Designation: ~~D1667 – 17~~ 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~~ safety, health, and ~~health~~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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

~~D395~~D883 ~~Test Methods for Rubber Property—Compression Set~~Terminology Relating to Plastics

~~D573 Test Method for Rubber—Deterioration in an Air Oven~~

D1056 Specification for Flexible Cellular Materials—Sponge or Expanded Rubber

[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] 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**

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:*

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

3.2.1 *flexible cellular ~~material~~—material, n*—a cellular ~~organic polymeric material which~~ polymer that will not visibly rupture ~~when a specimen 200 by 25 by 25 mm (8 by 1 by 1 in.)~~ within a specified time when a specimen 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).~~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~~—skin, n*—the smooth surface on the material formed during manufacture by contact with the molds, cover plate, or air.

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

3.2.4 *vinyl or ~~PVC~~—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.

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).

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

Basic Requirements		Optional Requirements Added by Suffix Letters		
	Compression Deflection, 25 % Deflection	Suffix B	Suffix L Water Absorption, max	
Grade Number	kPa (psi)	Compression Set, 25 % Deflection, 22 h at Room Temperature, 24 h Recovery, % max	kg/m^2 cut surface	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

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 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. Test Methods~~

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

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.

~~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.~~

12. General Test Methods

12.1 ~~The following~~ Unless specifically stated otherwise, all tests shall be ~~applicable~~made in ~~the physical testing of closed~~accordance with the methods specified in Sections 15~~cell~~-26 ~~poly(vinyl chloride) or copolymers thereof:~~, which include the following:

12.1.1 *Compression Deflection*—~~Test method described in~~ Sections ~~16~~15 – 20.

12.1.2 *Compression Set Under Constant Deflection*—~~Test method described in~~ Sections 21 – ~~25~~26.

12.1.3 *Water Absorption*—~~Test method described in~~ Sections ~~26~~27 – ~~30~~32.

NOTE 3—Additional test methods are listed in the ~~appendix.~~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 ± 2°C (73.4 ± 3.6°F) for at least 12 h before testing.

13.2 Tests shall be conducted at 23 ± 2°C (73.4 ± 3.6°F) unless otherwise specified in the individual test method.

14. Measurement of Test Specimens

14.1 ~~The length and width~~ Dimensions up to and including 25.4 mm (1 in.) shall be measured ~~with a steel scale or tape. Care shall be taken not to distort the material.~~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 ~~up to and including 25 mm (1~~over 25.4 mm (1.0 in.) shall be measured using ~~a dial-type gauge 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~~the gauge specified in 14.1 ~~mm (1 in.) shall be measured~~ or by using a sliding caliper ~~gage or as specified in~~gauge graduated to a minimum ~~15.1.~~ of 0.025mm (0.001 in.). When a sliding caliper ~~gage~~gauge is employed, the ~~gage~~gauge setting shall be made with the ~~gage~~gauge out of contact with the closed cell vinyl. The ~~specimen~~sample shall be passed through the previously set ~~gage,~~gauge and the proper setting shall be the one ~~when~~ in which the ~~measured~~measuring faces of the ~~gage~~gauge contact the surfaces of the article without compressing it.

14.3 ~~The steel scale or tape used to measure length or width shall be graduated in divisions not over 1~~Length and width measurements over 25.4mm (1.0 in.) shall be measured using the gauge specified in 14.1~~mm (0.031 in.). The dial gage for~~, a sliding caliper specified in 14.2 ~~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~~ or a steel rule or tape graduated to a maximum of 1 mm (0.039 in.).

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

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 ~~The apparatus used for this test shall have a flat indentor foot,~~ An apparatus capable of compressing the specimen between a flat supporting plate and a flat compression foot that is larger than the specimen ~~being tested, connected to a force-measuring device, and mounted in such a manner that the specimen shall be deflected at a rate between 0.2 and 0.8 mm/s (0.5 and~~to be tested, at a uniform rate of speed of 31.75 ± 12.7 mm/min (1.25 ± 0.5 in. ~~2.0 in./min). /~~min). The apparatus shall be ~~arranged to support the specimen on a level, horizontal plate.~~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 ± 0.20~~645.16 ± 1.56 mm^2 (~~1~~(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. ~~The thickness of the test specimens shall be measured and stated in the report. Maximum thickness shall be 25.4 mm (1.0 in.).~~ 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.

~~NOTE 4—Other specimen sizes can be used as agreed upon between user and supplier.~~

18. Procedure

18.1 ~~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 12.7 mm (~~Record the thickness and area of the specimen. ~~½ in.) as possible.~~ Deflect the specimen 25 % of its original ~~height. Maintain~~height, maintain the deflection at 25 % ~~with automatic or manual control and record the force in newtons or pounds force 60 ± 1 s after the 25 % deflection is reached. The result obtained in this test is influenced by temperature, and tests that are to be compared shall be conducted under substantially the same temperature. In all cases, report the actual temperature during the test.~~and determine the final force in N or lbs, after 60 ± 1 s.

~~19.2 In case of dispute perform the test at a temperature of 23 ± 2°C (73.4 ± 3.6°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 5—Humidity does not affect the results.~~

19. Calculation

19.1 Load (lbs) / Area ($in.^2$) = psi

20. Report

20.1 Report the ~~unit force required,~~ average compression deflection of three specimens, expressed in kPa or ~~psi.~~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 ± 2°C (73.4 ± 3.6°F).

22. Apparatus

22.1 ~~The apparatus~~A *~~and procedure shall be the same as that prescribed in Method B of Test Methods D395 except as follows:~~*

~~*The apparatus is a compression device*~~*compression device,* consisting of two ~~parallel plates using at least four studs and nuts to accomplish compression. Normally, compression is 25 %, but any value to which both buyer and seller agree, may be used. The compression plates may be aluminum or any other smooth, clean material, which won't deflect under the force necessary to produce the desired deflection.~~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 ~~The specimen shall be~~ 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. ~~The specimen~~ 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 ± 1 % of its original height. Hold the specimen in this compressed condition 22 h ± 15 min at room ~~temperature, then release the specimen~~temperature. Remove the specimens from the ~~clamping device and allow it to rest for 24 h ± 15 min at room temperature. Again, accurately determine the height of the specimen.~~ test apparatus and measure the final thickness after 24 h ± 30 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. ~~Skin on one or both sides of the specimen is allowable. Only one test specimen is necessary for a valid test.~~Unless otherwise specified the presence of skin on the top or bottom surfaces shall be optional.

29. Apparatus

29.1 ~~*Suggested equipment:*~~ 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.