



Standard Test Methods for Flexible Cellular Materials Made From Olefin Polymers¹

This standard is issued under the fixed designation D3575; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope

1.1 These test methods apply to flexible closed cell materials made from olefin polymers or blends of olefin polymers with other polymers as defined in Section 3.

1.2 These test methods cover test procedures only. Product requirements are outlined in Specification D4819.

1.3 Unless specifically stated otherwise, by agreement between the purchaser and supplier, all tests shall be performed in accordance with the test methods specified in this standard.

1.4 The values stated in SI units are to be regarded as the standard.

1.5 *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 or regulatory limitations prior to use.*

NOTE 1—This standard and ISO 7214 address the same subject matter, but differ in technical content.

2. Referenced Documents

2.1 ASTM Standards:²

- C177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
- C518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
- D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension
- D624 Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
- D1056 Specification for Flexible Cellular Materials—Sponge or Expanded Rubber

¹ These test methods are under the jurisdiction of ASTM Committee D20 on Plastics and are 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.

- D1349 Practice for Rubber—Standard Conditions for Testing
- D1596 Test Method for Dynamic Shock Cushioning Characteristics of Packaging Material
- D1667 Specification for Flexible Cellular Materials—Poly (Vinyl Chloride) Foam (Closed-Cell)
- D2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
- D4819 Specification for Flexible Cellular Materials Made From Polyolefin Plastics
- E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
- E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
- F355 Test Method for Impact Attenuation of Playing Surface Systems and Materials

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *blend*—mixture of olefin polymers with other monomer(s) or polymer(s) in which at least 51 mass percent is the olefin polymer.

3.1.2 *cellular material, flexible*—a cellular organic polymeric material that will not rupture when a specimen 203.2 by 25.4 by 25.4 mm (8 by 1 by 1 in.) is bent around a 25.4-mm (1-in.) diameter mandrel at a uniform rate of one lap in 5 s at a temperature between 18 and 29°C.

3.1.3 *constant compression creep*—the time-dependent change in thickness of a material under a constant compressive stress or compression force.

3.1.4 *olefin polymers*—polymers made by the polymerization of olefins or copolymerization of olefins with other monomers, the olefins being at least 51 mass percent.

4. Summary of Test Methods

4.1 Table 1 contains a list of all the assigned suffix letters that may be used in describing the cellular products covered by these test methods.

4.2 These test methods do not contain test methods for all the suffix letters listed in Table 1. Where the test method is not included, it shall be arranged between the purchaser and supplier.

TABLE 1 Suffix Letter Designations

NOTE 1—These suffix letters have been assigned by Subcommittee D11.33 and are consistent with those in Specifications D1056 and D1667.

Suffix Letter	Property	Section
A	Heat resistance	9 – 16
B	Compression set under constant deflection	
C	Ozone or weather resistance	17 – 24
D	Compression deflection	
E	Oil resistance	
F	Low temperature	25
G	Tear resistance	
H	Flex resistance	
I	Not assigned because of similarity to numeral 1	26 – 32
J	Abrasion resistance	
K	Adhesion capability	
L	Water absorption	
M	Flammability resistance	
N	Impact resistance	
O	Electrical properties	
P	Staining resistance	
Q	Not assigned because of similarity to letter O	
R1	Resilience	
R2	Energy absorption	
S	Thermal stability	35 – 42
T	Tensile strength and elongation	43
U	Not assigned	44 and 45
V	Thermal conductivity	
W	Density	46 – 49
X	Not assigned	50 – 56
Y	Not assigned	
Z	Special requirements	
AA	Buoyancy	
BB	Constant compressive creep	
CC	Dynamic cushioning	
DD	Open cell	
EE	Not assigned	
FF	Water vapor transmission	

4.3 Test methods included in this standard are indicated in **Table 1** by showing the applicable section numbers after the suffix letter.

4.4 In cases involving referee decisions, SI units shall be used.

5. Significance and Use

5.1 The test procedures provide a standard method of obtaining data for research and development, quality control, acceptance and rejection under specifications, and special purposes.

5.2 The data obtained by these test methods are applicable to the material under conditions of the particular test and are not necessarily the same as obtained in other environments or use conditions.

6. Sampling

6.1 When possible, use the completed manufactured product for the tests specified. Randomly select representative samples of the lot being examined, as required.

6.2 Extruded or molded shapes or sizes too small for cutting standard test specimens are difficult to classify or test by these test methods and will usually require special testing procedures or the use of standard test sheets.

6.3 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, specify the method of cutting and the exact position from which specimens are to be taken. The apparent density and the state of crosslinking may vary in different parts of the finished product, especially if the article is of complicated shape or of varying thickness, and these factors affect the physical properties of the specimens. Also, the apparent density is affected by the number of cut surfaces as opposed to the number of skin-covered surfaces on the test specimen.

6.4 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, solid covers, adhesion to metal, or other reasons, prepare standard test sheets. When differences due to the difficulty in obtaining suitable test specimens from the finished part arise, the manufacturer and purchaser may agree on acceptable deviations. This can be done by comparing the results of standard test specimens and those obtained on actual parts.

6.5 If the material to be tested is anisotropic, prepare the test specimens so as to measure the property in the direction of interest in the application.

7. Conditioning

7.1 Conduct tests under known conditions of temperature and humidity or as specified in the individual test procedure. In case of dispute, conduct the test at a temperature of $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) and in an atmosphere of $50 \pm 10\%$ relative humidity. The product shall be conditioned, undeflected, and undistorted, at the temperature and humidity of test for at least 24 h before being tested.

7.2 It is recommended, for referee purposes, that all tests shall be performed 96 h or more after the foam has been manufactured.

8. Measurement of Test Specimens

8.1 Measure dimensions up to and including 25.4 mm (1 in.) using a dial-type gauge with a minimum foot area of 645.1 mm² (1 in.²). Pressure on the foot shall be held to 190 ± 50 Pa (0.028 ± 0.007 psi).

NOTE 2—Where foam is appreciably compressed by this test method, foot area and loading shall be as agreed upon between the purchaser and the supplier.

NOTE 3—Thickness of materials having irregular surface characteristics shall be measured as agreed upon between the purchaser and the supplier.

8.2 Dimensions over 25.4 mm (1 in.) may be measured with a dial gauge, scale, or tape. Take care not to distort the test specimen.

8.3 The scale, tape, or gauge shall be graduated to permit measurements within $\pm 1\%$ of the dimension to be measured.

8.4 Results reported shall be the average of a minimum of three equally spaced measurements of length and width and for thickness shall be the average of the center and four equally spaced measurements around the perimeter of the specimens.

Suffix Tests Suffix B—Compression Set Under Constant Deflection

9. Scope

9.1 This test method covers the deflection of the foam specimen under a compressive force and under specified conditions of time and temperature, then noting the effect on the thickness of the specimen after releasing the compressive force.

10. Apparatus

10.1 *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.

11. Test Specimens

11.1 The test specimens shall have parallel top and bottom surfaces and essentially perpendicular sides.

11.2 Specimens shall be 50.8 by 50.8 by 25.4 mm (2 by 2 by 1 in.) unless otherwise specified. Specimens less than 25.4 mm in thickness shall be plied up, without the use of an adhesive, to produce a total thickness of 25.4 mm.

NOTE 4—To obtain accurate data when testing foams with large cells or irregular surfaces, or both, larger samples approximately 101.6 by 101.6 by 25.4 mm (4 by 4 by 1 in.) are recommended.

12. Number of Specimens

12.1 Test three specimens for each sample. The values reported shall be the mean of those observed. If any value deviates more than 20 % from this mean, test two additional specimens and report the mean for all five values.

13. Procedure

13.1 Perform the entire test procedure at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$).

NOTE 5—See Practice D1349 if conditions other than these are desired.

13.2 Measure the test specimen original thickness (t_o) in accordance with the procedure in Section 8.

13.3 Place the test specimen or specimens in the apparatus in a manner that will not allow the specimens to come into contact with each other upon being compressed and deflect the specimens to $50\% \pm 1\%$ of their thickness.

13.4 Allow the test specimen to remain deflected in the apparatus for $22\text{ h} \pm 30\text{ minutes}$.

13.5 Remove the specimen from the test apparatus at the end of the 22-h period. Measure the final thickness (t_f) after $24\text{ h} \pm 30\text{ minutes}$ of recovery.

14. Calculation

14.1 Calculate the constant deflection compression set, expressed as a percentage of the original thickness, as follows:

$$C_d = \frac{(t_o - t_f)}{t_o} \times 100 \quad (1)$$

where:

C_d = compression set expressed as a percent of the original thickness,

t_o = original thickness, mm (in.), and

t_f = thickness of the specimen after the specified recovery period, mm. (in.)

15. Report

15.1 Report the average compression set value, of the three specimens tested, for each sample, except as noted in 13.1.

16. Precision and Bias

16.1 See Section 67 for precision and bias data.

Suffix D—Compression Deflection (Also called Load Deflection or Compressive Strength)

17. Scope

17.1 This test method covers the measurement of the force necessary to produce a 25 % compression over the entire top area of the foam specimen.

NOTE 6—Compression deflection tests other than at 25 % may be specified as agreed upon between the purchaser and the supplier.

18. Apparatus

18.1 An apparatus shall be provided having a flat compression foot, larger than the specimen to be tested, connected to a force-measuring device and mounted in a manner such that the product or specimen can be deflected (compressed) at a speed of 0.21 to 0.84 mm/s (0.5 to 2 in./min). The apparatus shall be arranged to support the specimen on a level horizontal plate.

19. Test Specimens

19.1 The test specimen shall be 50.8 by 50.8 by 25.4 mm (2 by 2 by 1 in.) with parallel top and bottom surfaces. The thickness shall be no greater than 75 % of the minimum top dimension.

19.2 Specimens shall be a minimum of 2580.6 mm² (4 in.²) in area and have a minimum thickness of 25.4 mm (1 in.). Specimens less than 25.4 mm thick shall be plied up, without the use of cement, to a minimum of 25.4 mm.

NOTE 7—Specimens less than 25.4 mm (1 in.) thick may be tested without being plied up, but the thickness must be specified.

20. Number of Specimens

20.1 Test three specimens for each sample. The values reported shall be the mean of those observed. If any value deviates more than 20 % from this mean, test two additional specimens and report the mean for all five values.

21. Procedure

21.1 Place the specimen centered in the line of the axial load on the supporting plate of the apparatus.

21.2 Bring the compression foot into contact with the specimen and determine the thickness after applying a total pretest-pressure of $190 \pm 50\text{ Pa}$ ($0.028 \pm 0.007\text{ psi}$) to the specimen area. Compress the specimen $25 \pm 0.5\%$ of this

thickness at 12.7 mm/min (0.5 in./min) and take the reading of the load immediately, unless another speed is specified.

NOTE 8—Where foam is appreciably compressed by this pretest-pressure, foot area and loading shall be as agreed upon between the purchaser and the supplier.

22. Calculation

22.1 Calculate the 25 % compression deflection force, per unit area of specimen, expressed as kilopascals (or pounds-force per square inch), as follows:

$$CD = \frac{F}{A} \quad (2)$$

where:

- CD = compression deflection force per unit of specimen area, kPa (psi),
 F = force required to compress the specimen 25 % of the thickness as measured in 8.2, N (lbf), and
 A = specimen compression contact surface area, m² (in.²).

23. Report

23.1 Report the average thickness after pretest pressure and the average compression deflection, for the three specimens tested, in kilopascals (or pounds-force per square inch), required for 25 % compression, except as noted in 20.1.

24. Precision and Bias

24.1 See Section 67 for precision and bias data.

Suffix G—Tear Resistance, Test Method D624

25. Test Method D624

25.1 Die C shall be used.

25.2 Test the material at the thickness to be supplied, unless otherwise arranged by agreement between the purchaser and the supplier.

Suffix L—Water Absorption

26. Scope

26.1 This test method covers the measurement of the water absorbed by olefin polymer flexible cellular materials during submersion under pressure.

27. Test Specimens

27.1 Test specimens shall be 101.6 by 101.6 mm (4 by 4 in.) by the thickness of material being supplied. The specimen may or may not have natural skins on top, bottom, or both surfaces.

28. Number of Specimens

28.1 Test three specimens for each sample. The values reported shall be the mean of those observed. If any value deviates more than 20 % from this mean, test two additional specimens and report the mean for all five values.

29. Procedure

29.1 Measure the area of the cut surfaces in accordance with Section 8 and calculate the area of the cut surfaces.

29.2 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 surfaces and reweigh.

NOTE 9—To remove visible and entrapped water from the surface and cut edges, direct a stream of air (using approximately 30 psi air pressure) at the surfaces and cut edges at approximately a 45 degree angle and from the distance of approximately 6.35 mm (0.25 in.) from the surface for approximately 4 min.

30. Calculation

30.1 Calculate the water absorption, expressed in kg/m² (lb/ft²) of cut surfaces (surfaces without skin or rind) as follows:

$$\text{Water Absorption} = \frac{W_2 - W_1}{A} \quad (3)$$

where:

- W_1 = specimen mass before immersion, kg (lb),
 W_2 = specimen mass after immersion, kg (lb), and
 A = area of cut surface, m² (ft²).

31. Report

31.1 Report the average water absorption in kg/m² (lb/ft²) of the three specimens tested, except as noted in 28.1.

32. Precision and Bias

32.1 See Section 67 for precision and bias data.

Suffix M—Flammability Ease of Ignition

33. See Test Method D2863

Suffix R₂—Energy Absorption

34. See Test Method F355

34.1 Procedure A of Test Method F355 shall be used.

34.2 The impact velocity shall be 3.45 ± 0.17 m/s.

NOTE 10—Approximate drop height is 60 cm (24 in.).

34.3 Conduct the test at 23 ± 2°C (73.4 ± 3.6°F).

34.4 The test specimens shall be 25.4 mm (1 in.) thick.

Suffix S—Thermal Stability

35. Scope

35.1 This test method covers the determination of dimensional stability of foam in any direction, at elevated temperature.

36. Apparatus

36.1 *Oven*, circulating-air, capable of holding the set temperature to a tolerance of ±1 %.

37. Test Specimen

37.1 The test specimens shall be 254 by 254 by 25.4 mm (10 by 10 by 1 in.). Where finished goods with smaller than the

specified test specimen are to be tested, the full available dimensions shall be used.

NOTE 11—An alternative test method is to cut 304.8 by 304.8-mm (12 by 12-in.) specimens and mark off the 254 by 254-mm (10 by 10-in.) dimensions.

38. Number of Specimens

38.1 A single specimen shall be tested for each sample.

39. Procedure

39.1 Determine all three dimensions in accordance with the procedure in Section 8.

39.2 Adjust the oven temperature to $70 \pm 2^\circ\text{C}$ ($158 \pm 3.6^\circ\text{F}$).

39.3 Expose the test specimen in the oven at the above temperature for $24 \text{ h} \pm 15 \text{ minutes}$.

39.4 Remove the test specimen and allow to cool at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) for $2 \text{ h} \pm 15 \text{ minutes}$.

39.5 Determine all three dimensions at the end of the cooling period.

40. Calculation

40.1 Calculate the dimensional change for each dimension as a percent of original as follows:

$$\% \text{ dimensional change} = \frac{L_f - L_o}{L_o} \times 100 \quad (4)$$

where:

L_o = original dimension, mm (in.), and

L_f = dimension at end of test, mm (in.).

41. Report

41.1 Report the dimensional change of each direction of interest as a percent of the original dimension.

41.2 Report shrinkage as negative values and growth as positive values.

42. Precision and Bias

42.1 See Section 67 for precision and bias data.

Suffix T—Tensile Strength and Elongation

43. See Test Methods D412

43.1 The samples shall be cut using the Die A, as described in Test Methods D412.

43.2 Test the material in the thickness to be supplied, unless otherwise agreed upon between the purchaser and the supplier.

Suffix V—Thermal Conductivity

44. Test Method A

44.1 See Test Method C177.

45. Test Method B

45.1 See Test Method C518.

Suffix W—Density

46. Test Method A

46.1 *Scope*—This test method covers the determination of density of foam by calculation from the mass and volume of a regularly shaped specimen.

46.2 *Test Specimen*—A representative test specimen of regular shape, not less than 16.4 cm^3 (1 in.^3) shall be cut from the sample to be tested.

NOTE 12—Larger specimens may be necessary when testing coarse cell foams.

46.3 *Number of Specimens*—A single specimen shall be tested for each sample.

46.4 *Procedure*:

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

46.4.2 Determine the dimensions of the specimen in accordance with Section 8.

46.5 *Calculation*—Calculate the density as follows:

$$D = \frac{m}{v} \quad (5)$$

where:

D = density, kg/m^3 (lb/ft^3),

m = mass, kg (lb), and

v = volume, m^3 (ft^3).

46.6 *Report*—Report density to the nearest 1.0 kg/m^3 (0.1 lb/ft^3).

47. Precision and Bias

47.1 See Section 67 for precision and bias data.

48. Test Method B

48.1 *Scope*—This test method covers the determination of the density of closed-cell foams where the volume is determined by a liquid displacement method and mass.

NOTE 13—This test method is particularly appropriate when testing small or irregularly shaped samples.

48.2 *Apparatus*:

48.2.1 *Scale or Balance*.

48.2.2 *Immersion Vessel*, as shown in Fig. 1.

48.2.3 *Receiving Vessel*, as shown in Fig. 1.

48.3 *Test Specimen*—Cut a representative test specimen not less than 16.4 cm^3 (1 in.^3) from the sample to be tested.

NOTE 14—Larger specimens may be necessary when testing coarse cell foams or foams with irregular surfaces.

48.4 *Number of Specimens*—Test a single specimen for each sample.

48.5 *Procedure*:

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

48.5.2 Fill the immersion vessel with liquid until it overflows. Insert the lid in the vessel.

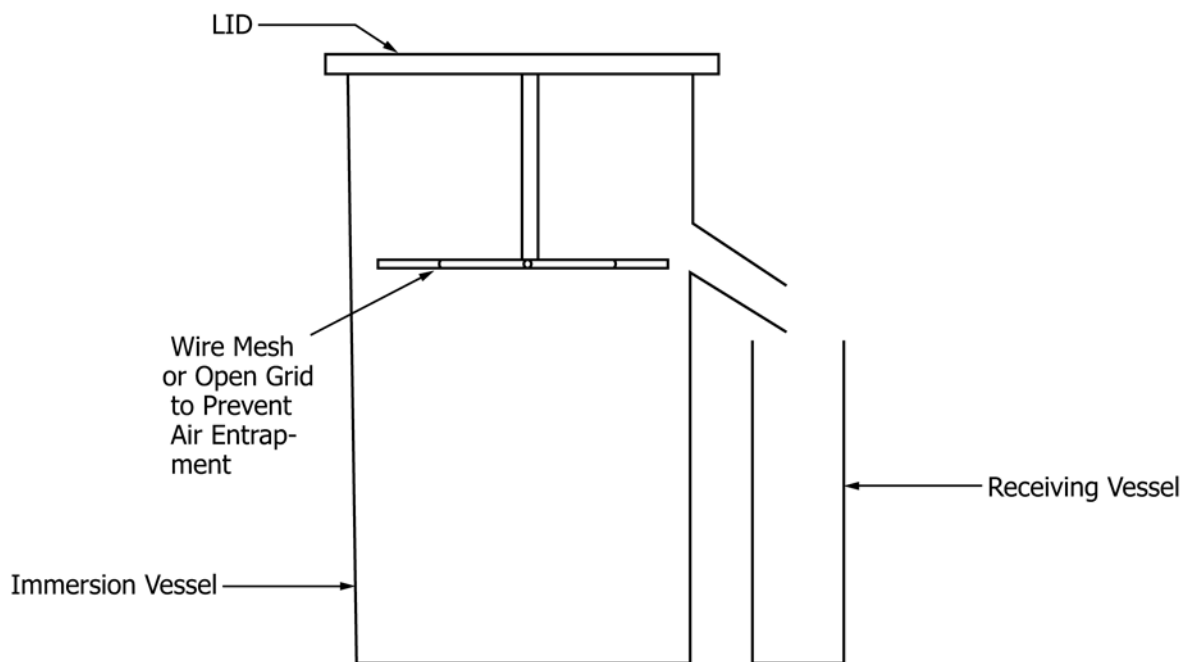


FIG. 1 Apparatus for Density Test Method B

48.5.3 Determine the tare mass of the receiving vessel and, when the flow rate has decreased to less than two drops per minute, place under the overflow spout of the immersion vessel.

48.5.4 Remove the lid, place the test specimen in the immersion vessel, and replace the lid.

48.5.5 When the flow rate has decreased to less than two drops per minute, weigh the receiving vessel.

48.6 Calculation—Calculate the density as follows:

$$d = \frac{m_s}{m_f - m_e} \times d_1 \quad (6)$$

where:

- d = density, kg/m³ (lb/ft³),
- m_s = mass of test specimen, g (lb),
- m_f = mass of receiving vessel and liquid, g (lb),
- m_e = tare mass of receiving vessel, g (lb), and
- d_1 = density of liquid, kg/m³ (lb/ft³).

48.7 Report—Report density to the nearest 1.0 kg/m³ (0.1 lb/ft³).

49. Precision

49.1 The repeatability standard deviation has been determined to be 0.47. The reproducibility of this test method is being determined and will be available on or before December 2009. Values of data ranged from 64.1 to 65.6.

	Density, kg/m ³ (Test Method B)
1	64.1
2	65.6
3	65.6
4	65.6
5	65.6
6	65.6
7	65.6
8	65.6

9	65.6
10	65.6
Average	65.6
Standard deviation	0.47

Suffix AA—Buoyancy (Also called Specific Buoyancy)

50. Scope

50.1 This buoyancy test is applicable to closed-cell materials for determining the buoyancy of the foam in fresh water at a standard temperature of 20°C (68°F).

51. Apparatus

51.1 Scale, Tape, or Gauge, as outlined in Section 8, for determining the density using Test Method A or balance and container as outlined in Section 48 for determining the density using Test Method B.

51.2 Rigid Tank, containing fresh water at 20 ± 3°C (68 ± 5.4°F) in which specimens are submerged.

51.3 Basket(s), wire or mesh weighted, to hold specimens in submerged position.

51.4 Scales, mounted over the water tank to weigh the basket and specimens while submerged.

52. Test Specimens

52.1 The test specimens shall be 304.8 by 304.8 mm (12 by 12 in.) by the thickness of buoyant material furnished.

NOTE 15—It is not advisable to ply up layers because this could cause entrapment of air between the layers giving erroneous results.

53. Number of Specimens

53.1 Test three specimens for each sample. The values reported shall be the mean of those observed. If any value deviates more than 20 % from this mean, test two additional specimens and report the mean for all five values.

54. Procedure

54.1 Determine the volume of each specimen using the procedure described in Section 46 or 48.

54.2 Maintain the water temperature at $20 \pm 3^\circ\text{C}$ ($68 \pm 5.4^\circ\text{F}$) throughout the test.

54.3 Weigh the inverted, empty basket, including all weights necessary to hold the specimen under water, while submerged to a depth of 50.8 mm (2 in.).

54.4 Place the specimen under the inverted basket and submerged so the upper surface of the specimen is 50 ± 6.375 mm (2 ± 0.25 in.) below the surface of the water.

54.5 Submerge the specimen for $24 \text{ h} \pm 15 \text{ min}$ and reweigh the submerged basket and specimen without removing them from the water.

54.6 Calculate the fresh water buoyancy as follows:

$$B_m = \frac{W_B - W_s}{V} \quad (7)$$

where:

- B_m = measured fresh water buoyancy, kg/m^3 (lb/ft^3),
- W_B = mass of submerged basket, kg (lb),
- W_s = mass of submerged basket and specimen after 24 h, kg (lb), and
- V = volume of specimen, m^3 (ft^3).

55. Report

55.1 Report the average fresh water buoyancy of the three specimens tested, except as noted in 53.1.

56. Precision and Bias

56.1 The repeatability standard deviation has been determined to be 0.9. The reproducibility of this test method is being determined and will be available on or before December 2009. Values of data ranged from 58 to 60.6.

Buoyancy	
1	58
2	58.4
3	58.5
4	58.7
5	58.9
6	59.3
7	59.7
8	60.2
9	60.3
10	60.6
Average	59.26
Standard deviation	0.9

Suffix BB—Constant Compression Creep

57. Scope

57.1 This test method covers the determination of creep properties of flexible polyolefin foam materials in the form of sheets, boards, or blocks, when subjected to a constant compressive force.

58. Summary of Test Method

58.1 A loaded, movable platen is placed on a test specimen to stimulate static constant compressive loading. By measuring

the change in thickness with time, creep properties of the foam material can be obtained.

58.2 The data may be affected by specimen area, thickness, varying ambient conditions of temperature, humidity, vibration, and impact.

59. Apparatus

59.1 The apparatus shall consist of a rigid base plate and a force movable platen. Provisions shall be made for applying a force to the movable platen. The base plate and movable platen shall have minimum dimensions of 114.3 by 114.3 mm (4.5 by 4.5 in.). The force shall be applied to the movable platen at a pivot point located at the geometric center of the platen. A dial micrometer shall be attached to the base plate or frame of the apparatus to permit continuous measurements of the travel of the movable platen. Any force-inducing mechanism that does not interfere with measurement of the movement of the movable platen is acceptable. A suitable apparatus is shown in Fig. 2.

60. Test Specimen

60.1 Test specimens shall be right square prisms or right cylinders with minimum area of 25.8 cm^2 (4 in.^2) and the maximum dimension shall be no greater than the size of the platen in 59.1. The thickness shall not exceed half of the lateral dimensions.

61. Number of Specimens

61.1 Test four specimens for each sample. The values reported shall be the mean of these observed. If any value deviates more than 20 % from this mean, test two additional specimens and report the mean of these six values.

62. Procedure

62.1 Measure the thickness of the specimen in accordance with Section 8. Record this value as the original thickness (T).

62.2 Measure the length and width of the specimen in accordance with Section 8 and record.

62.3 Assemble the apparatus described in 59.1. With the removable platen in contact with the base plate, position the dial micrometer to read thickness at the geometric center of the platen and adjust the micrometer to read zero. Raise the movable platen and center the test specimen under the movable platen on the base plate. Using appropriate means, apply the force agreed upon between the purchaser and the supplier, to the test specimen by placing the standard masses gently on the platen. Measure the total force. Start to measure the thickness of the test specimen while under load $60 \pm 5 \text{ s}$ after the force has been applied. Record this thickness as the initial thickness under force (T_i).

62.4 *Creep Determination*—Measure the thickness of the compressively stressed test specimen at any desired time interval, but at least at 6 min, 1 h, 24 h, and 168 h, after application of the force. More frequent readings are recommended to establish a creep versus time curve. Record the thickness at each specified time interval as the deflection thickness (T_d).

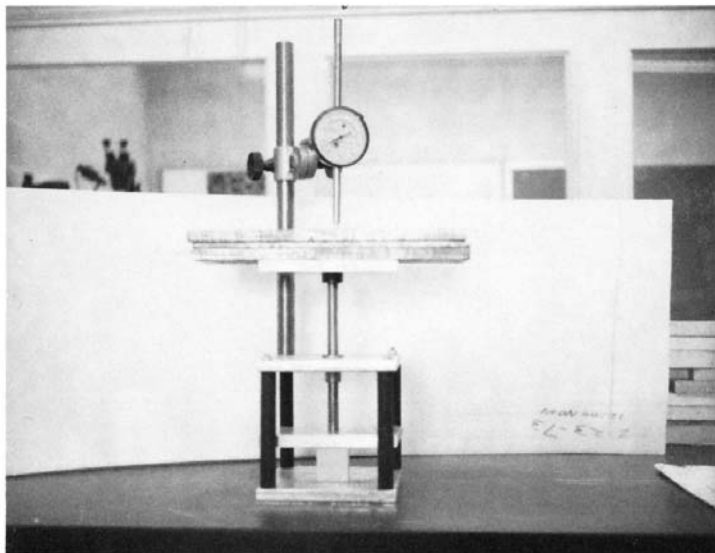


FIG. 2 Creep Test Apparatus

62.5 *Temperature and Humidity*—In order to establish data that will simulate actual conditions of experience, creep may be determined at varied temperatures and humidities. Record the temperature and humidity used.

63. Calculation

63.1 Calculate the static compressive stress in pascals (or pounds-force per square inch) for the given force as follows:

$$\text{Static stress} = \frac{F}{L \times W} \quad (8)$$

where:

- F = applied force, N (or lbf),
- L = length of the specimen, m (or in.), and
- W = width of the specimen, m (or in.).

63.2 Calculate creep based on initial thickness under compressive force as follows:

Creep at any given time interval, %

$$= \frac{(T_i - T_d)}{T_i} \times 100 \quad (9)$$

where:

- T_i = initial thickness under load, mm (in.), and
- T_d = deflection thickness, mm (in.).

64. Report

- 64.1 Report the following information:
 - 64.1.1 Origin and description of material tested,
 - 64.1.2 Dates of test,
 - 64.1.3 Number of specimens tested,
 - 64.1.4 Original dimensions of test specimens,
 - 64.1.5 Temperature and humidity used,
 - 64.1.6 Static stress, and
 - 64.1.7 Plot the average creep of the four specimens tested as a percent of the average initial thickness under load versus time.

Suffix CC—Dynamic Cushioning

65. See Test Method D1596

65.1 $A345 \pm 17$ cm/s (135 ± 7 in./s) impact velocity shall be used.

NOTE 16—Approximate drop height 61 cm (24 in.).

65.2 The test shall be conducted at $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) and $50 \pm 10\%$ relative humidity.

65.3 The test specimen shall be 50.8 ± 1.6 mm (2 ± 0.063 in.).

65.4 The missile mass varies with the sample size and shall be such that it would be equal to 6.9 kPa (1 psi).

65.5 Record the average values for Drops 2 through 5.

66. Precision and Bias

66.1 The repeatability standard deviation has been determined to be 0.03 (6 min), 0.11 (60 min), 0.13 (24 h), and 0.18 (168 h). The reproducibility of this test method is being determined and will be available on or before December 2009. Values of data ranged from 1.9 to 2.22 after 168 h.

	Constant Compression Creep			
	6 min	60 min	24 h	168 h
1	0.3	0.6	1.3	1.9
2	0.4	0.8	1.3	2
3	0.4	0.8	1.5	2.1
4	0.4	0.8	1.5	2.2
5	0.4	0.8	1.6	2.2
6	0.4	0.9	1.6	2.3
7	0.4	0.9	1.6	2.3
8	0.4	0.9	1.6	2.3
9	0.4	0.9	1.6	2.4
10	0.4	1	1.7	2.5
Average	0.39	0.84	1.53	2.22
Standard deviation	0.03	0.11	0.13	0.18

67. Precision and Bias

67.1 The precision of this test method is based on an interlaboratory study of this standard, conducted in 2013. Ten

laboratories participated in this study. Each of the labs was instructed to report triplicate test results for three different types of cellular materials. Every “test result” reported represents an individual determination. Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report No. D20-1262.

67.1.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

67.1.1.1 Repeatability can be interpreted as the maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

67.1.1.2 Repeatability limits are listed in Tables 2-8.

67.1.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

67.1.2.1 Reproducibility can be interpreted as the maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

67.1.2.2 Reproducibility limits are listed in Tables 2-8.

67.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

67.1.4 Any judgment in accordance with statements 67.1.1 and 67.1.2 will have an approximate 95 % probability of being correct. The precision statistics obtained in this ILS must not be treated as exact mathematical quantities which are applicable to all circumstances and uses. The limited number of materials tested may lead to times when differences greater than predicted by the ILS results will arise, sometimes with considerably greater or smaller frequency than the 95 % probability limit would imply.

67.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

67.3 The precision statement was determined through statistical examination of 501 results, from ten laboratories, on the three materials listed below.

Material A:	Low Density Polyethylene
Material B:	Medium Density Polyethylene
Material C:	High Density Polyethylene

To judge the equivalency of two test results, it is recommended to choose the cellular material closest in characteristics to the test material.

68. Keywords

68.1 closed cell materials; flexible cellular; olefin polymers

TABLE 2 Compression Set (%) 10 labs (78 results)

Material	Average ^A	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	\bar{x}	s_r	s_R	r	R
Material A	17.20	0.81	2.02	2.27	5.66
Material B	7.32	0.62	1.32	1.73	3.69
Material C	4.93	0.63	0.67	1.77	1.88

^AThe average of the laboratories' calculated averages.

TABLE 3 Thermal Stability - Width (%) 8 labs (72 results)

Material	Average [^]	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	\bar{x}	s_r	s_R	r	R
Material A	-2.23	0.18	0.81	0.49	2.28
Material B	-1.14	0.16	0.52	0.45	1.44
Material C	-0.68	0.15	0.35	0.42	0.99

[^]The average of the laboratories' calculated averages.

TABLE 4 Thermal Stability – Length (%) 8 labs (72 results)

Material	Average [^]	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	\bar{x}	s_r	s_R	r	R
Material A	-2.25	0.26	0.73	0.71	2.03
Material B	-1.17	0.12	0.57	0.34	1.59
Material C	-0.61	0.39	0.54	1.09	1.52

[^]The average of the laboratories' calculated averages.

TABLE 5 Thermal Stability – Thickness (%) 8 labs (72 results)

Material	Average [^]	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	\bar{x}	s_r	s_R	r	R
Material A	-1.71	0.27	0.73	0.76	2.04
Material B	-0.53	0.21	0.37	0.60	1.03
Material C	-0.16	0.48	0.56	1.34	1.58

[^]The average of the laboratories' calculated averages.

TABLE 6 Retest Compression Deflection (KPa) 7 labs (63 results)

Material	Average [^]	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	\bar{x}	s_r	s_R	r	R
Material A	34.05	0.84	2.91	2.36	8.14
Material B	108.43	2.16	7.45	6.06	20.85
Material C	117.58	2.98	6.99	8.35	19.58

[^]The average of the laboratories' calculated averages.

TABLE 7 Density (kg/m3) 10 labs (90 results)

Material	Average [^]	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	\bar{x}	s_r	s_R	r	R
Material A	36.87	1.12	3.55	3.14	9.95
Material B	54.61	3.38	4.34	9.47	12.15
Material C	110.96	2.13	4.85	5.96	13.58

[^]The average of the laboratories' calculated averages.

TABLE 8 Water Absorption (kg/m²) 6 labs (54 results)

Material	Average [^]	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	\bar{x}	s_r	s_R	r	R
Material A	0.0831	0.0058	0.0666	0.0162	0.1864
Material B	0.0407	0.0035	0.0367	0.0098	0.1028
Material C	0.0231	0.0026	0.0187	0.0074	0.0523

[^]The average of the laboratories' calculated averages.

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