



Standard Test Method for Drop Impact Resistance of Blow-Molded Thermoplastic Containers¹

This standard is issued under the fixed designation D 2463; 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

1.1 This test method provides measures of the drop impact resistance of blow-molded thermoplastic containers as a summation of the effects of material, manufacturing conditions, container design, and perhaps other factors.

1.2 Three procedures are provided as follows:

1.2.1 *Procedure A, Static Drop Height Method*—This procedure is particularly useful for quality control since it is quick.

1.2.2 *Procedure B, Bruceon Staircase Method*—This procedure is used to determine the mean failure height and the standard deviation of the distribution.

1.3 The values stated in SI units are to be regarded as standard. The inch-pound units given in parentheses are for information only.

NOTE 1—There is no similar or equivalent ISO standard.

1.4 *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. Referenced Documents

2.1 ASTM Standards:

B 177 Practice for Chromium Electroplating on Steel for Engineering Use²

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method³

2.2 Society of Plastics Industry Standard:

PBI-4 Test for Drop Impact Resistance of Plastic Bottles⁴

¹ This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.20 on Plastic Products.

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² *Annual Book of ASTM Standards*, Vol 02.05.

³ *Annual Book of ASTM Standards*, Vol 14.02.

⁴ Available from the Society of the Plastics Industry, Inc., 1295 K Street, N.W., Washington, DC 20005.

3. Terminology

3.1 Definitions:

3.1.1 *failure*—any rupture visible to an observer with the unaided eye and normal eyesight is considered a failure. Any evidence of contained liquid on the outside of the container through any aperture other than the molded opening is also a failure. Container should be squeezed gently after impact to determine any pinhole type failures. If a cap pops off during impact, consider that sample as a NO TEST and replace the sample with another container.

4. Summary of Test Method

4.1 The drop impact resistance is determined by dropping conditioned blow-molded containers filled with water from a platform onto a prescribed surface. Data developed with a water-filled container may not be representative of what might be expected with a carbonated liquid, an aerosol pack, a product of high specific gravity, or a powder of low bulk density.

4.1.1 *Procedure A* consists of dropping at least 20 containers from a fixed height and reporting the percent failures.

4.1.2 *Procedure B* consists of dropping at least 20 test containers from varying heights above and below the mean failure height of the set. A mean failure height and standard deviation are then calculated from the data.

5. Significance and Use

5.1 These procedures provide measures of the drop impact resistance of the group or lot of blown containers from which the test specimens were selected.

5.2 These procedures may be used for routine inspection purposes.

5.3 These procedures will evaluate the effect of construction, materials, and processing conditions on the impact resistance of the blown containers.

5.4 Before proceeding with this test method, reference should be made to the specification of the material being tested. Any test specimen preparation, conditioning, dimensions, or testing parameters, or combination thereof, covered in the

materials specification shall take precedence over those mentioned in this test method. If there are no material specifications, then the default conditions apply.

6. Apparatus

6.1 *Drop Testing Machine*⁵ (see Fig. 1), having the following features:

6.1.1 A platform (see Fig. 2) upon which to set the test specimens, which can be raised or lowered either manually or by means of an electric motor.

6.1.2 The platform shall be adjustable so that it may be leveled but shall also be stable so that it will not tilt under the weight of the test specimen.

6.1.3 The platform should be spring-loaded so that upon release it will move rapidly out of the path of the test specimen and will not interfere with its fall.

6.1.4 A manually or electrically operated platform release mechanism that will hold the platform securely when being loaded but will release the platform instantaneously and will not interfere with its path of travel.

6.2 A surface on which the containers are dropped consisting of a flat hot-rolled steel plate, or equivalent, with minimum dimensions of 1000 mm by 1000 mm by 13 mm (36 in. by 36 in. by ½ in.) having an unpolished chrome-plated surface, plated in accordance with Practice B 177, and securely attached to an industrial concrete surface or floor, so that the line of drop of the containers is perpendicular to the chrome-plated surface.

⁵ Suitable equipment may be purchased from Custom Scientific Instruments, Inc., 13 Wing Drive, Whippany, NJ 07981. Detail drawings of this apparatus are available at a nominal cost from ASTM. Order Adjunct: ADJD2463.



FIG. 1 Apparatus for Dropping Containers

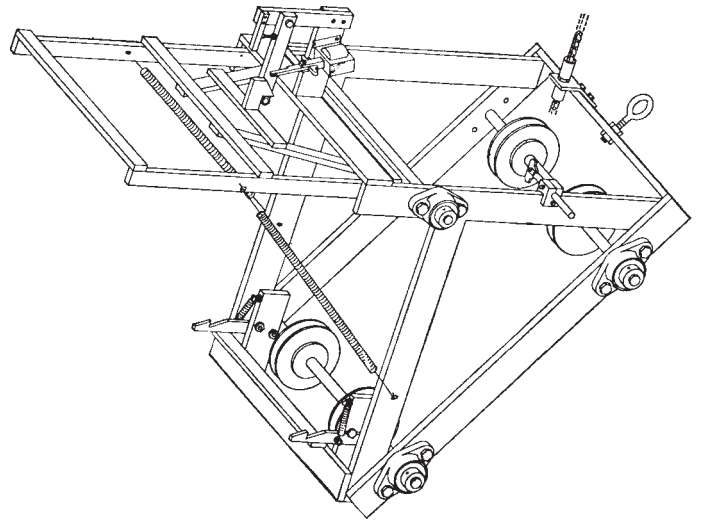


FIG. 2 Platform Assembly

6.3 A means of measuring the height of the platform above the impact surface.

NOTE 2—If a more stringent impact test is desired, a positioning jig capable of holding a test container at the proper angle for a 45° angle impact may be securely fastened to the platform. When such a jig is used, the drop height must be measured from the lowest part of the container. Precision data are not available for testing under these conditions.

7. Test Specimens

7.1 A minimum of 20 containers shall be selected so they are representative of the lot being tested for any one of the test procedures. These shall be fitted with suitable closures.

8. Preparation of Apparatus

8.1 Periodically, or before each test series, the platform of the drop impact machine may need to be adjusted to ensure that the specimen will strike the impact area squarely on the desired surface. If this is necessary, use the following procedure:

8.1.1 Move the platform to the approximate mean failure height of the containers to be tested with a specimen on the platform in the desired position.

8.1.2 Release the platform allowing the specimen to fall onto the impact surface.

8.1.3 Take a snapshot picture of the container just before it strikes the impact surface. Two photographs should be taken at right angles to each other to ascertain that the container impacts as desired—front to back and side to side. The position of the container relative to the impact surface as it appears in the photographs will indicate whether or not adjustments in the platform are necessary.

NOTE 3—The camera should be set up approximately 300 mm (12 in.) above and 1800 mm (72 in.) from the impact area.

NOTE 4—The camera⁶ from which prints are immediately available is most suitable.

8.1.4 Make adjustments in the platform and repeat the procedure as specified in 8.1.3 as necessary.

⁶ A Polaroid Land Camera available from the Polaroid Corp., 741 Main St., Cambridge, MA, is suitable for this purpose.

8.1.5 With certain drop testing machines, it may also be necessary to check the position at impact both above and below the approximate mean failure height.

9. Conditioning

9.1 Fill containers with tap water to their nominal fill capacity and condition them uncapped for 24 h at $23 \pm 2^\circ\text{C}$ ($73 \pm 3.6^\circ\text{F}$).

9.2 If the test is intended for immediate quality control, fill the containers with room temperature water and test at that temperature. A correlation should have been previously developed by the testing laboratory between this type of test and that requiring 24-h conditioning.

NOTE 5—Conditioning temperatures other than $23 \pm 2^\circ\text{C}$ may be used if desired, provided such conditioning is reported and adequate precautions are taken to ensure the containers are at that temperature during testing.

10. Procedure

10.1 Procedure A:

10.1.1 Set the platform at the test height of interest.

10.1.2 Drop at least 20 containers individually recording failures and non-failures.

10.2 Procedure B:

10.2.1 This procedure, used to determine the mean failure height of the test specimens, is called the “Up and Down” or Bruceton Staircase Method.⁷ It consists of dropping a set of test specimens from various heights, the drop height being raised or lowered depending on the result obtained on the specimen most recently tested; that is, if the previous specimen failed, the drop height is lowered; if the previous specimen did not fail, the drop height is raised.

10.2.2 Drop the first test container from 300 mm (12 in.) below the expected mean failure height. If the mean failure height is unknown several trial samples should be tested via the staircase procedure to obtain at least two failures and two non-failures to establish the starting height.

10.2.3 If the first test container dropped did not fail, drop the second container from a height of 300 mm (12 in.) higher. If the first container failed, drop the second container from a height of 300 mm (12 in.) lower.

10.2.4 Continue the testing until a minimum of 20 test containers have been dropped, raising or lowering the platform one interval (300 mm (12 in.)) depending on the results obtained on the most recently tested container.

10.2.5 Record the drop height and the results (failed or did not fail) on each container tested.

10.2.6 The increment in height of drop may be more or less than 300 mm (12 in.). In such cases, the appropriate increment must be reported and used in the calculations in 11.2.

11. Calculations

11.1 Procedure A:

11.1.1 The percentage failures is calculated as follows:

$$\text{Failure, \%} = (X/N) \times 100$$

where:

X = number of failures, and
 N = number of containers tested.

11.2 Procedure B (see X1.1 and Table X1.2 for clarification):

11.2.1 Mean Failure Height—Calculate the mean failure height from the test data obtained from Procedure B as follows:

$$h = h_o + d[(A/N) \pm 1/2]$$

where:

h = mean failure height,
 d = increment in height of drop,
 N = number of failures or non-failures whichever is lesser,
 h_o = lowest height at which any one of N occurs, and
 A = $\sum_{i=0}^{i=k} in_i$ where h_o, h_1, h_2, h_3 , etc., are the heights in progressive order of magnitude in the range of heights where N occurs, i is the subscript of h , and n is the number of failures or non-failures, whichever is pertinent at the level of i . The negative sign is used in the parentheses to calculate h when N refers to failures and the positive sign when N is the number of non-failures.

11.2.2 Standard Deviation—Calculate the estimated deviation of the individual measurements from:

$$s = 1.620d \frac{NB - A^2}{N^2} + 0.029$$

where:

d, N , and A are as in 11.2.1 and

$$B = \sum_{i=0}^{i=k} i^2 n_i$$

12. Report

12.1 Report the following information:

12.1.1 A complete description of the containers tested including size, style, material, method of processing, weight, date of manufacture, lot number, and any other information that would be important.

12.1.2 Description of contents if other than water, conditioning period, and temperature if other than $23 \pm 2^\circ\text{C}$ ($73 \pm 3.6^\circ\text{F}$).

12.1.3 The number of containers tested.

12.1.4 The test procedure used and the following:

12.1.4.1 For Procedure A:

(1) Percentage of failures and the drop height.

12.1.4.2 For Procedure B:

(1) Calculated mean failure height,

(2) Estimated standard deviation,

(3) Increment in height of drop,

(4) Lowest drop height at which a container failed, and

(5) Highest drop height at which a container did not fail.

NOTE 6—(4) and (5) of 12.1.4.2 indicate the range over which the containers were tested.

⁷ See Dixon, W. J., and Massey, F. J., Jr., *Introduction to Statistical Analysis*, Second Edition, McGraw-Hill Book Co., Inc., New York, NY, 1957, Chapter 19.

13. Precision and Bias ⁸

13.1 An interlaboratory study was conducted using PVC bottles from one manufacturer. The average between-laboratory coefficients of variation were as follows:

- Procedure A 46%
- Procedure B 38%
- Procedure C 20%

13.2 An interlaboratory study was conducted using PE bottles from one manufacturer. The average between-laboratory coefficient of variation using Procedure B was 16 %.

13.3 An interlaboratory study (seven laboratories) was conducted by the Test Methods Subcommittee of the Plastics Bottle Institute of the Society of the Plastics Industry using one size of PVC bottles and two sizes of PE bottles. The testing was conducted as described in Technical Bulletin PBI-4. The

procedure in PBI-4 is equivalent to Procedure A of this test method. The results are as follows:

Bottle, oz	Material	Drop Height, ft	Values expressed as % Failed Based on 20 Bottles				
			Average	<i>S</i> (<i>r</i>)	<i>S</i> (<i>R</i>)	<i>I</i> (<i>r</i>)	<i>I</i> (<i>R</i>)
7.5	PVC	4	41.1	13.6	15.2	38.6	43.0
64	HDPE	5	65.5	11.3	22.1	31.9	62.5
128	HDPE	6	33.8	7.7	12.8	21.8	36.2

S(*r*) is the pooled within laboratory standard deviation of the average of 20 determinations. *S*(*R*) is the total among laboratory standard deviation of the average of 20 determinations. *I*(*r*) = 2.83 *S*(*r*), and *I*(*R*) = 2.83 *S*(*R*). The data was analyzed using Practice E 691. Other materials or bottles, or both, may give somewhat different results.

NOTE 7—The above values are greatly influenced by testing bottles made in several cavities as if they came from a single population that has been found, in many cases, not to be true. Therefore, if bottles from only one cavity are tested, the repeatability is expected to be considerably lower than the above values.

14. Keywords

14.1 blow-molded containers; drop impact; plastic containers

⁸ The round-robin data may be obtained from ASTM Headquarters. Request RR: D20-1045.

APPENDIX

(Nonmandatory Information)

X1. SAMPLE CALCULATIONS

X1.1 Procedure B

X1.1.1 Test results and calculations can be done as in Table X1.1.

TABLE X1.1 Procedure B

Drop Height, ft	Outcome of Test (X = failure; 0 = non-failure)																				<i>n_x</i>	<i>n_o</i>	<i>i</i>	<i>n_i</i>	<i>in_i</i>	<i>i²n_i</i>	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20							
5	0				0		0												0		0	4	
6		0		X		X		0		0			0							X	4	4	0	4	0	0	0
7			X						X		0		X		0				X		4	2	1	4	4	4	4
8												X				X					2	0	2	2	4	8	8
	Totals																				10 (<i>N_x</i>)	10 (<i>N_o</i>)	...	10 (<i>N</i>)	8 (<i>A</i>)	12 (<i>B</i>)	

Ten failed and ten did not fail so either failures or non-failures may be used in the calculation. This illustration has been based on failures (negative sign used).

$h_o = 6, N = N_x = 10, d = 1$
 $h = h_o + d(A/N - 1/2)$
 $h = 6 + 1(8/10 - 1/2) = 6.3 \text{ ft}$
 $s = 1.62d((NB - A^2/N^2) + 0.029)$
 $s = (1.62)(1) ((10)(12) - (8)(8)/(10)(10) + 0.029) = 0.95 \text{ ft}$

TABLE X1.2 Procedure C

Height of Drop, ft	Number Failing	Percent Failing	Cumulative % Failing
3	3	15	15
4	2	10	25
5	3	15	40
6	4	20	60
7	5	25	85
8	3	15	100

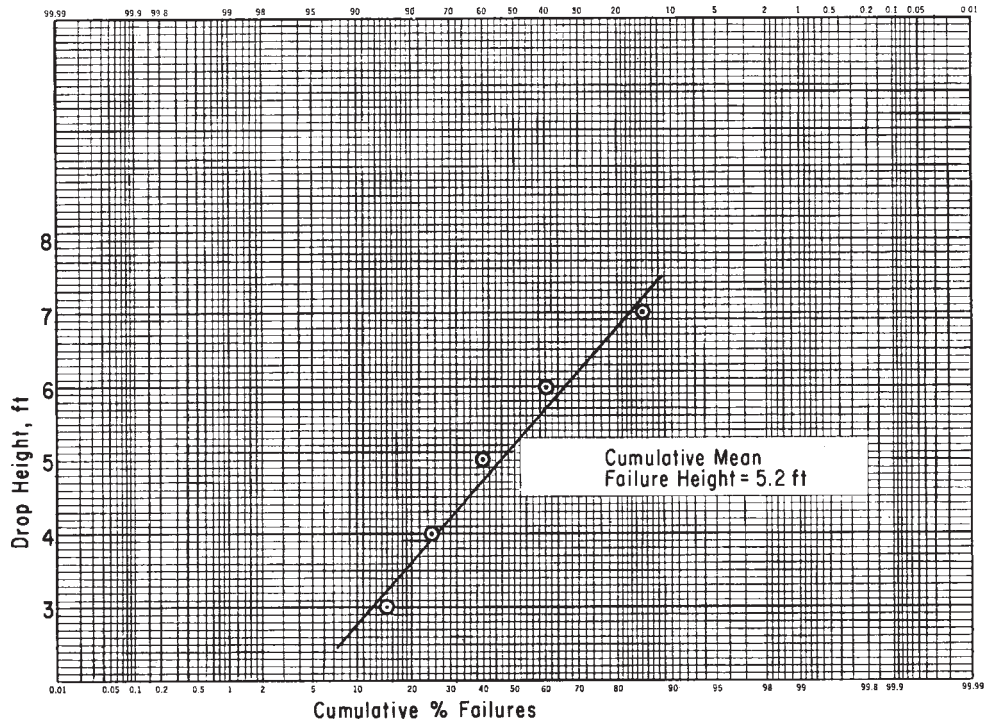


FIG. X1.1 Cumulative Mean Failure Height by the Graphic Method

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