



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

This standard is issued under the fixed designation D 1667; 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 specification has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This specification covers flexible closed-cell or noninterconnecting 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 should 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 and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There is no equivalent ISO standard.

2. Referenced Documents

2.1 ASTM Standards:

D 395 Test Methods for Rubber Property—Compression Set²

D 573 Test Method for Rubber—Deterioration in an Air Oven²

¹ This specification is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.22 on Cellular Materials—Plastics and Elastomers.

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² *Annual Book of ASTM Standards*, Vol 09.01.

D 1056 Specification for Flexible Cellular Materials—Sponge or Expanded Rubber³

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *closed cell*—an expanded structure consisting of a multitude of individual, nonconnecting, gas-tight cells.

3.1.2 *flexible cellular material*—a cellular organic polymeric material which will not rupture when a specimen 200 by 25 by 25 mm (8 by 1 by 1 in.) is bent around at 25-mm (1-in.) diameter mandrel at a uniform rate of one lap in 5 s at a temperature between 18 and 29°C (65 and 85°F).

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

3.1.4 *V*—the ASTM symbol designating nonrigid vinyl cellular plastics.

3.1.5 *vinyl or PVC*—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.

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).

³ *Annual Book of ASTM Standards*, Vol 08.01.

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

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

Basic Requirements		Requirements Added by Suffix Letters			
Grade Number	kPa (psi)	Compression Set, 25 % Deflection, 22 h at Room Temperature, 24 h Recovery, % max	Suffix B	Suffix L	Water Absorption, max
			kg/m ² cut surface	lb/ft ² cut surface	
VE-40	3.5 to 15 (0.5 to 2)	20	0.5	0.1	
VE-41	15 to 35 (2 to 5)	20	0.5	0.1	
VE-42	35 to 65 (5 to 9)	20	0.5	0.1	
VE-43	65 to 90 (9 to 13)	20	0.5	0.1	
VE-44	90 to 120 (13 to 17)	20	0.5	0.1	
VE-45	120 to 170 (17 to 25)	20	0.5	0.1	

5.2 Suffix letters may 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.

7. Workmanship, Finish, and Appearance

7.1 Closed cell vinyl furnished under this specification shall be manufactured from poly(vinyl chloride) or copolymers

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 %

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 may 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 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 may 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. Test Methods

11.1 Unless specifically stated otherwise, make all tests in accordance with the methods specified in Section 14.

12. Inspection and Rejection

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

12.2 The purchaser may make the tests and inspection to govern acceptance or rejection of the material at his own laboratory or elsewhere.

12.3 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.

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

13. Packaging and Package Marking

13.1 The material shall be properly and adequately packaged. Each package or container shall be legibly marked with the name of the material, name or trademark of the manufacturer, and any required purchaser's designations.

14. General Test Methods

14.1 The following tests shall be applicable in the physical testing of closed cell poly(vinyl chloride) or copolymers thereof:

14.1.1 *Compression Deflection*—Test method described in Sections 16-20.

14.1.2 *Compression Set Under Constant Deflection*—Test method described in Sections 21-25.

14.1.3 *Water Absorption*—Test method described in Sections 26-29.

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

15. Measurement of Test Specimens

15.1 The length and width shall be measured with a steel scale or tape. Care shall be taken not to distort the material.

15.2 Thicknesses up to and including 25 mm (1 in.) shall be measured using a dial-type gage having a maximum stem and foot mass of 25 g and a foot 32 mm (1.25 in.) in diameter, taking care not to compress the specimen. Thicknesses over 25 mm (1 in.) shall be measured using a sliding caliper gage or as specified in 15.1. When a sliding caliper gage is employed the gage setting shall be made with the gage out of contact with the closed cell vinyl. The specimen shall be passed through the previously set gage, and the proper setting shall be the one when the measured faces of the gage contact the surfaces of the article without compressing it.

15.3 The steel scale or tape used to measure length or width shall be graduated in divisions not over 1 mm (0.031 in.). The dial gage for measuring thickness shall be graduated in divisions not over 0.02 mm (0.001 in.). The calipers used for measuring thickness shall be graduated in divisions not over 0.1 mm (0.005 in.).

15.4 Results reported shall be the average of a minimum of three measurements.

COMPRESSION DEFLECTION TEST METHOD

16. Scope

16.1 This test consists of measuring the force necessary to produce a 25 % deflection on a 650-mm²(1-in.²) test specimen. An alternative specimen of 1000 mm² may be used to facilitate calculations where using SI units (value measured in newtons equals compressive stress in kilopascals).

17. Apparatus

17.1 The apparatus used for this test shall have a flat indenter foot, larger than the specimen being tested, connected to a force-measuring device, and mounted in such a manner that the specimen can be deflected at a rate between 0.2 and 0.8 mm/s (0.5 and 2.0 in./min.). The apparatus shall be arranged to support the specimen on a level, horizontal plate.

18. Test Specimens

18.1 The specimens shall be cylinders 650 mm²(1 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. The thickness of the test specimens may vary, but shall be measured and stated in the report. Maximum thickness shall be 25 mm (1.0 in.). The specimens may be cut with a revolving die using a soap solution as a lubricant. 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. An alternative specimen of 1000 mm² may be used to facilitate calculations where using SI units (value measured in newtons equals compressive stress in kilopascals).

19. Procedure

19.1 Test closed-cell vinyl (grades VE-40 to VE-45) samples less than 6.0 mm (0.236 in.) in thickness by plying up to obtain a thickness as near 12.5 mm (½ in.) as possible. Deflect the specimen 25 % of its original height. Maintain the deflection at 25 % with automatic or manual control and record the force in newtons or pound-force 60 s after the 25 % deflection is reached. The result obtained in this test is influenced by temperature, and tests which are to be compared shall be conducted under substantially the same temperature. In all cases, report the actual temperature during the test.

19.2 In case of dispute perform the test at a temperature of 23 ± 1°C (73.4 ± 1.8°F). Condition the specimen undeflected and undistorted at this temperature for at least 12 h before testing. Ordinarily only one test shall be made, but in case of dispute express the result as the average of three tests on three different specimens.

NOTE 4—Humidity is known not to affect the result.

20. Report

20.1 Report the unit force required, expressed in kPa or psi.

**COMPRESSION SET UNDER CONSTANT
DEFLECTION (SUFFIX B)**

21. Scope

21.1 This test determines the compression set after constant deflection at room temperature $23 \pm 1^\circ\text{C}$ ($73.4 \pm 1.8^\circ\text{F}$).

22. Apparatus

22.1 The apparatus and procedure shall be the same as that prescribed in Method B of Test Methods D 395 except as follows: the apparatus shall be a compression device consisting of two parallel plates between which the test specimen may be deflected 25 % of its original thickness and held in this position by means of at least four studs and nuts. Chrome-plated metal plates are not required. Aluminum plates or any stiff plates that are clean and smooth, and that will not deflect measurably under the force necessary for deflection of the specimen may be used.

23. Test Specimen

23.1 The specimen shall be any convenient size with parallel top and bottom surfaces, that shall be at right angles to the side surfaces. The specimen may be round or rectangular. The minimum dimension across the top shall be at least equal to the thickness and at least 650 mm^2 (1 in.^2) in area. The minimum thickness shall be 12.5 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 % of its original height. Hold the specimen in this compressed condition 22 h at room temperature, then release the specimen from the clamping device and allow it to rest for 24 h at room temperature. Again, accurately determine the height of the specimen.

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.

WATER ABSORPTION (SUFFIX L)

26. Scope

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

27. Test Specimens

27.1 Test specimens shall be 100 by 100 mm (4 by 4 in.) square and approximately 25 mm (1 in.) in thickness. The specimen may have the natural skin on the top and bottom surfaces.

28. Procedure

28.1 Weigh the specimens and submerge under a 3-m (10-ft) head of water (equal to 30 kPa or 4.35 psi) at room temperature 18 to 29°C (65 to 90°F), for 48 h. Then place the specimens in a stream of air for the minimum time required to remove visible water from the surface, and reweigh them.

29. Calculation

29.1 Calculate the results in terms of kilograms or pounds of water gain per square metre or square foot of surface without a skin or rind.

30. Precision and Bias

30.1 The precision and bias for these described test methods is unknown. Data for a precision and bias statement is being developed through a round robin in progress.

31. Keywords

31.1 closed cell; flexible cellular material

APPENDIXES

(Nonmandatory Information)

X1. SUGGESTED TEST METHOD FOR VOLUME CHANGE AFTER HEAT AGING (SUFFIX S)

X1.1 Scope

X1.1.1 This test method describes the procedure for determining the volume change of closed cell vinyl after being aged for seven days at 60°C (140°F).

X1.2 Apparatus

X1.2.1 An oven as described in Section 6 of Test Method D 573 is required.

X1.3 Specimens

X1.3.1 Test specimens shall consist of pieces 300 ± 20 by 300 ± 20 mm (12 ± 0.75 by 12 ± 0.75 in.) when the thickness of the material is 20 mm (0.75 in.) or less and 100 ± 12.7 by 100 ± 12.7 mm (4 ± 0.5 by 4 ± 0.5 in.) when the thickness of material is over 20 mm (0.75 in.). When the piece is an object of molded shape, the largest single piece so molded shall be used for this test.

NOTE X1.1—Shrinkage will vary with thickness.

X1.4 Procedure

X1.4.1 Determine the volume before and after the heat aging test by measuring the amount of water displaced by the material. This may be done most easily on a piece this size by weighing the specimen first in air and then in water, using a cage or other arrangement which will be heavy enough to sink the specimen. The volume in cubic centimeters is equal to the mass of the specimen in air plus the mass of the cage in water minus the mass of both in water, all in grams. If more convenient take all masses in pounds and multiply the result by 27.7 to get the volume in cubic inches.

X1.4.2 Place the specimens in the oven with the temperature maintained at $60 \pm 1^\circ\text{C}$ ($140 \pm 2^\circ\text{F}$) for a period of seven

days. At the end of that period remove the specimens from the oven and allow them to recover for 5 h at $23 \pm 1.0^\circ\text{C}$ ($73.4 \pm 1.8^\circ\text{F}$). Then remeasure the volume.

X1.5 Calculation

X1.5.1 Calculate the percentage change in volume as follows:

$$\text{change in volume, \%} = [(V_1 - V_2)/V_1] \times 100 \quad (\text{X1.1})$$

where:

V_1 = original volume, and

V_2 = volume after oven aging.

X2. SUGGESTED TEST METHOD FOR LOW-TEMPERATURE TEST (SUFFIX F)

X2.1 Scope

X2.1.1 This test method determines the change in compressibility of closed cell vinyl at low temperatures.

X2.2 Apparatus

X2.2.1 Any device such as described in Section 17, that can take the compression while the specimen is in the cold box, may be used.

X2.2.2 A cold box that can be accurately controlled for low temperatures. If the box is cooled by dry ice, the specimen should not make direct contact with gaseous CO_2 .

X2.3 Test Specimens

X2.3.1 The test specimens shall be as described in Section 18.

X2.4 Procedure

X2.4.1 The compression-deflection of the specimen shall first be measured at room temperature as described in Section 19. Record the force in newtons or pounds-force required for

25 % deflection. Place the specimens in the cold box for 5 h at the specified temperature, $-18 \pm 1^\circ\text{C}$ ($0 \pm 1.8^\circ\text{F}$). Then with the specimen still in the cold box apply the previously determined force which produced 25 % deflection at room temperature. Maintain this force for 60 s, then measure the specimen height under force (see Note X2.1). Determine the percentage deflection.

NOTE X2.1—It is necessary to measure the uncompressed height before applying the force due to shrinkage of the sample.

X2.5 Calculation

X2.5.1 Calculate the low temperature change as follows:

$$C = [(D - E)/D] \times 100 \quad (\text{X2.1})$$

where:

C = change in deflection, %,

D = deflection at room temperature, %, and

E = deflection at temperature of test, %.

NOTE X2.2—Lower figures indicate better low temperature properties.

X3. SUGGESTED TEST METHOD FOR DENSITY (SUFFIX W)

X3.1 Scope

X3.1.1 This test method describes the procedure for determining the density by calculation from the mass and volume.

X3.2 Test Specimens

X3.2.1 Representative specimens of regular shape, not less than 16 mm^3 (1 in.^3) in volume, shall be cut from the sample to be tested.

X3.3 Procedure

X3.3.1 Weigh the specimen on a balance or scale graduated so as to permit weighings within $\pm 1\%$ of the mass to be measured.

X3.3.2 Determine the volume of the specimen. If the specimen is less than 10 mm (0.4 in.) in length or width, use a rule graduated to 0.2 mm (0.01 in.).

X3.4 Calculation

X3.4.1 Calculate the density as follows:

$$\text{density, kg/m}^3 = A/B \quad (\text{X3.1})$$

where:

A = mass of specimen, kg, and

B = volume of specimen, m^3 .

NOTE X3.1—To convert this value to lb/ft^3 multiply by 0.0624.

SUMMARY OF CHANGES

Committee D-20 has identified the location of selected changes to this specification since the last issue that may impact the use of this specification:

D 1667 – 97:

- | | |
|--|---|
| (1) Added ISO equivalency statement. | from 20 in./min to 2.0 in./min). |
| (2) Moved three test methods to a new appendix. | (6) Fractions changed to decimal equivalent throughout. |
| (3) Precision and bias statement added. | (7) Table 1 and Table 2 revised (inches and millimetres values placed together; compression deflection ranges follow Test Method D 1056, hard metric values). |
| (4) Test methods revised slightly for clarity. | |
| (5) Error in 17.1 corrected in the rate of deflection (changed | |

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