



Standard Test Method for Drop Testing of Glass Aerosol Bottles¹

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1. Scope

1.1 This test method covers the determination of the acceptability of a bottle design in a glass container for packaging a given aerosol formulation by drop testing.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Summary of Test Method

2.1 The arithmetic mean height of a specific glass aerosol bottle design is determined by dropping the bottles, loaded with the given formulation.

2.2 Dropping an additional group of similarly filled bottles at the arithmetic mean height provides a means of evaluating any potential bursting hazard of the final package, incorporating factors of bottle design, formulation, loading techniques, etc.

3. Definition

3.1 *break*—ruptured bottle no longer usable. In plastic-coated bottles, glass ruptures, even though the plastic coating remains intact.

4. Apparatus

4.1 *Drop Surface*, consisting of a 12 by 12-in. (305 by 305-mm) square steel plate, ¼ in. (6.4 mm) thick, imbedded in an 18 by 18-in. (457 by 457-mm) square concrete pad, 2 in. (51 mm) thick.

4.2 *Dropping Mechanism*, consisting of a rubber stopper with a ½-in. (13-mm) hole, connected to a suitable vacuum system (for example, a vacuum pump, laboratory line vacuum, or water aspirator) to hold the bottles above the drop surface. The line connecting the stopper with the vacuum system shall be provided with a three-way stopcock to release the vacuum. The rubber stopper shall be fastened by any suitable means above the dropping surface in such a position that the falling bottle will land as near as possible to the center of the dropping surface.

¹ This test method is under the jurisdiction of ASTM Committee D-10 on Packaging and is the direct responsibility of Subcommittee D10.32 on Consumer Packages. Originally developed by the Chemical Specialties Manufacturers Assn.

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4.2.1 Several rubber stoppers, with ½-in. (13-mm) hole, will be needed for the various shapes of the bottles to be tested. A stopper with a flat surface will be suitable for flat bottles, while stoppers with curved surfaces cut into them will be necessary to obtain a tight seal for bottles having other shapes.

4.2.2 Other mechanisms that give equivalent control of the drop positions may be substituted for the vacuum system.

4.3 *Air Ovens*, two, maintained at 70 and 100°F (21 and 38°C).

5. Sampling

5.1 Samples shall be selected at random from the production batch.

6. Test Specimens

6.1 A total of 75 bottles, maintained at either 70 or 100°F (21 or 38°C), shall be tested from one given drop position.

7. Conditioning

7.1 Place the bottles to be tested in the air ovens for a minimum of 3 h prior to testing.

8. Procedure

8.1 During Development Stage:

8.1.1 Place a bottle in position against the rubber stopper at the terminal of the vacuum system. Open the vacuum system to atmospheric pressure by means of the three-way stopcock, allowing the vacuum to be released and the bottle to fall to the drop surface from a height of 6 ft (1.8 m).

NOTE 1—Take care to position and release the bottles properly, to prevent twisting and rotation in the air as the bottle falls.

8.1.2 Repeat 8.1.1 with the remaining bottles, dropping each bottle only once, as follows:

8.1.2.1 If the first bottle breaks, drop the next bottle from a height of 4 ft (1.2 m). If this bottle breaks, drop the next bottle from 2 ft (0.6 m).

8.1.2.2 If the third bottle does not break, drop the next bottle from 4 ft (1.2 m). If the fourth bottle breaks, drop the next bottle from 2 ft (0.6 m).

8.1.2.3 Continue this pattern throughout the testing of the 75 bottles.

NOTE 2—The drop schedule is based on a statistical design known as

the “up and down” method of sensitivity testing.² If a bottle breaks at a given height, the next bottle is dropped from a height one interval lower. If a bottle does not break, the next bottle is dropped from a height of one interval higher.

8.1.2.4 The interval between adjacent drop levels, d , is 2 ft (0.6 m) (that is, drop levels are at 2, 4, 6, 8, 10 ft (0.6, 1.2, 1.8, 2.4, 3 m), etc. For statistical purposes, the schedule for drop heights must be followed exactly. If, due to ceiling limitations, it is impossible to use very high drop heights, it is permissible to stop at a maximum height of approximately 14 or 16 ft (4.3 or 4.9 m).

8.1.3 Record for each drop height the number of bottles that break, and the number of bottles that did not break. Tabulate these data in accordance with the following sample table, a summary of drop data:

Height, ft (m)	Number of Bottles That Break	Number of Bottles That Do Not Break
10 (3)	2	0
8 (2.4)	22	2
6 (1.8)	11	23
4 (1.2)	2	11
2 (0.6)	0	2
Total	37	38

8.1.3.1 The values in the sample table must meet this test: the number of breaks at any given height must be equal to, more than, or one less than the number of “no breaks” at a height of one interval, d , lower.

8.1.3.2 In the table it is seen that no bottles broke at 2 ft (0.6 m), 2 bottles broke at 4 ft (1.2 m), 11 at 6 ft (1.8 m), 22 at 8 ft (2.4 m), and 2 at 10 ft (3 m). If a bottle breaks at 2 ft, it is proper to record the next bottle as a “no break” at 0 ft, and to set it aside as if it had been dropped.

8.1.3.3 The total number of breaks (37) is one less than the total number of “no breaks.” Therefore, the breaks are referred to as the less frequent event. If, however, there are more breaks than “no breaks,” the “no breaks” are referred to as the less frequent event.

8.1.4 Record the data for the less frequent event in accordance with the following sample table for drop test statistical data:

i	n_i	in_i
3	2	6
2	22	44
1	11	11
0	2	0
Totals	$N = 37$	$A = 61$

8.1.4.1 The values of i are 0, 1, 2, 3, etc., where $i = 0$ is the lowest height at which breaks occur (for example, 4 ft (1.2 m)), $i = 1, 2, 3$, etc., are increasingly higher levels at which the breaks occurred, and n_i values are the frequency or number of breaks at each level of i . Multiply i by n_i to obtain the in_i values. Add the in_i values to obtain the sum, A .

² Dixon, W. J. and Massey, F. J., Jr. *Introduction to Statistical Analysis*, Chapter 19, McGraw-Hill Book Co., Inc., 1952.

Eisenhart, Churchill, et al. *Selected Techniques of Statistical Analysis*, McGraw-Hill Book Co., Inc., 1974, p. 341.

8.1.5 Calculation:

8.1.5.1 Calculate the arithmetic mean height, X , as follows:

$$\begin{aligned}
 X &= y^1 + (A/N) + \frac{1}{2}d \\
 &= 4 + (61/37) - \frac{1}{2}(2) \\
 &= 4 + 1.65 - 1 \\
 &= 4.65 \text{ ft}
 \end{aligned} \tag{1}$$

where:

y^1 = lowest height at which the less frequent event occurred, ft, and

N = sum of n_i values.

8.1.5.2 The plus sign is used when the equation is based on “no breaks” and the minus sign is used when the equation is based on breaks.

8.1.6 In the initial testing of a new aerosol bottle (formulation, design, etc.) data are first collected to determine the weakest and most vulnerable position of the bottle. In most cases, the number of drop positions is determined by the bottle design. One position is the bottle bottom. Other positions depend on the wall shape. If the bottle is symmetrically designed, there is only one drop position on the side. If the bottle is elliptical or some other shape nonsymmetrical with respect to its longitudinal axis, there are at least two side drop positions; one on the edge and one on the flat side.

8.1.6.1 Repeat 8.1.1-8.1.5.2 for each remaining possible drop position.

8.1.6.2 Select the weakest and most vulnerable position as that position corresponding to the lowest value of the arithmetic mean height, X_a .

8.1.7 It is apparent that there will be cases where an aerosol container may break, and still may not present a consumer hazard. Assess this hazard, in relation to the extent of flying glass or other fragments which are projected from the broken container, as follows:

8.1.7.1 At random, select 200 additional containers, and place 100 in the oven maintained at 70°F (21°C) and 100 in the oven maintained at 100°F (38°C) for a minimum of 3 h.

8.1.7.2 Drop each container only once from a constant drop height, which is set at a height equal to the arithmetic mean height, X_a , corresponding to the weakest point, or 6 ft (1.8 m), whichever is lower.

8.1.7.3 Record the number of “no breaks,” number of breaks, and the number of breaks that project flying fragments from the container in accordance with the following sample table:

	70°F (21°C)	100°F (38°C)
Total bottles dropped from arithmetic mean height X_a ft (m) (or 6 ft (1.8 m), whichever is lower)	100	100
Number of nonbreaks	50	50
Number of breaks	50	50
Number of the breaks that project flying fragments	2	4

8.1.7.4 With the data from 8.1.7.3, the loader, seller, etc., will be in a position to decide for himself whether or not the formulation and container constitute a package that meets his safety standards.

8.2 Testing During Production:



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