Designation: D 4495 – 9800

An American National Standard

Standard Test Method for Impact Resistance of Poly(Vinyl Chloride) (PVC) Rigid Profiles by Means of a Falling Weight[1]

This standard is issued under the fixed designation D 4495; 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 covers the determination of the energy required to crack or break rigid poly(vinyl chloride) (PVC) profile under specified conditions of impact by means of a falling weight.

1.2 This test method may is able to be used by itself or in conjunction with other methods of measuring PVC product toughness.

1.3 Because of the wide variety of profile sizes and shapes and the wide variety of manufacturing procedures and field abuse, this test method may does not correlate universally with all types of abuse. Therefore, correlations must be established as needed.

1.4 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this standard.

1.5 The values stated in inch-pound units are to be regarded as the standard.

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

1.6 *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:*

[1] This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommitte D20.24 on Plastic Building Products.
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*A Summary of Changes section appears at the end of this standard.

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]
D 883 Terminology Relating to Plastics[2]
E 178 Practice for Dealing with Outlying Observations[3]

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology D 883, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *failure*— the presence of a brittle failure readily visible by the naked eye, including a sharp crack, split, or shatter in any part of the profile as a result of the impact of the falling weight. Failure does not include ductile tears (where the surfaces at the tip of the crack have a greater than 0° angle), or ductile breaks (hinged breaks where the cracked part remains joined to the unbroken part throughout the length of the cracked part or section), (Fig. 1).

3.2.2 *mean failure height*—the height from which the falling weight will cause 50 % of the specimens to fail.

3.2.3 *mean failure energy*—energy required to produce 50 % failures. The product of the weight and mean failure height.

3.2.4 *outlier*—an observation that appears to deviate markedly from other members of the sample in which it occurs.

4. Summary of Test Method

4.1 The profile is cut into lengths of at least 6 in. The test method establishes the height from which a standard falling weight will cause 50 % of the specimens to fail.

[2] *Annual Book of ASTM Standards*, Vol 08.01.
[3] *Annual Book of ASTM Standards*, Vol 10.03.

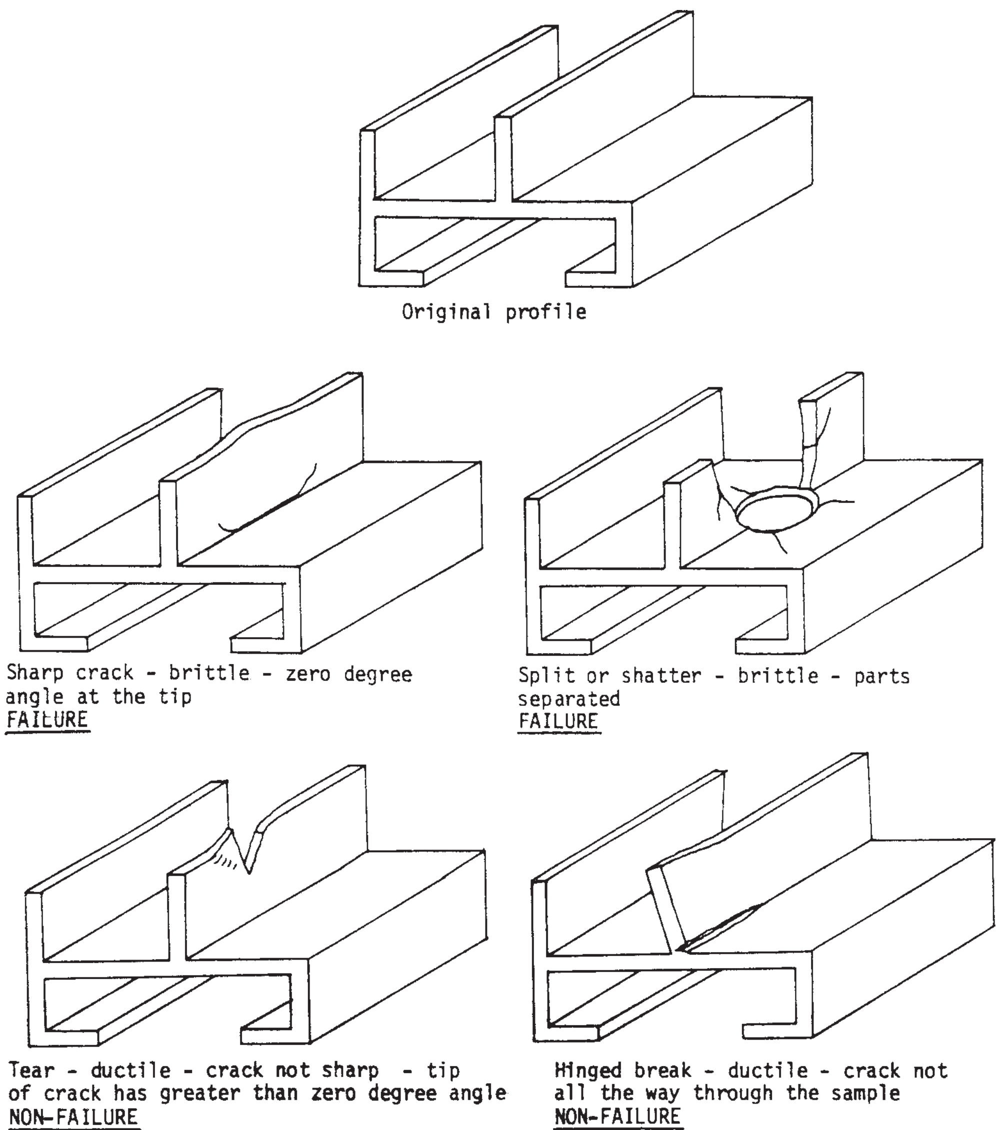

FIG. 1 Types of Breaks

5. Significance and Use

5.1 The impact strength of PVC profiles relates to suitability for service and to quality of processing. Impact tests are used for quality-control purposes and as an indication that products can withstand handling during assembling, installation, or in service.

5.2 Results obtained by use of this test method can be used in two ways:

5.2.1 As the basis for establishing impact-test requirements in product standards, and

5.2.2 To measure the effect of changes in materials or processing.

6. Apparatus

6.1 *General*—One type of impact tester is illustrated in Fig. 2.

6.2 *Falling Weight*, shall be cylindrical and 2 ½ in. in diameter, with a flat-bottom surface that strikes the test specimen.

NOTE 2—It is suggested that the striking portion of the weight be made of scratch-resistant steel to reduce damage to the striking surface. Badly scarred surfaces may affect test results.

6.2.1 The mass of the falling weight shall be 10 ± 0.5 lb.

6.3 *Drop Tube*, shall be of sufficient length (approximately 12 ft (4 m)) to provide for a fall of at least 10 ft (3 m) and shall be mounted so that the lengthwise direction is vertical, as measured with a plumb bob or a spirit level at least 2 ft (600 mm) in length.

6.3.1 Care must be taken to ensure that the weight falls freely; it must not "chatter" down the tube.

NOTE 3—No particular material for the drop tube is specified. However, a cold-drawn seamless steel tubing with an inside diameter of 2 ⅝ to 2 ¾ in. (67 to 70 mm) has been found to be satisfactory. It may also be necessary to provide a protective barrier around the specimen, particularly for larger sizes of profile, to protect the operator from flying broken pieces.

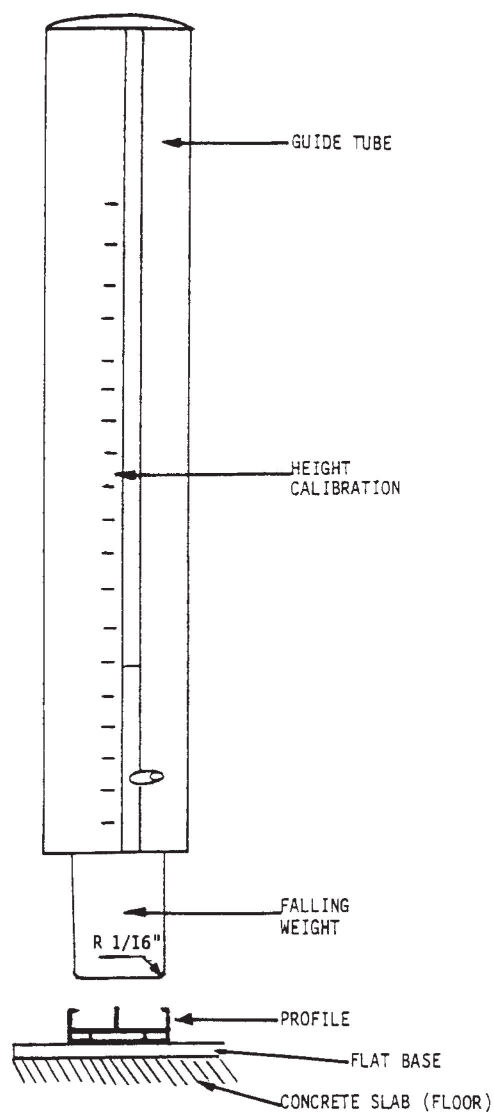

FIG. 2 Testing Apparatus

NOTE 4—The dropped weight may not fall freely if the clearance between the weight and tube is too large or too small, or if it is restrained by a partial vacuum above the weight, such as can be caused by the hold and release device.

6.3.2 Means shall be provided to hold the weight to be dropped at steps of 2 in. (50 mm) for a distance of 2 to 10 ft (600 mm to 3 m) above the flat-plate holder, to release the weight in a reproducible manner, and to allow the weight to fall freely.

6.4 *Specimen Holder*—The flat plate shall be used as a specimen holder.

6.4.1 The rigid steel flat-plate holder shall consist of a plate approximately 8 by 12 by 1 in. (200 by 300 by 25 mm). The specimen holder shall be fastened to a concrete slab (floor). Means shall be provided to center the specimens under the drop tube.

7. Test Specimens

7.1 The profile shall be not less than 6 in. (150 mm) in length.

7.2 When the approximate mean-failure height for a given sample is known, 20 specimens usually yield sufficiently precise results. If the mean failure height ~~cannot~~ is not able to be approximated, six or more specimens ~~should~~ shall be used to determine the appropriate starting point of the test.

NOTE 5—As few as five specimens often yield sufficiently reliable estimates of the mean failure height. However, in such cases, the estimated standard deviation will be relatively large.[4]

8. Conditioning

8.1 Unless otherwise specified, condition the test specimens at 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity for not less than 24 h prior to test in accordance with Procedure A of Methods D 618. In cases of disagreement, the tolerance shall be ±1.8°F (±1°C) and ±2 % relative humidity.

8.2 *Quality-Control Tests*—Condition the test specimens at 73.4 ± 3.6°F (23 ± 2°C) for 4 h in air.

9. Procedure

9.1 Cut the profile into samples 6 in. (152 mm) long.

9.2 Choose a specimen at random from the sample.

9.3 After raising the weight, place the specimen on the specimen holder between two pair of snug-fitting right-angle-slotted brackets in such a way that it rests in the most stable position and is centered under the weight. The brackets are used to prevent any lateral movement of the profile and any sliding out during impact.

NOTE 6—During the round robin, it was found that choice of the side of the profile impacted made no difference on impact resistance. Even then, the position was defined so that it is likely that all would hit the same side.

9.4 Raise the weight in the tube to the approximate failure height value for the specific sample and release it so that it drops on the specimen.

NOTE 7—Height is determined as the distance between the top surface of the profile and which is under impact, and the bottom surface of the falling weight.

9.5 Remove the specimen and examine it to determine whether or not it has failed.

9.6 If the first impact of the specimen results in failure, decrease the drop height one increment. If the first impact of the specimen does not cause failure, increase the drop height one increment. Then test a second specimen.

9.7 In this manner, select the impact height for each successive test from the results observed with the specimen just previously tested. Do not test the same target point on a specimen more than once.

9.8 Keep a running plot of the data. See Appendix X1. Use one symbol, such as "X" to indicate a failure and a different symbol such as "O" to indicate a non-failure at each height level.

9.9 For any specimen that gives a break behavior that appears to be an outlier, the conditions of that impact shall be examined. The specimen ~~may be~~ is discarded only if a unique cause for the anomaly can be found, such as an internal flaw visible in the broken specimen. Note that break behavior ~~may vary~~ varies widely within a set of specimens. Data from specimens that show atypical behavior shall not be discarded simply on the basis of such behavior. Refer to Practice E 178 for detailed information on how outliers shall be handled.

10. Calculation

10.1 *Mean Failure Height (Procedure A)*— Calculate the mean failure height from the test data obtained as follows:

$$h = h_o + d_h (A/N \pm 0.5)$$

where:

h = mean failure height, in. (cm),

[4] Brownless, K. A., Hodges, J. L., Jr., and Rosenblatt, Murray, "The Up-and-Down Method With Small Samples", American Statistical Association Journal, *JSTNA*, Vol 48, 1953, pp. 262–277.

d_h = increment of weight height, in. (cm),
N = total number of failures or non-failures, whichever is *smaller*. For ease of notation, call whichever are used "events",
h_o = lowest height at which an event occurred, in. (cm),
A =

$$\sum_{i=0}^{k} in_i,$$

i = 0, 1, 2 . . . k (counting index, starts at h_o),
n_i = number of events which occurred at h_i, and
h_i = $h_o + id_h$.

In calculating h, the negative sign is used when the events are failures. The positive sign is used when the events are non-failures.

10.2 *Mean Failure Energy (Procedure A)*— Compute the mean failure energy as follows:

$$MFE = h \times w$$

where:
MFE = mean failure energy, in./lb (J),
h = mean failure height, in. (cm), and
w = weight.

10.3 *Estimated Standard Deviation*—Calculate the estimated standard deviation from the test data as follows:

$$s = 1.620\ d\left[\left[\frac{(NB - A^2)}{N^2}\right] + 0.029\right]$$

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

11. Report

11.1 The report shall include the following:

11.1.1 Complete identification of the sample tested, manufacturer's code, form, and previous history.

11.1.2 Weight being used.

11.1.3 Number of test specimens (target points) employed to determine the mean failure height.

11.1.4 Mean failure energy.

11.1.5 Estimated standard deviation.

11.1.6 Any departures from the specified test procedures.

12. Precision and Bias

12.1 *Precision*—An interlaboratory study with five laboratories was conducted in which various rigid poly(vinyl chloride) (PVC) extruded profiles were tested by means of a falling weight.

12.1.1 The average within-laboratory and between-laboratory coefficients of variation were as follows:

Average V	
Within Laboratory	Between Laboratory
13.6	23.5

where:
V =

$$\frac{100\ S}{MFE\ average}$$

12.2 *Bias*—No statement of bias ~~can be~~ is provided because of the lack of a referee method for impact behavior of plastics which can provide a "true" or reference value.

13. Keywords

13.1 impact resistance; profile toughness; PVC rigid profiles

APPENDIX

(Nonmandatory Information)

X1. SAMPLE CALCULATIONS

Height in.	Outcome of X—Failure 0—Non-Failure																			
40																				
38																				
36																				
34																				
32																				
30										X				X		X				X
28							X		O		X		O		O		X		O	
26						O		O				O						O		
24					O															
22		X		O																
20	O		O																	

Height in.	N_x	N_o	i	Ni	iNi	i^2Ni
~~30~~	~~4~~	~~0~~	~~4~~	~~4~~	~~16~~	~~64~~
30	4	0	4	4	16	64
~~28~~	~~3~~	~~4~~	~~3~~	~~3~~	~~9~~	~~27~~
28	3	4	3	3	9	27
~~26~~	~~0~~	~~4~~	~~2~~	~~0~~	~~0~~	~~0~~
26	0	4	2	0	0	0
~~24~~	~~0~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~
24	0	1	1	0	0	0
~~22~~	~~1~~	~~1~~	~~0~~	~~1~~	~~0~~	~~0~~
22	1	1	0	1	0	0
~~20~~	~~0~~	~~2~~				
20	0	2				
Totals	8 (N_x)	12 (N_o)		8 (N)	25 (A)	91 (B)

$$h_o = 22, \; N = N_x = 7 \; d = 2 \text{ in.}$$

$$h = h_o + d\left(\frac{A}{N} - 0.5\right)$$

$$h = 22 + 2\left(\frac{25}{8} - 0.5\right)$$

$$h = 27.2 \text{ in.}$$

$$S = 1.620\, d\left(\frac{NB - A^2}{N^2} + 0.029\right)$$

$$S = 1.620(2)\left(\frac{728 - 625}{64} + 0.29\right)$$

$$S = 5.3 \text{ in.}$$

SUMMARY OF CHANGES

Committee D 20 has identified the location of the following changes to this standard since the last issue (D 4495-95) that may impact on the use of this standard.

(*1*) Clarified notes and footnotes in 1.4.
(*2*) Added reference to Practice E 178 in 2.1.
(*3*) Defined outlier in 3.2.
(*4*) Detailed outlier handling instructions in 9.9.
(*5*) Removal of permissive language in document.