substituted for the additional free weights. (**Warning**—The potential exists for catastrophic stress-crack failure causing an instability of the applied top load. Precautionary steps should be taken (that is, through restraining or guiding of the top load) to reduce the chance for injury to the operators or damage to the test chamber and surrounding test containers.)

7. Reagents

7.1 *Procedure A; Nonyl Phenoxypropyl (Ethyleneoxy) Ethanol Solution*—Prepare a 10 % solution, by volume, of the stress-cracking agent³ and water.

NOTE 1—Due to the viscosity of the stress-cracking agent, it is helpful to prepare the solution at an elevated temperature. A maximum temperature of 122°F (50°C) is an acceptable level provided caution is used to avoid prolonged heating and eventual volume losses.

7.2 *Procedure B*—Any reagent or proprietary product (liquid, solid, etc.) that is potentially a stress-cracking agent.

8. Sampling

8.1 A minimum of three containers are required for this test method. When possible for direct comparison, the test containers should be produced on the same equipment, including mold and under identical conditions from the same production lot. It is suggested that test container resin, machine, mold, and molding conditions be thoroughly documented to improve statistical reliability of the test data. (Practice E122.)

9. Conditioning

9.1 Condition empty test containers at $73 \pm 2^\circ\text{F}$ ($23 \pm 1.3^\circ\text{C}$) 50 ± 3 % relative humidity for 48 hours prior to testing (see Practice D4332).

10. Procedure

10.1 *Procedure A—Specified Stress-Crack Resistance Method:*

10.1.1 Place the environmental chamber set point control at $122 \pm 2^\circ\text{F}$ ($50 \pm 1.3^\circ\text{C}$) and allow it to reach equilibrium. Fill each test specimen to 98 % of the container's maximum volumetric capacity (with cover in place) with the test reagent. Apply the cover to the pail as specified by the manufacturer's closing instructions.

10.1.2 Place test specimens in the environmental chamber on an even horizontal surface. Place an identical pail filled to rated capacity with sand or water on top of each test specimen. Apply additional weight (if needed) to the top of the pail filled with sand or water to bring the total top load weight (sand or water pail plus weight) up to the values specified in Table 1. Record the time and date the test was started.

10.1.3 Inspect the test pails and covers daily for any evidence of stress-crack failure. Inspection of the cover may require the removal of the top load from the test container. Stress crack may be more easily detected by placing the pail on

³ The sole source of supply of the stress-cracking agent (nonyl phenoxypropyl (ethyleneoxy) ethanol solution, known as Igepal CO-630 (Antanox CO-630)) known to the committee at this time is Rhodia, Inc. Home, Personal Care and Industrial Ingredients, CN 7500, 259 Prospect Plains Road, Cranbury, NJ 08512-7500 (1888-776-7337). If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.

TABLE 1 Top Load Weight Requirements

Top Loads	
Pail Rated Capacity, gal (L) ^A	Top Load Weight, lb (kg)
3 (11.36)	120 (54.43)
4 (15.14)	160 (72.58)
5 (18.93)	200 (90.72)
6 (22.71)	240 (108.86)

^A For pails having a capacity other than those shown in Table 1, the top load is calculated using the following equation: capacity in gallons (litres) × 40 lb (4.792 kg) = top load in pounds (kilograms).

top of a moisture indicating medium, such as paper. The moisture indicating medium will allow the detection of small leaks that otherwise may evaporate. Record the time, date, and location of any failure that occurs.

10.2 Procedure B—User Selected Stress-Crack Resistance Method:

10.2.1 The following are individual elements that may attribute to the weakening of a polymer and eventual stress-crack failure. Use these guidelines in establishing and selecting test intensity levels.

10.2.2 *Container Production Techniques*—The processing methods involved with injection molding of a container may have an effect on environmental stress-crack resistance. Document all factors significant to the production of the test containers.

NOTE 2—Molded in stress resulting in warpage or dimensional changes can alter the chemical resistance of some polymers.

10.2.3 *Reagent*—Select a stress-crack agent or suspect product and fill each test container to 98 % of the container's maximum volume capacity. (**Warning**—If the containers are only partially filled, the potential exists for the development of excessive internal pressures that may affect test results and create unstable test conditions.)

NOTE 3—The concentration level of the reagent may affect the rate of chemical reaction.

10.2.4 *Container Preparation*—Apply the cover to the pail as specified by the manufacture's closing instructions (**Warning**—Some products may exhibit internal pressure as a result of exposure to high temperatures. Review the product Safety Data Sheet (SDS) and incorporate vented closures when required.)

10.2.5 *Temperature Level*—Select a temperature level based on desired test durations or measured environmental conditions. Set oven and allow it to reach equilibrium.

NOTE 4—The chemical attack of a polymer may be accelerated by exposure to high temperatures. The effects of humidity on a polymer are undetermined.

NOTE 5—When information about the environment is unknown, evaluate containers using levels expressed in Procedure A in 10.1.1.

10.2.6 *Test Surface*—Place test containers on a surface that is representative of shipment and storage conditions (for example, style of pallet). (**Warning**—An extreme test surface may cause catastrophic pail failure. Care should be taken to prevent reagent spillage and ensure top load stability.)

NOTE 6—When information about the distribution surface is unknown, evaluate containers on a flat, horizontal surface.

10.2.7 *Applied Top Load*—Select a top load representative of the specific gravity or density of the intended lading and the maximum container stack height achieved during warehousing. This value is calculated using the following formula:

Determination of Top Load:

$$W = \frac{H}{h} - 1 \times (C \times S.G. \times 8.34 \text{ lb/gal}) + T.W. \quad (1)$$

where:

- H* = required stack height, in.,
- h* = height of one container, in.,
- C* = container capacity, gal,
- S.G.* = specific gravity of product,
- T.W.* = sample tare weight, lb, and
- W* = constant top load weight, lb.

or:

$$M = \frac{H}{h} - 1 \times (C \times S.G. \times 1.00 \text{ kg/L}) + T.W. \quad (2)$$

where:

- H* = required stack height, mm,
- h* = height of one container, mm,
- C* = container capacity, L,
- S.G.* = specific gravity of product,
- T.W.* = sample tare weight, kg, and
- M* = constant top load mass, kg.

10.2.7.1 With the top load determined, place an identical pail filled with sand, water, test reagent, or product on top of each test container. Apply additional weight to reach the calculated top load value. Record the time and date the test was started.

NOTE 7—When the product specific gravity or maximum container stack height are unknown, select a top load value as specified in Procedure A in 10.1.2, and in Table 1.

10.2.8 *Frequency of Evaluation*—Select a method of evaluation based on test data requirements (for example, “Pass/Fail,” etc ...). Inspection is performed by removal of top load at predetermined intervals or by visual inspection only. (**Warning**—Avoid operator injury during top load removal by providing the inspector with protective clothing.)

NOTE 8—Test results may be affected by removing the top load (release of any built up internal pressure), improper reneating of test containers, placing a container on its side during inspection causing a coating of the cover with reagent, if manual external pressure is applied during inspection, or if concentration of the test reagent increases during the test due to evaporative loss.

10.2.9 *Test Duration*—Select a duration for the test containers exposure to the chemical and physical stresses by using internal or in-house requirements and test objectives.

11. Report

11.1 Report the following information:

11.1.1 Procedure used (Procedure A or B).

11.1.2 Complete description of the containers tested, including resin properties, injection molding conditions, pigment loading levels, percent of regrind resin, percent of post consumer resin, and any other available information.

11.1.3 Number of containers tested.

- 11.1.4 Reagent or product description.
- 11.1.5 Temperature conditioning levels.
- 11.1.6 Applied top load value.
- 11.1.7 Method and frequency of evaluation for stress-crack failure.
- 11.1.8 Days to failure for each test container.
- 11.1.9 Location and types of failures.
- 11.1.10 Detailed description of pass/fail criteria and how the test specimens performed to the criteria.
- 11.1.11 Description of the top load used for the test set up.

12. Precision and Bias

12.1 *Procedures A and B*—No statement is made about either the precision or bias of this test method for measuring environmental stress-crack resistance since the results merely state whether there is conformance to the criteria for success specified in the procedure.

13. Keywords

13.1 injection molded pails; plastic container; plastic pails; stress cracking

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