Designation: D 1056 – 00

Standard Specification for Flexible Cellular Materials—Sponge or Expanded Rubber[1,2]

This standard is issued under the fixed designation D 1056; 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 Department of Defense to replace Methods 12001, 12005, 12011, 12021, 12031, 12041, 12151, and 12411 of Federal Test Method Standard No. 601.

This standard has been approved for use by agencies of the Department of Defense to replace MIL-STD-670 and MIL-STD-C 3133, which were discontinued in 1986.

1. Scope

1.1 This specification covers flexible cellular rubber products known as sponge rubber and expanded rubber, but does not apply to latex foam rubber or ebonite cellular rubber. The base material for an open/closed cellular product may be made of synthetic, natural, or reclaimed rubber, or a mixture, and may contain other polymers or chemicals, or both, which may be modified by organic or inorganic additives. These elastomeric materials have properties similar to those of vulcanized rubber, namely (1) the ability to be converted from a thermoplastic to a thermosetting state by crosslinking (vulcanization) or (2) the substantial recovery of their original shapes when strained or elongated, or both.

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

1.3 In case of conflict between the provisions of this general specification and those of detailed specifications or test methods for a particular product, the latter shall take precedence. Reference to the test methods in this specification should specifically state the particular test or tests desired.

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

1.5 The following safety hazards caveat pertains only to the test methods portions 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—ISO 6916-1 is similar to this specification.

2. Referenced Documents

2.1 *ASTM Standards:*

D 395 Test Methods for Rubber Property—Compression Set[3]

D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension[3]

D 471 Test Method for Rubber Property—Effect of Liquids[3]

D 573 Test Method for Rubber—Deterioration in an Air Oven[3]

D 575 Test Methods for Rubber Properties in Compression[3]

D 832 Practice for Rubber Conditioning for Low-Temperature Testing[3]

D 883 Terminology Relating to Plastics[4]

D 1171 Test Method for Rubber Deterioration—Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens)[3]

D 3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets[3]

D 3183 Practice for Rubber—Preparation of Pieces for Test Purposes from Products[3]

2.2 *ISO Standard:*[5]

ISO 6916-1 Flexible Cellular Polymeric Materials: Sponge and Expanded Cellular Rubber Products—Specification Part 1 Sheet

3. Terminology

3.1 *Definitions*—See Terminology D 883.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cellular material*—a generic term for materials containing many cells (either open or closed, or both) dispersed throughout the mass.

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

Current edition approved April 10, 2000. Published July 2000. Originally published as D 1056 – 49 T. Last previous edition D 1056 – 98.

[2] This version supercedes all prior versions of this specification.

[3] *Annual Book of ASTM Standards*, Vol 09.01.

[4] *Annual Book of ASTM Standards*, Vol 08.01.

[5] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

Copyright © ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States.

3.2.2 *closed cell*—a product whose cells are totally enclosed by its walls and hence not interconnecting with other cells.

3.2.3 *expanded rubber*—cellular rubber having closed cells made from a solid rubber compound.

3.2.4 *flexible cellular material*—a flexible cellular organic polymeric material that will not rupture within 60 s when a specimen 200 by 25 by 25 mm (8 by 1 by 1 in.) is bent around a 25-mm (1-in.) diameter mandrel at a uniform rate of 1 lap/5 s in the form of a helix at a temperature between 18 and 29°C (65 and 85°F).

3.2.5 *open cell*—a product whose cells are not totally enclosed by its walls and open to the surface, either directly or by interconnecting with other cells.

3.2.6 *rubber*—a material that is capable of recovering from large deformations quickly and forcibly, and can be, or already is, modified to a state in which it is essentially insoluble (but can swell) in boiling solvent (such as benzene, methyl ethyl ketone, and ethanol-toluene azeotrope).

3.2.7 *Discussion*—A rubber in its modified state, free of diluents, retracts within 1 min to less than 1.5 times its original length after being stretched at room temperature (20 to 27°C) to twice its length and held for 1 min before release.

3.2.8 *skin*—the textured outer surface on the material formed during manufacture by contact with molds, cover plate, air, or other curing medium.

3.2.9 *Discussion*—Normally, this skin is formed by contact with the mold or cover plates during manufacture. Molded open-cell (sponge) parts usually have a skin on all surfaces, except when cut to length from longer strips. Parts made by cutting from open-cell (sponge) sheets usually have skin on two faces and open cells at the cut edges. Closed-cell (expanded) rubber sheets are frequently split from thicker pieces and consequently do not have the skin faces. On some products it is desirable to add a solid rubber skin coating. The use to which the cellular rubber product is to be put determines the thickness of added skin required. Products subject to abrasion or open-cell (sponge) rubber that must withstand absorption of water or transmission of gases will ordinarily require an applied skin coating. Closed-cell (expanded) rubber does not usually require an added skin for these reasons.

3.2.10 *sponge rubber*—cellular rubber consisting predominantly of open cells made from a solid rubber compound.

4. Classification (Types, Classes, Grades, and Suffix Letters)

4.1 *Types*—These specifications cover two types of cellular rubber designated by the prefix numbers 1 and 2.

4.1.1 *Type 1*—Open-cell rubber.

4.1.2 *Type 2*—Closed-cell rubber.

4.1.3 See Section 3 for definitions of open and closed cell.

4.2 *Classes*—Both types are divided into four classes designated by the letters A, B, C, and D added to the number prefix. Basic requirements for classes are found in Tables 1 and 2.

4.2.1 *Class A*—Cellular rubber made from synthetic rubber, natural rubber, reclaimed rubber, or rubber-like materials, alone or in combination, where specific resistance to the action of petroleum base oils is not required.

4.2.2 *Class B*—Cellular rubber made from synthetic rubber or rubber-like materials alone or in combination, having specific requirements for oil resistance with low mass change.

4.2.3 *Class C*—Cellular rubber made from synthetic rubber or rubber-like materials alone or in combination, having specific requirements for oil resistance with medium mass change.

4.2.4 *Class D*—Cellular rubber made from synthetic rubber or rubber-like materials alone or in combination having specific requirements for extreme temperature resistance (−75 to 175°C) (−103 to 347°F); but specific resistance to the action of petroleum-base oils is not required.

4.3 *Grades*—Each type and class has been divided into a number of different grades. Each grade is based on a specific range of firmness as expressed by compression-deflection (see Sections 19 to 22). Grades are designated by digit, the softer grades being identified with the lower numbers and the higher grades being identified with the higher numbers.

4.3.1 *Grade 0*—For Types 1 and 2 cellular rubber, a compression-deflection range from 0 to 15 kPa (0 to 2 psi).

4.3.2 *Grade 1*—For Types 1 and 2 cellular rubber, a compression-deflection range from 15 to 35 kPa (2 to 5 psi).

4.3.3 *Grade 2*—For Types 1 and 2 cellular rubber, a compression-deflection range from 35 to 65 kPa (5 to 9 psi).

4.3.4 *Grade 3*—For Types 1 and 2 cellular rubber, a compression-deflection range from 65 to 90 kPa (9 to 13 psi).

4.3.5 *Grade 4*—For Types 1 and 2 cellular rubber, a compression-deflection range from 90 to 120 kPa (13 to 17 psi).

4.3.6 *Grade 5*—For Types 1 and 2 cellular rubber, a compression-deflection range from 120 to 170 kPa (17 to 25 psi).

NOTE 2—For conversion of types, classes, and grades to previous versions of Specification D 1056, see Appendix X1.

5. Materials and Manufacture

5.1 *Sponge Rubber*—Sponge rubber is made by incorporating into the compound a blowing agent, such as sodium bicarbonate, that gives off a gas which expands the mass during the vulcanization process. Sponge rubber is manufactured in sheet, strip, molded, or special shapes. Unless otherwise specified, sheet and strip sponge rubber shall have a natural skin on both the top and bottom surfaces. Fabric surface impressions are ordinarily not objectionable. The coarseness of the impressions shall be agreed upon between the parties concerned.

5.2 *Expanded Rubber*—Closed-cell rubber is made by incorporating gas-forming ingredients in the rubber compound, or by subjecting the compound to high-pressure gas, such as nitrogen. Expanded rubber is manufactured in sheet, strip, molded, tube, cord, and profile shapes by molding or extruding. Unless otherwise specified, the presence of skin on the top or bottom surfaces of sheet and strip expanded rubber shall be optional. Extruded shapes have skin on all surfaces except cut ends.

TABLE 1 Physical Requirements of Cellular Rubbers, Type 1, Open-Cell Sponge

Grade Number	Compression Deflection, 25 % Deflection (Limits), kPa (psi)	Compression Deflection after Oven Aging, Change from Original		Oil-Aged 22 h at 70°C (158°F), Change in Volume in ASTM Oil No. 3 (IRM 903) (Limits),%	Compression Set, 50 % Deflection, max,%		Low-Temperature Flex, 5 h at 55°C (−67°F)
		168 h at 70°C (158°F)	22 h at 150°C (302°F)		22 h at 70°C (158°F)	22 h at 100°C (212°F)	
Basic Requirements							
Class A, Non-oil-Resistant							
1A0	less than 15 (2)	±20[A]	...	...	15	...	...
1A1	15 to 35 (2 to 5)	±20	...	...	15	...	...
1A2	35 to 65 (5 to 9)	±20	...	...	15	...	...
1A3	65 to 90 (9 to 13)	±20	...	...	15	...	...
1A4	90 to 120 (13 to 17)	±20	...	...	15	...	...
1A5	120 to 170 (17 to 25)	±20	...	...	15	...	...
Class B, Oil-Resistant, Low Mass Change[B]							
1B0	less than 15 (2)	±20[A]	...	−25 to + 10	40	...	...
1B1	15 to 35 (2 to 5)	±20	...	−25 to + 10	40	...	...
1B2	35 to 65 (5 to 9)	±20	...	−25 to + 10	40	...	...
1B3	65 to 90 (9 to 13)	±20	...	−25 to + 10	40	...	...
1B4	90 to 120 (13 to 17)	±20	...	−25 to + 10	40	...	...
1B5	120 to 170 (17 to 25)	±20	...	−25 to + 10	40	...	...
Class C, Oil-Resistant, Medium Mass Change[B]							
1C0	less than 15 (2)	±20[A]	...	+ 10 to + 60	50	...	...
1C1	15 to 35 (2 to 5)	±20	...	+ 10 to + 60	50	...	...
1C2	35 to 65 (5 to 9)	±20	...	+ 10 to + 60	50	...	...
1C3	65 to 90 (9 to 13)	±20	...	+ 10 to + 60	50	...	...
1C4	90 to 120 (13 to 17)	±20	...	+ 10 to + 60	50	...	...
1C5	120 to 170 (17 to 25)	±20	...	+ 10 to + 60	50	...	...
Class D, High-Temperature-Resistant							
1D0	less than 15 (2)	...	±5	...	...	50	pass
1D1	15 to 35 (2 to 5)	...	±5	...	...	50	pass
1D2	35 to 65 (5 to 9)	...	±5	...	...	30	pass
1D3	65 to 90 (9 to 13)	...	±5	...	...	30	pass
1D4	90 to 120 (13 to 17)	...	±5	...	...	30	pass
1D5	120 to 170 (17 to 25)	...	±5	...	...	30	pass

TABLE 1 *Continued*

Requirements Added by Suffix Letters							
Grade Number	Compression Deflection, 25 % Deflection (Limits), kPa (psi)	A4	B1	F			M
		Compression Deflection after Oven Aging, Change from Original, 22 h, at 175°C (347°F), Limits, %	Compression Set, 50 % Deflection, 22 h at 70°C (158°F), max %	Low-Temperature Flex			Combustion Characteristics, max, 100 mm/min, (4 in./min)
				F1	F2	F3	
				5 h at −40°C (−40°F)	5 h at −55°C (−67°F)	5 h at −75°C (−103°F)	
	Class A, Non-oil-Resistant[A]						
1A0	less than 15 (2)	. . .	. . .	pass	pass	. . .	pass
1A1	15 to 35 (2 to 5)	. . .	. . .	pass	pass	. . .	pass
1A2	35 to 65 (5 to 9)	. . .	. . .	pass	pass	. . .	pass
1A3	65 to 90 (9 to 13)	. . .	. . .	pass	pass	. . .	pass
1A4	90 to 120 (13 to 17)	. . .	. . .	pass	pass	. . .	[pass
1A5	120 to 170 (17 to 25)	. . .	. . .	pass	pass	. . .	pass
	Class B, Oil-Resistant, Low Mass Change[B]						
1B0	less than 15 (2)	. . .	. . .	pass	. . .	. . .	pass
1B1	15 to 35 (2 to 5)	. . .	. . .	pass	. . .	. . .	pass
1B2	35 to 65 (5 to 9)	. . .	. . .	pass	. . .	. . .	pass
1B3	65 to 90 (9 to 13)	. . .	. . .	pass	. . .	. . .	pass
1B4	90 to 120 (13 to 17)	. . .	. . .	pass	. . .	. . .	pass
1B5	120 to 170 (17 to 25)	. . .	. . .	pass	. . .	. . .	pass
	Class C, Oil-Resistant, Medium Mass Change[B]						
1C0	less than 15 (2)	. . .	25	pass	. . .	. . .	pass
1C1	15 to 35 (2 to 5)	. . .	25	pass	. . .	. . .	pass
1C2	35 to 65 (5 to 9)	. . .	25	pass	. . .	. . .	pass
1C3	65 to 90 (9 to 13)	. . .	25	pass	. . .	. . .	pass
1C4	90 to 120 (13 to 17)	. . .	25	pass	. . .	. . .	pass
1C5	120 to 170 (17 to 25)	. . .	25	pass	. . .	. . .	pass
	Class D, High-Temperature-Resistant						
1D0	less than 15 (2)	±25	. . .	pass	. . .	pass	pass
1D1	15 to 35 (2 to 5)	±25	. . .	pass	. . .	pass	pass
1D2	35 to 65 (5 to 9)	±25	. . .	pass	. . .	pass	pass
1D3	65 to 90 (9 to 13)	±25	. . .	pass	. . .	pass	pass
1D4	90 to 120 (13 to 17)	±25	. . .	pass	. . .	pass	pass
1D5	120 to 170 (17 to 25)	±25	. . .	pass	. . .	pass	pass

[A] If this grade after aging still falls within the compression-deflection requirement of <15 kPa (2 psi), it shall be considered acceptable even though the change from the original is greater than ±20 %.

[B] Terminology was changed in 1997 from low swell to low mass change to better reflect the data obtained.

TABLE 2 Physical Requirements of Cellular Rubbers, Type 2, Closed-Cell Expanded

Basic Requirements									
Grade Number	Compression Deflection, 25 % Deflection (Limits), kPa (psi)	Oven-Aged, Change from Original Compression Deflection Values (Limits), %		Water Absorption, max, Change in Weight, %		Fluid Immersion, 7 Days at 23°C (73.4°F), max %[A]		Compression Set, 50 % Constant Deflection, 22 h at 100°C (212°F), max %	Low-Temperature Flex, 5 h at −55°C (−67°F)
		168 h at 70°C (158°F)	22 h at 150°C (302°F)	Density over 160 kg/m^3(10 lb/ft^3)	Density of 160 kg/m^3(10 lb/ft^3) or less	Density over 160 kg/m^3(10 lb/ft^3)	Density of 160 kg/m^3(10 lb/ft^3) or less		
	Class A, Nonfuel-Resistant								
2A0	less than 15 (2)	±30	...	5	10	...	...	...	...
2A1	15 to 35 (2 to 5)	±30	...	5	10	...	...	...	...
2A2	35 to 65 (5 to 9)	±30	...	5	10	...	...	...	...
2A3	65 to 90 (9 to 13)	±30	...	5	10	...	...	...	...

TABLE 2 *Continued*

2A4	90 to 120 (13 to 17)	±30	...	5	10	...	...	...	...
2A5	120 to 170 (17 to 25)	±30	...	5	10	...	...	...	...
				Class B, Fuel-Resistant, Low Mass Change[B]					
2B0	less than 15 (2)	±30	...	5	10	50	100	...	...
2B1	15 to 35 (2 to 5)	±30	...	5	10	50	100	...	...
2B2	35 to 65 (5 to 9)	±30	...	5	10	50	100	...	...
2B3	65 to 90 (9 to 13)	±30	...	5	10	50	100	...	...
2B4	90 to 120 (13 to 17)	±30	...	5	10	50	100	...	...
2B5	120 to 170 (17 to 25)	±30	...	5	10	50	100	...	...
				Class C, Fuel-Resistant, Medium Mass Change[B]					
2C0	less than 15 (2)	±30	...	5	10	150	250	...	...
2C1	15 to 35 (2 to 5)	±30	...	5	10	150	250	...	...
2C2	35 to 65 (5 to 9)	±30	...	5	10	150	250	...	...
2C3	65 to 90 (9 to 13)	±30	...	5	10	150	250	...	...
2C4	90 to 120 (13 to 17)	±30	...	5	10	150	250	...	...
2C5	120 to 170 (17 to 25)	±30	...	5	10	150	250	...	...
				Class D, High-Temperature-Resistant					
2D0	less than 15 (2)	...	±5	5	10	...	...	80	pass
2D1	15 to 35 (2 to 5)	...	±5	5	10	...	...	80	pass
2D2	35 to 65 (5 to 9)	...	±5	5	10	...	...	60	pass
2D3	65 to 90 (9 to 13)	...	±5	5	10	...	...	60	pass
2D4	90 to 120 (13 to 17)	...	±5	5	10	...	...	60	pass
2D5	120 to 170 (17 to 25)	...	±5	5	10	...	...	60	pass

Requirements Added By Suffix Letters

Grade Number	Compression Deflection 25 % Deflection (Limits), kPa (psi)	A				B		F			M
		Compression Deflection After Oven Aging, Change from Original Limits, %				Compression Set, 50 % Deflection, max %		Low Temperature Flex, 5 h at Temperature			Combustion Characteristics, 100 mm/min, max, (4 in./min)
		22 h at 100°C (212°F)	22 h at 125°C (257°F)	22 h at 150°C (302°F)	22 h at 175°C (350°F)	22 h at 23°C (73.4°F)	22 h at 23°C (73.4°F)	–40°C (–40°F)	–55°C (–67°F)	–75°C (–103°F)	
		A1	A2	A3	A4	B2	B3	F1	F2	F3	
2A0	less than 15 (2)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2A1	15 TO 35 (2 TO 5)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2A2	35 TO 65 (5 TO 9)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2A3	65 TO 90 (9 TO 13)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2A4	90 TO 120 (13 TO 17)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2A5	120 TO 170 (17 TO 25)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2B0	less than 15 (2)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2B1	15 TO 35 (2 TO 5)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2B2	35 TO 65 (5 TO 9)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2B3	65 TO 90 (9 TO 13)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2B4	90 TO 120 (13 TO 17)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2B5	120 TO 170 (17 TO 25)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2C0	less than 15 (2)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2C1	15 TO 35 (2 TO 5)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2C2	35 TO 65 (5 TO 9)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2C3	65 TO 90 (9 TO 13)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2C4	90 TO 120 (13 TO 17)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2C5	120 TO 170 (17 TO 25)	±30 %	±30 %	±30 %	±30 %	25 %	35 %	pass	pass	pass	pass
2D0	less than 15 (2)	NA[C]	NA[C]	NA[C]	±30 %	25 %	35 %	NA[C]	NA[C]	pass	pass
2D1	15 TO 35 (2 TO 5)	NA[C]	NA[C]	NA[C]	±30 %	25 %	35 %	NA[C]	NA[C]	pass	pass
2D2	35 TO 65 (5 TO 9)	NA[C]	NA[C]	NA[C]	±30 %	25 %	35 %	NA[C]	NA[C]	pass	pass
2D3	65 TO 90 (9 TO 13)	NA[C]	NA[C]	NA[C]	±30 %	25 %	35 %	NA[C]	NA[C]	pass	pass
2D4	90 TO 120 (13 TO 17)	NA[C]	NA[C]	NA[C]	±30 %	25 %	35 %	NA[C]	NA[C]	pass	pass
2D5	120 TO 170 (17 TO 25)	NA[C]	NA[C]	NA[C]	±30 %	25 %	35 %	NA[C]	NA[C]	pass	pass

[A] This test (see Sections 26-33) of weight change in Reference Fuel B is used in place of the usual oil-resistance test of volume change of No. 3 oil for the following reason: Oil or solvent immersion of flexible closed cellular materials usually causes loss of gas, by diffusion through the softened cell walls, that results in some shrinkage of the test sample. This shrinkage counteracts the swell that would normally occur, therefore invalidating test data based on volume change. Reference Fuel B is used because it produces a wider and more consistent differentiation among the A, B, and C classes than does the No. 3 oil.

[B] Standard oil resistance test methods give inconsistent results on closed cellular materials. This test gives a general indication of oil resistance but more reliable information should be obtained by testing in actual or simulated service conditions.

The values of 150 % maximum Class C and 50 % maximum Class B apply to cellular materials having densities of more than 160 kg/m ^{3}(10 lb/ft^3). For cellular materials with densities of 160 kg/m^3 or less, the values of maximum mass change allowed are 250 % for Class C and 100 % for Class B.

Terminology was changed in 1997 from low swell to low mass change to better reflect the data obtained.

[C] NA = Not applicable. Already covered as a basic requirement in Table 2.

6. Physical Properties

6.1 The various grades of cellular rubber shall conform to the requirements as to physical properties in Table 1 and Table 2together with any additional requirements indicated by suffix letters in the grade designations as described in Section 4 and Table 3.

7. Tolerances on Dimensions

7.1 Tolerances on dimensions of cellular rubber products shall be as specified in Table 4.

8. Color

8.1 Unless otherwise specified, the color of cellular rubber shall be black.

9. Workmanship, Finish, and Appearance

9.1 Cellular rubber furnished under this specification shall be manufactured from synthetic rubber, natural rubber, or rubber-like materials together with added compounding ingredients of such nature and quality that the finished product complies with the specification requirements. In permitting choice in use of those materials by the producer, it is not intended to imply that the different rubber materials are equivalent in respect to all physical properties. Any special characteristics other than those prescribed in this specification that may be desired for specific applications shall be specified in the product specifications, as they may influence the choice of the type of rubber material or other ingredients used. All materials and workmanship shall be in accordance with good commercial practice, and the resulting cellular rubber shall be free from defects affecting serviceability.

10. Test Methods

10.1 Unless specifically stated otherwise, all tests shall be made in accordance with the methods specified in Sections 14-67 and Table 3.

11. Sampling

11.1 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.

11.2 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 cure 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.

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

12. Inspection and Rejection

12.1 All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified. The manufacturer shall afford the inspector all reasonable facilities for tests and inspection.

12.2 The purchaser may make the tests and inspection to govern acceptance or rejection of the material at his own laboratory or elsewhere. Such tests and inspection shall be made not later than 15 days after receipt of the material.

12.3 All samples for testing, provided as specified in Section 11, shall be visually inspected to determine compliance with the material, workmanship, and color requirements.

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

12.5 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.

GENERAL TEST METHODS

14. Scope

14.1 Except as otherwise specified in these test methods, the following ASTM test methods and the various test methods in Table 3, applicable in general to vulcanized rubber, shall be complied with as required and are hereby made a part of these test methods:

14.1.1 *General Physical Test Requirements*— Practices D 3182 and D 3183.

14.1.2 *Aging Test*—Test Method D 573, with modifications as described in Sections 16-22 .

14.1.3 *Compression Set, Suffix B*—Test method described in Sections 49-55.

14.1.4 *Fluid Immersion, Suffix E*—Test Method D 471 and Sections 23-33.

14.1.5 *Low-Temperature Test, Suffixes F1, F2, and F3*—Test method described in Sections 56-60 . Suitable low-temperature cabinets and conditioning procedures are described in Practice D 832.

14.2 In case of conflict between provisions of the test methods referenced in 14.1.1-14.1.5 and the procedures specifically described herein for cellular rubbers, the latter shall take precedence.

15. Test Specimens and Slabs

15.1 *Test Specimens*—Standard test specimens shall be disks 28.00 ± 0.50 mm (1.10 ± 0.02 in.) in diameter, which yields a 645.70-mm^2(1-$in.^2$) specimen. The specimens may be

TABLE 3 ASTM Test Methods

NOTE 1—See Table 1 or Table 2 for established requirements for open or closed cell forms respectively.

NOTE 2—Test Methods D 412 was intended for testing dense rubber samples. It requires a sample thickness of between 1.5 and 3 mm (0.060 and 0.120 in.). This thickness is difficult to achieve on some foam products. In addition, foam samples, particularly low-compression deflection products can be difficult to measure gage. There is also no mention of allowance for skin or no skin samples. For these reasons, tensile samples tested in accordance with Specification D 1056 are allowed to be up to 6.5 mm (.250 in.) thick and should be tested with or without skin as used in the application.

Basic Requirements and Suffix Number Requirement or Suffix Letter	Basic Requirements	Suffix Number 1	Suffix Number 2	Suffix Number 3	Suffix Number 4
Compression deflection	Specification D 1056, Sections 17-22				
Heat resistance	Specification D 1056, Sections 16-22, change in compression deflection after aging 7 days at 70°C (158°F)				
Fluid resistance (1B and 1C rubber only)	Specification D 1056, Sections 23-33, 22 h at 70°C (158°F)				
Fluid resistance[A] (2B and 2C)	Specification D 1056 Sections 26-33, 7 days at 23°C (73.4°F)				
Compression set (1A, 1B, and 1C)	Specification D 1056, Sections 49-55, 22 h at 70°C (158°F), 50 % deflection, 30-min recovery at 23°C (73.4°F)				
Compression set (1D and 2D rubber only)	Specification D 1056, Sections 49-55, 22 h at 100°C (212°F), 50 % deflection, 30-min recovery at 23°C (73.4°F)				
Water absorption (2A, 2B, 2C, and 2D)	Specification D 1056, Sections 42-48				
Suffix A, heat resistance		Specification D 1056, Sections 16-22, change in compression deflection after aging 22 h at 100°C (212°F)	Specification D 1056, Sections 16-22, change in compression deflection after aging 22 h at 125°C (257°F)	Specification D 1056, Sections 16-22, change in compression deflection after aging 22 h at 150°C (302°F)	Specification D 1056, Sections 16-22, change in compression deflection after aging 22 h at 175°C (350°F)
Suffix B, compression set (B1 for 1A, 1B, and 1C only) (B2 & B3 for 2A, 2B, 2C, 2D only)		Specification D 1056, Sections 49-67, 22 h at 70°C (158°F), 50 % deflection, 30-min recovery at 23°C (73.4°F), 25 % max	Specification D 1056, Sections 49-67, 22 h at 23°C (73.4°F), 50 % deflection, 24-h recovery at 23°C (73.4°F), 25 % max	Specification D 1056, Sections 49-67, 22 h at 23°C (73.4°F), 50 % deflection, 24-h recovery at 23°C (73.4°F) 35 %, max	
Suffix C, ozone or weather resistance[B]		Test Method D 1171, ozone exposure, Test Method A	Test Method D 1171, outdoor exposure	Test Method D 1171, ozone exposure, Test Method B	
Suffix D, load deflection[C]					
Suffix E, fluid resistance[C]					
Suffix F, Low-temperature resistance		Specification D 1056, Sections 56-60, 5 h at −40°C (−40°F)	Specification D 1056, Sections 56-60, 5 h at −55°C (−67°F)	Specification D 1056, Sections 56-60, 5 h at −75°C (−103°F)	
Suffix G, tear resistance[B]					
Suffix J, abrasion resistance[C]					
Suffix K, adhesion capability[C]					
Suffix L, water absorption[C]					
Suffix M, combustion characteristics[D]		Test Method D 5132 100 mm/min, max (4 in./min, max)			
Suffix N, impact resistance[C]					
Suffix P, staining resistance[C]					
Suffix R, resilience[B]		Test Method D 2632 (Shore Rebound)			
Suffix T, Tensile/Elongation[B]		Test Method D 412 except specimen thickness, See Note 2			
Suffix W, density[B]		Specification D 1056 Sections 61-67			
Suffix Z, special requirements[C]					

[A] See Table 2 for materials having densities of 160 kg/m^3 (10 lb/ft^3) or less.
[B] Ratings to be arranged between the purchaser and the supplier.
[C] Test method and values to be arranged between the purchaser and the supplier.
[D] Specimen to be at application thickness.

TABLE 4 Tolerances on Dimensions of Cellular Rubber Products for General Applications

Form	Thickness		Length and Width	
	Dimension, mm (in.)	Tolerance, ±, mm (in.)	Dimension, mm (in.)	Tolerance, ±, mm (in.)
Sponge Rubber				
Sheet and strip	3.2 (0.125) and under	0.4 (0.016)	152 (6) and under	1.6 (0.063)
	Over 3.2 (0.125) to 12.7 (0.50), incl	0.8 (0.032)	Over 152 (6) to 457 (18), incl	3.2 (0.125)
	Over 12.7 (0.50)	1.2 (0.047)	Over 457 (18)	0.5 %
Molded or special shapes	6.4 (0.250) and under	0.8 (0.032)	6.4 (0.250) and under	0.8 (0.032)
	Over 6.4 (0.250) to 76.2 (3), incl	1.6 (0.063)	Over 6.4 (0.250) to 76 (3), incl	1.6 (0.063)
			Over 76 (3) to 457 (18), incl	3.2 (0.125)
			Over 457 (18)	0.5 %
Expanded Rubber				
Sheet and strip	3.2 (0.125) and under	1.6 (0.063)	152 (6) and under	6.4 (0.250)
	3.2 (0.125) to 12.7 (0.50), incl	1.6 (0.063)	152 (6) and under	6.4 (0.250)
	Over 12.7 (0.50)	2.4 (0.094)	Over 152 (6) to 305 (12), incl	9.6 (0.375)
			Over 305 (12)	3 %
Molded or special shapes	3.2 (0.125) to 12.7 (0.50), incl	1.6 (0.063)	152 (6) and under	6.4 (0.250)
	Over 12.7 (0.50) to 38.1 (1.50), incl	2.4 (0.094)	Over 152 (6) to 305 (12), incl	9.6 (0.375)
	Over 38.1 (1.50) to 76.2 (3), incl	3.2 (0.125)	Over 305 (12)	3 %

cut with a revolving die[6] using a soap solution as a lubricant. If a lubricant is used, the specimens shall be thoroughly dried before proceeding with the testing. In some cases it may be necessary to freeze the cellular rubber to obtain parallel cut edges. Samples shall not be compression die cut because this process distorts the sample, which will affect the final properties. When cut from standard test slabs they shall be cut from the center area as shown in Fig. 1. The thickness shall be measured as described in 15.3.2. As stated under the test methods, the minimum thickness of test specimens is 6.00 mm (0.24 in.). Plied-up samples may be used as indicated in the test methods for compression set and compression deflection (see Note 3 in 19.2).

15.2 *Test Slabs*—Standard test slabs of all types of cellular rubber shall be pieces 150 ± 5 mm (nominally 6 in.) square and 12.5 ± 0.5 mm (nominally 0.5 in.) in thickness made from the same compound and having the same apparent density and state of cure as the product they represent. In all cases the surface skin shall be left intact on both top and bottom faces of the test slab. Standard test slabs shall be prepared either by cutting them from flat sheets of the specified thickness or as described in 15.2.1 or 15.2.2.

15.2.1 When specially prepared standard test slabs of sponge rubber are required, they shall be made using the frame shown in Fig. 2 together with top and bottom plates each approximately 12.50 mm (0.50 in.) in thickness. The frame and plates shall be made of aluminum or steel. The stock shall be in sheet form, cut into squares slightly smaller than the frame

[6] A satisfactory die and its method of application are described in Section 4 of Test Methods D 575.

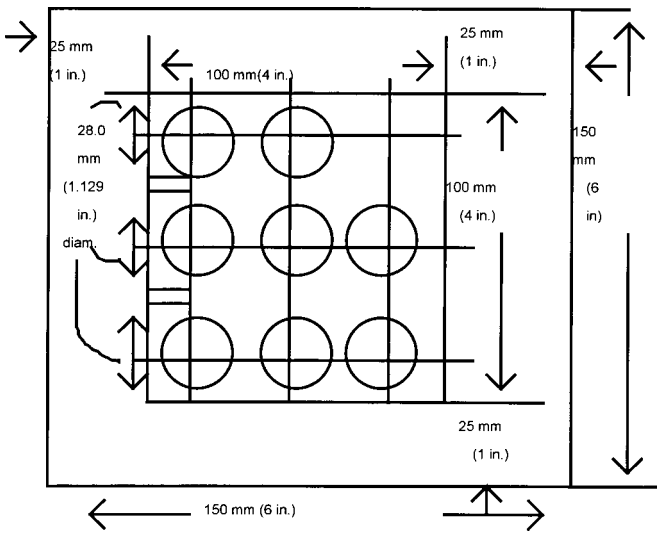

FIG. 1 Location from Which Standard Test Specimens Are to Be Cut When Testing Standard Test Slabs or Commercial Flat Sheet

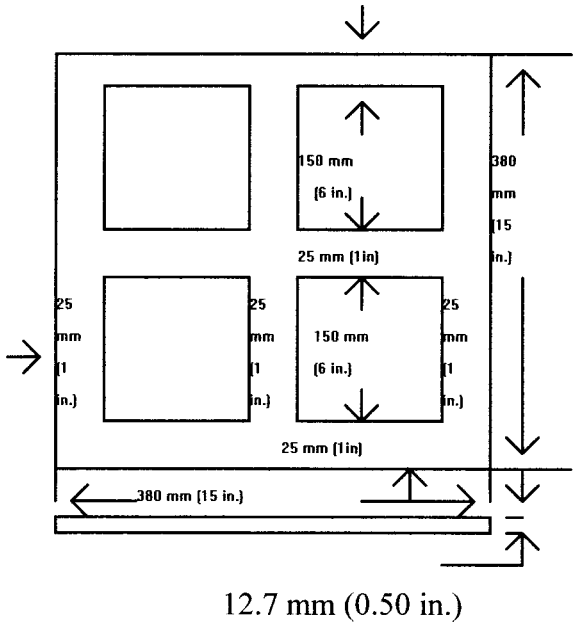

FIG. 2 Four-Cavity Frame for Standard Test Slabs of Cellular Rubbers

cavities. The thickness of the square sheets shall be such as to give the required apparent density when the material is blown during cure to fill the molding cavities. The squares of stock shall be dusted with talc and the excess brushed off to avoid pitting. They shall then be placed in the frame, and fabric sheeting shall be applied on the top and bottom between the frame and the plates to allow venting of gases produced during the cure. This fabric shall be a commercial sheeting with a mass of approximately 135 g/m^2(4 oz/yd^2), having approximately 2.75 ends/mm (70 ends/in.) and 2.36 picks/mm (60 picks/in.). The specimens shall be vulcanized in a platen press under conditions of time and temperature chosen to produce the same state of cure in the standard slabs as in the finished products they represent.

15.2.2 Where specially prepared standard test slabs of expanded rubber are required, they shall be made using the same process that was used for the product to be represented by the test slab. The specimens shall be prepared to have approximately the same density, and shall be vulcanized under conditions of time and temperature chosen to produce the same state of cure in the standard slabs as in the finished products they represent.

15.3 *Measurements of Test Specimens*:

15.3.1 The length and width shall be measured to 0.5 mm (0.02 in.). Care shall be taken not to distort the cellular rubber.

15.3.2 Thicknesses up to and including 25.0 mm (1 in.) shall be measured using a dial-type gage[7] having a maximum stem and foot mass of 25 g and a foot 30.0 mm (1.25 in.) in diameter. Thicknesses over 25 mm shall be measured using a sliding caliper gage. When a sliding caliper gage is employed, the gage setting shall be made with the gage out of contact with the cellular rubber. The sample shall be passed through the previously set gage and the proper setting shall be the one in which the measuring faces of the gage contact the surfaces of the article without compressing it.

15.3.3 The steel scale or tape used to measure length or width shall be graduated to 1 mm (0.031 in.). The dial gage for measuring thickness shall be graduated to 0.02 mm (0.001 in.). The calipers used for measuring thickness shall be graduated to 0.1 mm (0.005 in.).

15.3.4 Results shall be reported as the average of three measurements. If the results vary between the specimens more than 10 %, two additional specimens should be taken into the average.

ACCELERATED AGING TESTS

16. Test Specimen

16.1 The test specimen used in any of the aging tests shall be of the size and shape as specified by the appropriate called-out test method.

COMPRESSION-DEFLECTION TESTS

17. Scope

17.1 This test method consists of measuring the force necessary to produce a 25 % deflection on a test specimen.

18. Apparatus

18.1 Any compression machine that meets the following requirements will be satisfactory. The machine shall be capable of compressing the specimen at a rate of 12.5 to 50 mm/min (0.5 to 2 in./min) gently without impact. The machine may be motor- or hand-driven. It shall be equipped with a gage to measure the deflection caused by the increase in load. The rate of compression of the specimen is specified rather than the rate of the compressing platform of the machine. This is an important consideration when scales are used, since sponges of various compression-deflection characteristics will require different times to compress 25 % due to the travel of the scale platform under varying loads.

18.2 The deflection shall be read on a dial gage graduated in 0.02 mm (0.001 in.). No gage is necessary if the machine automatically compresses the specimen 25 %.

19. Test Specimens

19.1 Standard test specimens can be used for this test.

19.2 Test specimen size may vary provided the indenter foot of the apparatus used is larger than the sample. Test specimens may be cylindrical or square. They shall be cut so that opposite edges are parallel, either from the finished product in a manner agreed upon between the parties concerned or, as shown in Fig. 1, from standard test slabs or from flat sheets. The thickness of the test specimens may vary, but shall be measured and stated in the report. The minimum thickness shall be 6.0 mm (0.25 in.). Thin samples may be plied-up to obtain this thickness, or a standard test slab may be used if agreed upon between the manufacturer and the purchaser.

NOTE 3—In sponge rubbers, using the same compound, thin sections under 6 mm (0.25 in.) do not blow in the same manner as those over 6 mm. The thinner sections are usually higher in compression deflection and density. However, in closed-cell (expanded) rubbers where thin sheet are split from thicker sheets there is usually very little difference between the thin sheet and thicker sheets.

20. Procedure

20.1 Cellular rubber less than 6 mm (0.250 in.) in thickness shall be tested by plying up the proper number of plies to obtain a thickness as near 12.5 mm (0.50 in.) as possible. Compress the standard test specimen between the parallel metal plates of the machine until the thickness has been reduced 25 %, and take the reading of the load immediately. Repeat the test with the same specimen until the load readings do not change more than 5 %. The top and bottom plates shall be at least 38 mm (1.5 in.) in diameter.

21. Report

21.1 The unit load required for the last reading, expressed in kilopascals (or pounds per square inch), shall be reported as the result of the compression-deflection test.

22. Precsion and Bias

22.1 See Section 68.

[7] Supporting data are available from ASTM Headquarters. Request RR: D20-1198.

OIL-IMMERSION TEST, OPEN-CELL SPONGE (SEE Table 1)

23. Scope

23.1 This test method determines the fluid resistance (oil) of a sample (open cell sponge) by means of measuring volume change after a specified immersion time/temperature.

24. Test Specimens

24.1 Standard test specimens approximately 12.5 mm (0.50 in.) in thickness shall be used for this test. The diameter and thickness shall be measured before and after immersion in the specified petroleum-base oil for 22 h at 70°C (158°F) and the percent change in volume calculated. Three specimens shall be run on each test and the average of the three values reported.

25. Procedure

25.1 Follow the procedure of Test Method D 471, using petroleum base oil No. 3 (IRM 903).

NOTE 4—ASTM 3 oil was discontinued. IRM 903 is a recommended replacement. Results may vary between oils.

FLUID IMMERSION TEST, CLOSED CELL (EXPANDED) (SEE FOOTNOTE B, Table 2)

26. Scope

26.1 This test method determines the fluid resistance (fuel) of a sample (closed cell foam) by means of measuring weight change after a specified immersion time/temperature.

27. Apparatus

27.1 Equipment required are an analytical balance, screens, ASTM Reference Fuel B, paper towels, and 250-cm^3 (8-oz) containers (minimum size).

28. Test Specimens

28.1 The test specimens shall be 25 by 50 by 6 mm (nominally 1 by 2 by 0.250 in.). It is preferable that the specimens be cut with clean, square edges.

29. Procedure

29.1 Weigh the specimens to the nearest 0.01 g. Place a noncorrosive screen having 2-mm openings (10-mesh) on the bottom of the container. Alternatively place specimens of one material and screens into the cans. Use one can per material. Fill the cans with ASTM Reference Fuel B and seal with their lids. Store the cans for 7 days at a temperature of 23 ± 2°C (73.4 ± 3.6°F). Remove one specimen at a time from the test fluid. Without squeezing the specimen, place it on top of one sheet of paper towel and immediately place a second paper towel on top of it. Blot lightly without squeezing, then remove the top paper towel. Immediately determine the mass of the specimen to the nearest 0.01 g.

30. Calculation

30.1 Calculate the percent change in mass as follows:

$$W = [(A - B)/B] \times 100 \quad (1)$$

where:
W = change in mass, %,
A = final mass of specimen, and
B = initial mass of specimen.

31. Report

31.1 The report should include fluid type, time and temperature of test, data from three specimens, and the average of the three.

32. Requirements

32.1 See Table 1 and Table 2.

33. Precision and Bias

33.1 See Section 68.

TEST FOR COMPRESSION-DEFLECTION CHANGE AFTER OVEN AGING

34. Scope

34.1 This test method determines the heat aging properties of a sample by measuring the change in compression deflection after a specified time/temperature.

35. Test Specimen

35.1 *Sample Before Oven Aging*—A representative sample, approximately 12.5 mm (0.5 in.) thick and a minimum area of 161 cm^2 (25 $in.^2$).

35.2 *Specimen Size for Test Method*— Standard specimen size (in accordance with Section 15) shall be a disk 28.00 ± 0.50 mm (1.10 ± 0.02 in.) in diameter and approximately 12.5 mm (0.5 in.) thick. For thin materials the disks shall be stacked to approximately 12.5 mm in height.

36. Apparatus

36.1 The air-oven aging test as described in Test Method D 573 shall be used for cellular rubber, except that the sample and test specimen size shall be as described in Section 28. See Section 18 for compression deflection apparatus.

37. Procedure

37.1 Cut three standard test specimens out of a larger test sample and place the remaining part of the sample in an oven for 168± 1 h oven aging. Allow to cool for at least 2 but not more than 24 h and then cut three standard test specimens that are at least 1 in. from any edge or cut surface. Determine compression deflection (see Section 20). Determine percent change in compression deflection.

38. Calculation

38.1 Express the results as a percentage of the change in compression deflection, calculated as follows:

$$P = [(A - O)/O] \times 100 \quad (2)$$

where:
P = change in compression deflection, %,
O = original compression deflection, and
A = final compression deflection after oven aging.

39. Report

39.1 Report the following information:
39.1.1 Time and temperature of test,
39.1.2 Original and final compression deflection data,
39.1.3 Percent change for three specimens, and
39.1.4 Percent change, average of three specimens.

40. Requirements

40.1 See Table 1 and Table 2.

41. Precision and Bias

41.1 See Section 68.

WATER ABSORPTION TEST

42. Scope

42.1 This test method determines the water absorption properties of a closed cell foam by measuring the change in weight (mass) after a specified immersion period. This test method is indirectly a measure of the sample's cell structure/closed cell content. The water absorption test (see Footnote A of Table 2) is applicable to expanded rubber (closed-cell type). It should not be used on sponge rubber (open-cell type) unless they are completely encased in an added skin.

43. Test Specimens

43.1 Test specimens approximately 12.5 mm (0.050 in.) in thickness and 2500 mm^2 (4 $in.^2$) in area shall be used for this test. Round specimens are preferable.

44. Procedure

44.1 Submerge specimens in distilled water at room temperature (18 to 35°C (65 to 95°F)) 50 mm (2 in.) below the surface of the water, and reduce the pressure above the water to 17 kPa (2.5 psi) absolute for 3 min. Release the vacuum, and allow the specimen to remain submerged for 3 min at atmospheric pressure. Remove the specimen, blot dry, and calculate the percent change in mass.

45. Calculation

45.1 Calculate the percent change in mass as follows:

$$W = [(A - B)/B] \times 100 \quad (3)$$

where:
W = change in mass, %,
A = final mass of specimen, and
B = initial mass of specimen.

46. Report

46.1 Report the following information:
46.1.1 Original and final weights of three specimens,
46.1.2 Percent change in weight for each, and
46.1.3 Average percent change for the three specimens.

47. Requirements

47.1 See Table 2.

48. Precision and Bias

48.1 See Section 68.

TEST FOR COMPRESSION SET UNDER CONSTANT DEFLECTION (CALCULATIONS BASED ON AMOUNT OF DEFLECTION) SUFFIX B (1, 2, 3)

49. Scope

49.1 This test method determines the recovery properties of a sample when subjected to a constant deflection for a specified time/temperature/deflection by measuring its gage before and after the test period.

50. Test Specimens

50.1 Standard test specimens shall be used for this test. They shall be cut so that opposite edges are parallel, either from the finished product in a manner agreed upon between the parties concerned or, as shown in Fig. 1, 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. The minimum thickness for open-cell sponge rubber shall be 6 mm (0.250 in.). These samples of open-cell sponge rubber may be plied up to obtain this thickness. The minimum thickness for closed-cell expanded rubber shall be 12.5 mm (0.50 in.). Thin samples of closed-cell expanded rubber shall not be plied up to obtain this thickness. A standard test specimen may be used for either open-cell sponge or closed expanded material, if agreed upon between the manufacturer and the purchaser.

51. Procedure

51.1 The apparatus and procedure shall be the same as that prescribed in Method B of Test Methods D 395, except as follows: For open-cell (sponge) rubber, compress the test specimens to 50 % of their original thicknesses. Release the load at the end of 22 h and measure the thickness after a 30-min rest at room temperature. For closed-cell (expanded) rubber, compress the test specimens to 50 % of their original thicknesses. Release the load at the end of 22 h and measure the thickness after 24 h at room temperature. In both cases (open-cell sponge and closed-cell expanded rubber) measure the thickness as described in 15.3.2. The temperature of the test for open-cell (sponge) rubber shall be 70 ± 2°C (158 ± 3.6°F), except for Class 1D rubbers. The temperature of the test for closed-cell (expanded) rubber shall be 23 ± 2°C (73.4 ± 3.6°F), except for Class 2D rubber. For Class 1D and 2D rubber, the temperature of the test shall be 100 ± 1°C (212 ± 1.8°F). The time of the test shall be as specified. Chromium-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 load necessary for deflection of the specimen, may be used.

52. Calculation

52.1 Calculate percent compression set as follows:

$$\text{compression set, \%} = [(t_0 - t_1)/(t_0 - t_s)] \times 100 \quad (4)$$

where:
t_0 = original thickness,
t_1 = thickness of specimen after specified recovery period, and

t_s = thickness of spacer bar used.

53. Report

53.1 Report the following information:
53.1.1 Duration and temperature of oven exposure,
53.1.2 Original and final thickness for three specimens,
53.1.3 Percent set for each specimen, and
53.1.4 Average percent set for the specimens.

54. Requirements

54.1 See Table 1 and Table 2.

55. Precision and Bias

55.1 See Section 68.

LOW-TEMPERATURE FLEX TEST
SUFFIX F1, − 40± 1°C (−40 ± 2°F)
SUFFIX F2, − 55± 1°C (−67 ± 2°F)
SUFFIX F3, − 75± 1°C (−103 ± 2°F)

56. Scope

56.1 This test is to determine the brittleness of cellular rubber at low temperatures.

57. Apparatus

57.1 A low-temperature chamber capable of − 75°C (−103°F) 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. This chamber must be large enough to permit the bending of the test piece while it is still in the box.

57.2 Mandrel diameter shall be approximately 4 times the sample thickness.

58. Test Specimens

58.1 The test specimens shall be 50 ± 10 mm (2± 0.5 in.) wide by 140 ± 10 mm (6 ± 0.5 in.) long by 3 mm (0.125 in.) to 12.5 mm (0.50 in.) thick.

59. Procedure

59.1 Place three test specimens and mandrel in a low temperature chamber for 5 ± 0.25 h at − 40°C (−40°F), − 55°C (−67°F), or − 75°C (−103°F) as specified by the suffix letter and number.

59.2 At the end of the test period open the cold box and bend the specimen 180° around the mandrel taking no longer than 2 to 3 s to perform the bend. If there are multiple samples, bend and record results as soon as possible to maintain temperature to within ±5°C of set temperature.

60. Report

60.1 Report the following information:

60.1.1 Whether the sample showed any indication of cracking or if it was still pliable. All specimens must show no signs of cracking.

TEST FOR DENSITY
SUFFIX W

61. Scope

61.1 *Density Calculation (Suffix W)*— This test method describes the procedure for determining the density by calculation from the mass and volume of a specimen.

62. Test Specimen

62.1 Representative specimens of regular shape not less than 16 cm^3 (1 $in.^3$) in volume shall be cut from the sample to be tested.

63. Procedure

63.1 Weigh the specimen on a balance or scale graduated to permit weighing within ±1 % of the mass to be measured.

63.2 Determine the volume of the specimen to within± 1 % of the sample either by direct measurement or volume displacement.

64. Calculation

64.1 Calculate the density as follows:

$$\text{density, kg/m}^3 = A/B \quad (5)$$

where:
A = mass of specimen, kg, and
B = volume of specimen, m^3.

NOTE 5—To convert this value to lb/ft^3 multiply by 0.0624.

65. Report

65.1 Report the following information:

65.1.1 Mass, volume, and density of each specimen as well as the average value.

66. Requirements

66.1 To be determined between the supplier and the purchaser.

67. Precision and Bias

67.1 See Section 68.

PRECISION AND BIAS

68. Precision and Bias

68.1 Precision and bias for Specification D 1056 are based on a round robin study conducted in 1996/1997 in accordance with Practice E 691, involving three materials tested by 14 laboratories. For each material, all the samples were prepared at one source, but the individual specimens were prepared at the laboratories that tested them. Each test result was the average of three individual determinations. Each laboratory obtained two test results for each material. The number of data points for each test varied because not all laboratories were able to participate in each test. The data obtained and the number of laboratories participating in each test is indicated in Tables 5-10.

NOTE 6—**Caution:** The explanations of r and R (68.2-68.2.2) are only intended to present a meaningful way of considering the approximate

TABLE 5 Compression–Deflection in Accordance with Specification D 1056, Sections 17-22

NOTE 1— Values expressed in units of kPa.
NOTE 2— Data based on results from 14 laboratories.

Material	$\bar{x}$ (average)	S_r^A	S_R^B	r^C	R^D
C	30.84	0.88	4.48	2.45	12.55
B	43.36	1.19	4.51	3.32	12.62
A	104.11	1.95	12.64	5.47	35.38

[A] S_r = within laboratory standard deviation for the indicated material. It is obtained by pooling the within laboratory standard deviations of the test results from all of the participating laboratories, as follows:

$$S_r = [[(S_1)^2 + (S_2)^2 \ldots + (S_n)^2]/n]^{1/2}$$

[B] S_R = between laboratories reproducibility, expressed as a standard deviation, as follows:

$$S_R = [(S_r)^2 + (S_L)^2]^{1/2}$$

where S_L = standard deviation of laboratory means.
[C] r = within laboratory critical interval between the two test results = 2.8 × S_r.
[D] R = between laboratories critical interval between two test results = 2.8 × S_R.

TABLE 6 Compression Set in Accordance with Specification D 1056, Sections 49-55

NOTE 1—Values expressed in percent.
NOTE 2—Data based on results from 12 laboratories.

Material	$\bar{x}$ (average)	S_r^A	S_R^B	r^C	R^D
C	20.02	0.60	3.28	1.87	9.18
B	20.06	0.92	3.69	2.57	10.34
A	38.68	0.67	3.43	1.87	9.60

[A] S_r = within laboratory standard deviation for the indicated material. It is obtained by pooling the within laboratory standard deviations of the test results from all of the participating laboratories, as follows:

$$S_r = [[(S_1)^2 + (S_2)^2 \ldots + (S_n)^2]/n]^{1/2}$$

[B] S_R = between laboratories reproducibility, expressed as a standard deviation, as follows:

$$S_R = [(S_r)^2 + (S_L)^2]^{1/2}$$

where S_L = standard deviation of laboratory means.
[C] r = within laboratory critical interval between the two test results = 2.8 × S_r.
[D] R = between laboratories critical interval between two test results = 2.8 × S_R.

TABLE 7 Water Absorption in Accordance with Specification D 1056, Sections 42-48

NOTE 1—Values expressed in percent.
NOTE 2—Data based on results from 7 laboratories.

Material	$\bar{x}$ (average)	S_r^A	S_R^B	r^C	R^D
C	0.96	0.05	0.33	0.13	0.93
B	1.44	0.08	0.74	0.22	2.08
A	5.99	0.21	4.45	0.58	12.47

[A] S_r = within laboratory standard deviation for the indicated material. It is obtained by pooling the within laboratory standard deviations of the test results from all of the participating laboratories, as follows:

$$S_r = [[(S_1)^2 + (S_2)^2 \ldots + (S_n)^2]/n]^{1/2}$$

[B] S_R = between laboratories reproducibility, expressed as a standard deviation, as follows:

$$S_R = [(S_r)^2 + (S_L)^2]^{1/2}$$

where S_L = standard deviation of laboratory means.
[C] r = within laboratory critical interval between the two test results = 2.8 × S_r.
[D] R = between laboratories critical interval between two test results = 2.8 × S_R.

TABLE 8 Density in Accordance with Specification D 1056, Sections 61-67

NOTE 1—Values expressed in kg/m^3.
NOTE 2—Data based on results from 9 laboratories.

Material	$\bar{x}$ (average)	S_r^A	S_R^B	r^C	R^D
C	69.17	1.42	4.12	3.98	11.53
B	144.09	4.63	9.05	12.97	25.33
A	201.01	1.35	6.98	3.77	19.54

[A] S_r = within laboratory standard deviation for the indicated material. It is obtained by pooling the within laboratory standard deviations of the test results from all of the participating laboratories, as follows:

$$S_r = [[(S_1)^2 + (S_2)^2 \ldots + (S_n)^2]/n]^{1/2}$$

[B] S_R = between laboratories reproducibility, expressed as a standard deviation, as follows:

$$S_R = [(S_r)^2 + (S_L)^2]^{1/2}$$

where S_L = standard deviation of laboratory means.
[C] r = within laboratory critical interval between the two test results = 2.8 × S_r.
[D] R = between laboratories critical interval between two test results = 2.8 × S_R.

TABLE 9 Change in Compression Deflection after Oven Aging in Accordance with Specification D 1056, Sections 34-41

NOTE 1—Values expressed in percent.
NOTE 2—Data based on results from 11 laboratories.

Material	$\bar{x}$ (average)	S_r^A	S_R^B	r^C	R^D
C	−5.17	2.12	4.46	5.93	12.47
B	−8.44	3.61	5.60	0.83	15.93
A	21.95	4.28	6.33	11.97	17.71

[A] S_r = within laboratory standard deviation for the indicated material. It is obtained by pooling the within laboratory standard deviations of the test results from all of the participating laboratories, as follows:

$$S_r = [[(S_1)^2 + (S_2)^2 \ldots + (S_n)^2]/n]^{1/2}$$

[B] S_R = between laboratories reproducibility, expressed as a standard deviation, as follows:

$$S_R = [(S_r)^2 + (S_L)^2]^{1/2}$$

where S_L = standard deviation of laboratory means.
[C] r = within laboratory critical interval between the two test results = 2.8 × S_r.
[D] R = between laboratories critical interval between two test results = 2.8 × S_R.

TABLE 10 Fluid Immersion in Accordance with Specification D 1056, Sections 26-33

NOTE 1—Values expressed in percent.
NOTE 2—Data based on results from 11 laboratories.

Material	$\bar{x}$ (average)	S_r^A	S_R^B	r^C	R^D
C	113.15	3.60	21.61	10.07	60.52
B	153.46	5.54	28.82	15.51	80.70
A	250.21	11.02	36.36	30.85	101.82

[A] S_r = within laboratory standard deviation for the indicated material. It is obtained by pooling the within laboratory standard deviations of the test results from all of the participating laboratories, as follows:

$$S_r = [[(S_1)^2 + (S_2)^2 \ldots + (S_n)^2]/n]^{1/2}$$

[B] S_R = between laboratories reproducibility, expressed as a standard deviation, as follows:

$$S_R = [(S_r)^2 + (S_L)^2]^{1/2}$$

where S_L = standard deviation of laboratory means.
[C] r = within laboratory critical interval between the two test results = 2.8 × S_r.
[D] R = between laboratories critical interval between two test results = 2.8 × S_R.

precision of this test method. The data should not be applied to acceptance or rejection of materials, as these data apply only to the materials listed in the round robin and are unlikely to be rigorously representative of other lots, formulations, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in Practice E 691 to generate data specific to their materials and laboratory (or between specific laboratories).

68.2 *Concept of r and R in* Tables 5-10—If S_r and S_R have been calculated from a large enough body of data, and for test results that were averages from testing three specimens for each test result, then the following applies:

68.2.1 *Repeatability*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the *r* value for that material (*r* is the interval representing the critical difference between the two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory).

68.2.2 *Reproducibility*—Two test results obtained by different laboratories shall be judged not equivalent if they differ by more than the *R* value for that material (*R* is the interval representing the critical difference between two test results for the same material, obtained by different operators, using different equipment in different laboratories).

68.2.3 Any judgment in accordance with Tables 5-10 would have an approximate 95 % (0.9) probability of being correct.

68.3 *Bias*—There are no recognized standards by which to estimate bias for these test methods.

69. Keywords

69.1 expanded rubber; flexible cellular; sponge

APPENDIX

(Nonmandatory Information)

X1. CROSS REFERENCE TABLES

TABLE X1.1 Cross Reference to Previous Versions of Specification D 1056

NOTE 1—*Example:* Grade 1A1C1F1 denotes soft sponge rubber containing natural, reclaimed, synthetic or blends of these rubbers with a compression deflection value of 14 to 35 kPa (2 to 5 psi), having no specific solvent or oil resistance and requiring in addition to the basic tests, a weather resistance test run in accordance with Test Method D 1171, Ozone Chamber Exposure, Method A, and a low-temperature test at –40°C (–40°F).

D 1056–68	D 1056–73	D 1056–77	D 1056–85
RE 41 BF1	RE 41 BF1	RE 41 B2F1	2A1 B2F1
SBE 43 BCF2	RE 43 BCE2F2	RE 43 B2C1E2F2	2B3 B2C1F2
SCE 42	RE 42 E1	RE 42 E1	2C2
SBO 12 BF1	SBO 12 BF1	SBO 12 B1F1	1B2 B1F1
SCO 13 CF2	SCO 13 CF2	SCO 13 C2F2	1C3 C2F2

TABLE X1.2 Cross-Reference of Specification D 1056 versus MIL–STD–670B

NOTE 1—Reference Mil Std. 670B Notice 1—April 14, 1986.

D 1056 Grade Numbers	MIL-STD-670B Grade Numbers	D 1056 Grade Numbers	MIL-STD-670B Grade Numbers
RO 10	RO 1	RE 41	SBE 3
RO 11	RO 3	RE 42	SBE 7
RO 12	RO 7	RE 43	SBE 11
RO 13	RO 11	RE 44	SBE 15
RO 14	RO 15	RE 45	SBE 20
RO 15	RO 20		
SBO 10	SBO 1	RE 41	SCE 3
SBO 11	SBO 3	RE 42	SCE 7
SBO 12	SBO 7	RE 43	SCE 11
SBO 13	SBO 11	RE 44	SCE 15
SBO 14	SBO 15	RE 45	SCE 20
SBO 15	SBO 20		
SCO 10	SCO 1	TO 11	TO 3
SCO 11	SCO 3	TO 12	TO 7
SCO 12	SCO 7	TO 13	TO 12
SCO 13	SCO 11	TO 14	TO 18
SCO 14	SCO 15	TO 15	TO 25
SCO 15	SCO 20		
RE 41	RE 3	TE 41	TE 3
RE 42	RE 7	TE 42	TE 7
RE 43	RE 11	TE 44	TE 12
RE 44	RE 15	TE 45	TE 18
RE 45	RE 20		TE 25

TABLE X1.3 Specification D 1056 Equivalency Cross-Reference Chart for Years as Noted

	1965	1967T	1968	1973	1978	1985	1991	1996
		Type R Non-Oil Resistance		Type R General Purpose			Class A Non Oil Resistant	
G	RE41	RE41	RE41	RE41	RE41	2A1	2A1	2A1
R	RE42	RE42	RE42	RE42	RE42	2A2	2A2	2A2
A	RE43	RE43	RE43	RE43	RE43	2A3	2A3	2A3
D	RE44	RE44	RE44	RE44	RE44	2A4	2A4	2A4
E	RE45	RE45	RE45	RE45	RE45	2A5	2A5*	2A5
				All types and classes listed as RE				
	Type S, Class SB Oil Resistant - Low			Mass Change		Class B Oil Resistant Low	Mass Change	
G	SBE41	SBE41	SBE41@	No Type S		2B1	2B1	2B1
R	SBE42	SBE42	SBE42@	No Class SB		2B2	2B2	2B2
A	SBE43	SBE43	SBE43@	Use Suffix E2		2B3	2B3	2B3
D	SBE44	SBE44	SBE44@	Densities under		2B4	2B4	2B4
E	SBE45	SBE45	SBE45@	160 Kg/m^3 100 % Allowed (10 lbs/ft^3)		2B5	2B5*	2B5
	Type S, Class SC Oil Resistant - Medium			Mass Change		Class C Oil Resistant Medium	Mass Change	
G	SCE41	SCE41	SCE41@	No Type S		2C1	2C1	2C1
R	SCE42	SCE42	SCE42@	No Class SC		2C2	2C2	2C2
A	SCE43	SCE43	SCE43@	Use Suffix E1		2C3	2C3	2C3
D	SCE44	SCE44	SCE44@	Densities under		2C4	2C4	2C4
E	SCE45	SCE45	SCE45@	160 Kg/m^3 250 % Allowed (10 lbs/ft^3)		2C5	2C5*	2C5
Compression Set Only a Suffix Requirement As Noted Suffix B - 25 % Max.	Suffix Rqmt.	Suffix Rqmt.	Suffix Rqmt.	Suffix Rqmt.	Suffix Rqmt. B2 added RT Same as Old "B"	Suffix Rqmt. Listed as B Should say B2	Suffix Rqmt. Listed as B Should say B2	Suffix Rqmt. Listed as B Should say B2
Oil/Fuel Immersion Basic Rqmt. or Suffix Requirement As Noted Suffix E1 E2	Suffix Rqmt. Type R Can be called SBE & SCE	Suffix Rqmt. Type R Can be called SBE & SCE	Basic Rqmt. R Can't be SBE or SCE SBE 50 % SCE 150 % 1st time Fuel B	Suffix Requirement for E1 and E2 No SCE or SBE		Basic Rqmt. 2B 50 % & 100 % 2C 150 % & 250 %	Basic Rqmt. 2B 50 % & 100 % 2C 150 % & 250 %	Basic Rqmt. 2B 50 % & 100 % 2C 150 % & 250 %

Compression deflection
* Range Changed from 24 to 25 Max. T = Temporary
@ No Allowance for densities under 160 Kg/m^3(10 lbs/ft^3)

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).