



Designation: D1667 – 22

Standard Specification for Flexible Cellular Materials—Poly (Vinyl Chloride) Foam (Closed-Cell)¹

This standard is issued under the fixed designation D1667; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers flexible closed-cell or non-interconnecting cellular products, the elastomer content of which is predominantly poly(vinyl chloride) or copolymers thereof.

1.2 In the case of conflict between the provisions of this specification and those of detailed specifications or methods of test for a particular product, the latter shall take precedence.

1.3 Reference to the methods for testing closed-cell poly(vinyl chloride) contained herein shall specifically state the particular test or tests desired and not refer to these methods of test as a whole.

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

1.5 The following precautionary statement pertains to the test method portions only of this specification: *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There is no known ISO equivalent to this standard.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

¹ This specification is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.22 on Cellular Materials - Plastics and Elastomers.

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2. Referenced Documents

2.1 *ASTM Standards:*²

D883 Terminology Relating to Plastics

D1056 Specification for Flexible Cellular Materials—Sponge or Expanded Rubber

E456 Terminology Relating to Quality and Statistics

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 Terms used in this standard are defined in accordance with Terminology D883, unless otherwise specified. For terms relating to precision and bias and associated issues, the terms used in this standard are defined in accordance with Terminology E456.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *flexible cellular material, n*—a cellular polymer that will not visibly rupture within a specified time when a specimen is bent around a 25.4-mm (1.0-in.) mandrel 180 degrees within an agreed upon period of time and at a predetermined temperature.

3.2.2 *surface skin, n*—the smooth surface on the material formed during manufacture by contact with the molds, cover plate, or air.

3.2.3 *V, n*—the ASTM symbol designating nonrigid vinyl cellular plastics.

3.2.4 *vinyl or PVC, n*—these terms refer to poly(vinyl chloride) or copolymers thereof.

4. Materials and Manufacture

4.1 Closed-cell vinyl is produced in sheet, strip, molded, or simple specific shapes.

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.

*A Summary of Changes section appears at the end of this standard

5. Grades of Closed-Cell Vinyl or PVC-Symbol VE

5.1 Closed-cell vinyl shall be designated by two symbol letters VE, indicating V for vinyl and E for closed cell. The grade shall be designated by two digits, the first of which designates closed cell, and the second of which indicates the degree of firmness, the softer grades being identified with the lower numbers and the firmer grades with the higher numbers.

NOTE 2—Examples—VE-41 is a closed cell (expanded) vinyl of soft grade (see Table 1).

5.2 If suffix tests are required, suffix letters shall be added singly or in combination after any grade number to indicate additional requirements beyond those specified in Table 1 as basic requirements. The significance of the approved suffix letters is as follows:

- B—Compression Set under Constant Deflection
- C—Weather Resistance^A
- D—Load Deflection^A
- E—Oil Resistance^A
- F—Low Temperature—18°C (0°F)
- G—Tear Resistance^A
- H1—Flex Resistance (Dynamic)^A
- J—Abrasion Resistance^A
- K2—Adhesion (Cemented Bond Made After Molding)^A
- L—Water Absorption Test Required with Values as Specified in Table 1
- M—Flame Resistance^A
- P—Non-Staining^A
- R1—Rebound^A
- R2—Energy Absorption^A
- S—Volume Change after Heat Aging^A
- W—Density^A
- Z—Special Requirements^A

^A Test method and values to be arranged between the manufacturer and the purchaser.

6. Tolerances on Dimensions

6.1 Tolerances on dimensions of closed-cell vinyl products are given in Table 2.

TABLE 2 Tolerances on Dimensions of Closed Cell Vinyl Products

Thickness, mm (in.)	Tolerance, mm (in.)
3 to 15 (0.118 to 0.590)	±2 (0.079)
15 to 40 (0.590 to 1.574)	±2.5 (0.098)
Over 40 (over 1.574)	±3 (0.118)
Length and Width, mm (in.)	Tolerance, mm (in.)
Up to 150 (up to 6)	±6 (0.236)
150 to 300 (6 to 12)	±10 (0.393)
Over 300 (over 12)	±3 %

7. Workmanship, Finish, and Appearance

7.1 Closed cell vinyl furnished under this specification shall be manufactured from poly(vinyl chloride) or copolymers thereof, together with the added compounding ingredients of such nature and quality that the finished product complies with the specification requirements. In permitting a choice in use of materials by the manufacturer, it is not intended to imply that the different materials are equivalent in respect to all physical properties. Any special characteristics, other than those prescribed in this specification, which may be desired for specific applications shall be designated in the product specifications as they may influence the choice of the type of poly(vinyl chloride) or other ingredients used. All materials and workmanship shall be in accordance with good commercial practice and the resulting product shall be free of defects affecting serviceability.

7.2 Due to manufacturing conditions, material may have to be altered or repaired. This repaired or altered material will be acceptable under this specification provided the material used in such repairs or alterations shall be of the same composition and quality as the original product and provided such alterations do not affect the serviceability, size, and shape beyond the tolerances provided herein.

8. Color

8.1 Unless otherwise specified, the color of the material shall be optional with the manufacturer.

9. Sampling

9.1 When possible, the completed manufactured product shall be used for the tests specified. Representative samples of the lot being examined shall be selected at random as required.

9.2 When it is necessary or advisable to obtain test specimens from the article, as in those cases where the entire sample is not required or adaptable for testing, the method of cutting and the exact position from which specimens are to be taken shall be specified. The apparent density and the state of fusion could vary in different parts of the finished product, particularly if the article is of complicated shape or of varying thickness. These features affect the physical properties of the specimens. The apparent density is affected by the number of cut surfaces as opposed to the number of skin-covered surfaces on the test specimen.

9.3 When the finished product does not lend itself to testing or to the taking of test specimens because of complicated shape, small size, metal or fabric inserts, adhesion to metal, or other reasons, suitable test slabs shall be prepared as agreed

TABLE 1 Physical Requirements of Closed Cell Vinyl Products, Type VE

Basic Requirements		Optional Requirements Added by Suffix Letters		
Grade Number	kPa (psi)	Suffix B	kg/m ² cut surface	Suffix L Water Absorption, max lb/ft ² cut surface
VE-40	3.5 to 15 (0.5 to 2.17)	20	0.5	0.1
VE-41	15 to 35(2.17 to 5.07)	20	0.5	0.1
VE-42	35 to 65(5.07 to 9.42)	20	0.5	0.1
VE-43	65 to 90(9.42 to 13)	20	0.5	0.1
VE-44	90 to 120(13 to 17.4)	20	0.5	0.1
VE-45	120 to 170(17.4 to 24.6)	20	0.5	0.1

between the supplier and purchaser. When differences arise, due to the difficulty in obtaining suitable test specimens from the finished part, the supplier and the purchaser shall agree on acceptable deviations.

10. Physical Properties

10.1 The various grades of closed-cell vinyl shall conform to the requirements as to basic physical properties prescribed in **Table 1**, together with any additional requirements indicated.

11. Inspection and Rejection

11.1 All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified.

11.2 The purchaser reserves the right to make the tests and inspection for acceptance or rejection of the material at the laboratory of his choice.

11.3 Any material that fails in one or more of the test requirements shall be retested. For this purpose, two additional tests shall be made for the requirement in which failure occurred. Failure of either of the tests shall be cause for final rejection.

11.4 Rejected material shall be disposed of as directed by the manufacturer.

12. General Test Methods

12.1 Unless specifically stated otherwise, all tests shall be made in accordance with the methods specified in Sections **15–26**, which include the following:

12.1.1 *Compression Deflection*—Sections **15 – 20**.

12.1.2 *Compression Set Under Constant Deflection*—Sections **21 – 26**.

12.1.3 *Water Absorption*—Sections **27 – 32**.

NOTE 3—Additional test methods are listed in the appendix:

X1. Suggested Test Method for Volume Change After Heat Aging (Suffix S)

X2. Suggested Test Method for Low-Temperature Test (Suffix F)

X3. Suggested Test Method for Density (Suffix W)

13. General Test Conditions

13.1 Test specimens shall be conditioned undeflected and undistorted at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) for at least 12 h before testing.

13.2 Tests shall be conducted at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) unless otherwise specified in the individual test method.

14. Measurement of Test Specimens

14.1 Dimensions up to and including 25.4 mm (1 in.) shall be measured by using a dial or electronic display gauge having a maximum stem and foot mass of 25 g and a foot 31.75 mm (1.25 in.) in diameter. The dial or electronic display gauge shall be graduated to a minimum of 0.025 mm (0.001 in.). Care should be taken to ensure proper seating of the foot to the specimen without distorting the specimen.

14.2 Thicknesses over 25.4 mm (1.0 in.) shall be measured using the gauge specified in **14.1** or by using a sliding caliper gauge graduated to a minimum of 0.025mm (0.001 in.). When a sliding caliper gauge is employed, the gauge setting shall be

made with the gauge out of contact with the closed cell vinyl. The sample shall be passed through the previously set gauge and the proper setting shall be the one in which the measuring faces of the gauge contact the surfaces of the article without compressing it.

14.3 Length and width measurements over 25.4mm (1.0 in.) shall be measured using the gauge specified in **14.1**, a sliding caliper specified in **14.2** or a steel rule or tape graduated to a maximum of 1 mm (0.039 in.).

COMPRESSION DEFLECTION TEST METHOD

15. Scope

15.1 This test consists of measuring the force necessary to produce a 25 % deflection on a 645.16-mm^2 (1-in.²) test specimen.

16. Apparatus

16.1 An apparatus capable of compressing the specimen between a flat supporting plate and a flat compression foot that is larger than the specimen to be tested, at a uniform rate of speed of 31.75 ± 12.7 mm/min (1.25 ± 0.5 in./min). The apparatus shall be capable of measuring the force required to produce the specified compression and the displacement of the compression foot.

17. Test Specimens

17.1 Three test specimens shall be used for this test. The specimens shall be cylinders 28.67 ± 0.50 mm (1.129 ± 0.02 in.) in diameter, which yields 645.16 ± 1.56 mm² (1 ± 0.003 in.²) in area with parallel top and bottom surfaces. They shall be cut so that opposite edges are parallel, either from the finished product in a manner agreed upon between the manufacturer and the purchaser, or from standard test slabs, or from commercial flat sheets. Maximum thickness shall be 25.4 mm (1.0 in.). Samples less than 6.0 mm (0.236 in.) in thickness shall be plied up to obtain a thickness as near 12.7 mm (0.5 in.) as possible. The specimens shall be cut with either a revolving die or oscillating cutter. Use a soap solution if a lubricant is needed. If a lubricant is used, the specimen shall be thoroughly dried before proceeding with the testing. In some cases, it may be necessary to freeze the cellular vinyl to obtain parallel cut edges.

18. Procedure

18.1 Record the thickness and area of the specimen. Deflect the specimen 25 % of its original height, maintain the deflection at 25 % and determine the final force in N or lbs, after 60 ± 1 s.

19. Calculation

19.1 Load (lbs) / Area (in.²) = psi

20. Report

20.1 Report the average compression deflection of three specimens, expressed in kPa or psi to the nearest 0.1.

COMPRESSION SET UNDER CONSTANT DEFLECTION (SUFFIX B)

21. Scope

21.1 This test determines the compression set after constant deflection at room temperature $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$).

22. Apparatus

22.1 A *compression device*, consisting of two or more flat steel or aluminum plates that are of sufficient thickness to prevent deflection of the plates under load. The plates are held parallel to each other by bolts or clamps, and the space between the plates is adjustable to the required deflection thickness by means of spacers.

23. Test Specimen

23.1 Three specimens shall be used for this test. Specimens shall be any convenient size with parallel top and bottom surfaces, that shall be at right angles to the side surfaces. Specimens shall be either round or rectangular. The minimum dimension across the top shall be at least equal to the thickness and at least 645.16 mm^2 (1 in.^2) in area. The minimum thickness shall be 12.7 mm (0.5 in.).

24. Procedure

24.1 Accurately determine the height of the specimen as described in Section 14, and record the measurement. Place the specimen between the plates of the clamping device, and deflect it $25 \pm 1 \%$ of its original height. Hold the specimen in this compressed condition $22 \text{ h} \pm 15 \text{ min}$ at room temperature. Remove the specimens from the test apparatus and measure the final thickness after $24 \text{ h} \pm 30 \text{ min}$ of recovery.

NOTE 4—Other deflection values can be used as agreed upon between user and supplier.

25. Calculation

25.1 Calculate the percentage compression set as follows:

$$\text{compression set, \%} = [(t_o - t_f)/(t_o - t_s)] \times 100 \quad (1)$$

where:

t_o = original thickness,

t_f = thickness at specified time after removal from the clamp, and

t_s = thickness of spacer bar.

26. Report

26.1 Report the average compression set of three specimens to the nearest 0.1% .

WATER ABSORPTION (SUFFIX L)

27. Scope

27.1 The water absorption test is applicable to closed cell vinyl and is intended to show the non-interconnecting cell structure of the material.

NOTE 5—Water absorption requirements are optional unless Suffix L is specifically listed after the grade number.

28. Test Specimens

28.1 Three test specimens shall be used for this test. Use test specimens approximately 101.6 by 101.6 mm (4 by 4 in.) square and approximately 12.7 mm (0.5 in.) in thickness. Unless otherwise specified the presence of skin on the top or bottom surfaces shall be optional.

29. Apparatus

29.1 Any device capable of maintaining a pressure 30 kPa (4.35 psi) and large enough to contain and submerge the specimen size can be used.

NOTE 6—Do not perform this test in a vacuum.

30. Procedure

30.1 Measure and calculate the total area of the cut surfaces (surfaces without skin) of the specimen, weigh the specimen, and then submerge under a $3 \pm 0.152\text{-m}$ ($10 \pm 0.5\text{-ft}$) head of water (equal to $30 \pm 1.5 \text{ kPa}$ or $4.35 \pm 0.22 \text{ psi}$), for $48 \text{ h} \pm 15 \text{ min}$. Then place the specimens in a stream of air (30 psi max) for the minimum time required to remove visible water from the surface, and reweigh them. Record all measurements.

31. Calculation

31.1 Calculate the water absorption, expressed in kg/m^2 (lb/ft^2) of cut surfaces (surfaces without skin) as follows:

$$\text{Water Absorption} = \frac{W_2 - W_1}{A} \quad (2)$$

where:

W_1 = specimen mass before immersion, kg (lb),

W_2 = specimen mass after immersion, kg (lb), and

A = area of cut surface, m^2 (ft^2).

32. Report

32.1 The average water absorption in kg/m^2 (lb/ft^2) of the three specimens tested to the nearest 0.1 .

33. Precision and Bias

33.1 Precision and bias for this specification are based on a round robin study performed in accordance with Practice E691, involving three materials tested by ten laboratories. For each material, all samples were prepared at one source, but the individual test specimens were prepared at the individual laboratories. The data listed in the following tables is based on the average of three determinations for each material. The number of laboratories for each test varied due to the inconsistency in test methods seen from the individual laboratory data returned. The data obtained and the number of participating laboratories for each test can be seen in Tables 3-5. (Warning—The data in Tables 3-5 shall not be rigorously applied to acceptance or rejection of material, as those data are specific to the interlaboratory study and are not necessarily representative of other lots, conditions, materials, or laboratories. Users of this test method shall apply the principles outlined in Practice E691 to generate data specific to their laboratory and materials, or between specific laboratories.)