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Standard Test Methods for Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams[1]

This standard is issued under the fixed designation D3574; 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.

1. Scope*

1.1 These test methods apply to slab, bonded, and molded flexible cellular products known as urethane foams. Urethane foam ~~may be~~is generally defined as an expanded cellular product produced by the interaction of active hydrogen compounds, water, and isocyanates.

1.2 *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.*

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

NOTE 1—There is no known ISO equivalent to this standard, however certain test methods in this standard have similar or equivalent ISO standards and are listed in the scope of the individual test method sections.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D412 Test Methods for Vulcanized Rubber and Thermoplastic ElastomersTension
D624 Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers ~~D726Test Method for Resistance of Nonporous Paper to Passage of Air~~
D737 Test Method for Air Permeability of Textile Fabrics
D3576 Test Method for Cell Size of Rigid Cellular Plastics
D3675 Test Method for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source
E162 Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source
E662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *bonded foam*—a product produced by the adhesion of small pieces of urethane foam to each other with a suitable bonding agent.

3.1.2 *core*—the internal portion of a molded part, free of skin.

3.1.3 *cored foam*—a flexible cellular material containing a multiplicity of holes (usually, but not necessarily, cylindrical in shape), molded or cut into the material in some pattern, normally perpendicular to the foam rise direction, and extending part or all the way through the piece.

3.1.4 *convoluted foam*—a flexible cellular material specially cut into sheets with "egg carton"-like dimples. The dimple peaks and bases can have varied shapes and dimensions.

3.1.5 *flexible cellular product*—a cellular organic polymeric material that will not rupture when a specimen 200 by 25 by 25 mm is bent around a 25-mm diameter mandrel at a uniform rate of one lap in 5 s at a temperature between 18 and 29°C.

[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.

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

3.1.6 *molded foam*—a cellular product having the shape of the enclosed chamber in which it is produced by foaming.

3.1.7 *skin*—the smooth surface layer of a molded foam product, formed by contact with the mold or surfaces.

3.1.8 *slab*—a section of foam that is cut from the internal portion of a large bun.

3.1.9 *urethane foam*—a flexible cellular product produced by the interaction of active hydrogen compounds, water, and isocyanates.

3.1.10 *viscoelastic foam*—a specially formulated urethane foam characterized by having slow recovery, low resilience, and high hysteresis loss.

3.1.11 *cell count*—a measurement used to characterize different types of foams based on the size of the individual cells in the foam matrix, typically expressed as either average cell diameter or as the number of cells per linear distance. For measuring cell counts, see Test Method D3576

3.1.12 *clickability*—the ability of a flexible cellular material to recover from the pinching effects of die cutting.

4. Summary of Test Methods

4.1 Unless specifically stated otherwise between the supplier and the purchaser, all tests shall be made in accordance with the methods specified in Sections ~~9-124~~ 9-133 which include test procedures for the following:

Tests:		Sections
Test A	Density Test	9-15
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Test B_2	Indentation Residual Gauge Length Test—Specified Force (IRGL)	23-29
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Test I_2	Dynamic Fatigue Test, Roller Shear	86-94
~~Test I_3~~	~~Dynamic Fatigue Test by Constant Force Pounding~~	~~95-103~~
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~~Test I_4~~	~~Dynamic Fatigue Test for Carpet Cushion~~	~~104-112~~
Test I_4	Dynamic Fatigue Test, Carpet Cushion	104-112
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~~Aging Test J~~	~~Steam Autoclave Aging~~	~~113-118~~
Aging Test J	Steam Autoclave Aging	122-127
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~~Aging Test L~~	~~Wet Heat Aging~~	~~125-130~~
Aging Test L	Wet Heat Aging	134-139
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Test M	Recovery Time	140-145

Appendixes:

X1.	Suggested Method for Specifying Flexible Urethane Foams
X2.	Suggested Method of Construction for a Roller Shear Dynamic Flex Fatigue Apparatus
X3.	Definitions of Terms Used to Describe the Force-Deflection Curve of Flexible Urethane Foam
X4.	Suggested Tests for Determining Combustibility of Flexible Urethane Foam. (The combustion tests are given for informational purposes only and are not part of the standard.)
X5.	Suggested Method for Verification of an Inclined Oil Manometer
X6.	Suggested Method for Measuring Hysteresis Loss of Foams

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 in use.

6. General Test Conditions

6.1 Tests shall be conducted under known conditions of temperature and humidity or as specified in the individual test procedure. The product shall be conditioned undeflected, and undistorted at the temperature and humidity of test for at least 12 h before being tested. In cases of dispute, the tests shall be made at a temperature of 23 ± 2°C and in an atmosphere of 50 ± 5 % relative humidity.

6.2 It is recommended for referee purposes that all tests shall be performed 7 days or more after the foam has been manufactured.

6.3 For mechanical tests, it is advisable to carefully select the proper load cell for each test. It is recommended that the expected load for any individual test falls within 10-90 % of the load cell capacity.

7. Sampling

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

7.2 When it is necessary or advisable to obtain specimens from the articles, 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 density and the state of cure ~~may~~can 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 density is affected by the number of cut surfaces on the specimen. If a test specimen is die cut, ~~sufficient time should be allowed~~ ensure that the sides are not concaved and allow sufficient time for complete recovery of the thickness across the full width of the specimen before testing.

7.3 When the finished molded product does not lend itself to testing or to the taking of specimens because of complicated shape, small size, metal or fabric inserts, adhesion to metal, or other reasons, molded test slabs as agreed upon between the supplier and the purchaser shall be prepared.

7.4 When differences in test results arise due to the difficulty in obtaining suitable specimens from the finished parts, the supplier and the purchaser ~~may~~shall agree upon an acceptable location to take the specimen.

8. Measurement of Test Specimens

8.1 Measure the length and width with a scale, tape, or ~~tape.~~ caliper gauge. Take care not to distort the foam.

8.2 Measure thickness up to and including 25 mm using a ~~dial-type~~height or electronic display gauge with a minimum foot area of 650 mm^2. Hold the pressure of the ~~dial~~gauge foot to a maximum of 800 Pa (see Note 2). Thicknesses over 25 mm ~~may~~shall be measured with a ~~dial~~height or electronic display gauge, a sliding caliper gauge, or as specified in 8.1. When a sliding caliper gauge is employed, make the gauge setting with the gauge out of contact with the foam. Pass the specimen through the previously set gauge; the proper setting shall be the one when the measuring faces of the gauge contact the surfaces of the specimen without compressing it.

NOTE 2—For soft foams having compression force deflection values less than 1.65 kPa, the pressure on the ~~dial~~gauge or compression foot shall not exceed 200 Pa.

8.3 The scale, tape, or gauge shall be graduated so as to permit measurements within ±1 % of the dimensions to be measured.

8.4 Unless otherwise specified, results shall be the mean of the measurements.

TEST A—DENSITY TEST

9. Scope

9.1 This test method covers determination of the density of uncored foam by calculation from the mass and volume of the specimen. The density value thus obtained applies only to the immediate area from which the specimen has been taken. It does not necessarily relate to the bulk density of the entire molded pad.

NOTE 3—This standard is equivalent to ISO 845.

10. Test Specimen

10.1 *Core Density*—A representative specimen of regular shape, circular or square without skins or densification lines, not less than 1000 mm^3 in volume, shall be cut from a portion free of voids and defects and as near as possible to the section from which the tension and tear specimens were taken.

10.2 *Section Density*—A representative specimen with skins on the top and bottom surface measuring at least 0.1 m^2 in area by full-part thickness shall be cut from an area free of voids and defects and as near as possible to the location from which the tension and tear specimens were taken. When these dimensions are not possible, the largest representative portion as agreed upon between the supplier and the purchaser shall be used.

11. Number of Specimens

11.1 One specimen shall be tested, unless otherwise agreed upon by the supplier and the purchaser.

12. Procedure

12.1 Determine the mass of the specimen within 1 %.

12.2 Determine the dimensions of the specimen in accordance with Section 8, and calculate the volume.

13. Calculation

13.1 Calculate the density in kilograms per cubic metre as follows:

$$\text{Density} = M/V \times 10^6 \quad (1)$$

where:

M = mass of specimen, g, and

V = volume of specimen, mm^3.

14. Report

14.1 Report the following information:

14.1.1 Density to the nearest 0.1 kg/m^3, and

14.1.2 Type of specimen, core or section.

15. Precision and Bias

15.1 See Section ~~137~~ 146 for Precision and Bias statements.

TEST B_1 —INDENTATION FORCE DEFLECTION TEST—SPECIFIED DEFLECTION (IFD)

16. Scope

16.1 This will be known as the indentation force deflection test and the results as the IFD values. This test consists of measuring the force necessary to produce designated indentations in the foam product, for example, 25 and 65 % deflections. (See Appendix X3 ~~).~~ for additional information).

NOTE 4—This standard and ISO 2439 address the same subject matter, but differ in technical content and results cannot be directly compared between the two methods.

17. Apparatus

17.1 An apparatus having a flat circular ~~indentor~~indenter foot 200 +3/–0 mm in diameter connected by means of a swivel joint capable of accommodating the angle of the sample to a force-measuring device and mounted in such a manner that the product or specimen can be deflected at a speed of 50 to ~~500~~250 mm/min. The apparatus shall be arranged to support the specimen on a level horizontal plate which is perforated with approximately 6.5-mm holes on approximately 20-mm centers to allow for rapid escape of air during the test. Special support for contoured molded pads shall be perforated in the same manner as the flat plate unless agreed upon between the supplier and the purchaser. Pads longer than the base plate shall be supported from distortion at the 4.5-N contact force.

NOTE 5—Equipment design and test fixturing can affect the results of this test. As an example, load cells placed below the support plate can experience a bridging effect that likely does not occur in equipment which has the load cell mounted above the indenter foot.

18. Test Specimen

18.1 The test specimen shall consist of the entire product sample or a suitable portion of it, except that in no case shall the specimen have dimensions less than 380 by 380 by 100 mm. Specimens less or different than 100 mm in thickness shall have the thickness noted on the test report.

18.2 The IFD values for molded products are dependent on the specimen dimensions. Higher values are generally obtained for specimens that retain all molded surfaces.

19. Number of Specimens

19.1 One specimen shall be tested, unless otherwise agreed upon by the supplier and the purchaser.

20. Procedure

20.1 Place the test specimen in position on the supporting plate of the apparatus. If the product has one side cored or honeycombed, this face shall rest on the perforated plate. The specimen position shall be such that whenever, practicable the indentation will be made at the center of all articles, except where another location is agreed upon by the supplier and the purchaser.

~~20.2Preflex the area to be tested by twice lowering the indentor foot to a total deflection of 75 to 80% of the full-part thickness at a rate of 250 ± 25 mm/min. Mark the location of the test area with a pen by circumscribing the indentor foot while under a 4.5-N force. Allow the specimen to rest 6 ± 1 min after the preflex.~~

~~20.3Bring the indentor foot into contact with the specimen and determine the thickness after applying a contact force of 4.5 N (Note 5) to the indentor foot. Indent the specimen at 50 ± 5 mm/min 25% of this thickness and observe the force in newtons after~~

~~60 ± 3 s. Without removing the specimen, increase the deflection to 65% deflection, allowing the force to drift while maintaining the 65% deflection, and again observe the force in newtons after 60 ± 3 s.~~

~~NOTE5—For super-soft foam, foam with a 25% IFD less than 40 N, a reduction of pressure on the indentor foot shall be allowed. Sufficient contact force to make an accurate initial thickness measurement is required.~~

20.2 Preflex the area to be tested by twice lowering and raising the indenter foot to a total deflection of 75 to 80 % of the full-part thickness at a rate of 250 ± 25 mm/min, allowing the indenter to fully clear the top of the specimen after each preflex. In case repeat testing might be necessary or for fatigue tests, mark the location of the test area with a pen by circumscribing the indenter foot. Allow the specimen to rest for 6 ± 1 min after the final preflex.

20.3 Bring the indenter foot into contact with the specimen at 50 ± 5 mm/min and determine the thickness while applying a contact force of 4.5 N to the indenter foot. For super-soft foam, with a 25 % IFD less than 40 N, a reduction of pressure on the indenter foot shall be allowed. Sufficient contact force to make an accurate initial thickness measurement is required. Indent the specimen at 50 ± 5 mm/min by 25 % of this thickness and observe the force in Newtons after 60 ± 3 s. Without removing the specimen, increase the deflection to 65 % deflection, allowing the force to drift while maintaining the 65 % deflection, and again observe the force in Newtons after 60 ± 3 s.

21. Report

21.1 Report the force in ~~newtons~~Newtons required for 25 and 65 % indentation or other indentations (Note 6). These figures are known as the 25 % and 65 % IFD values, respectively. Report length, width, and thickness of the specimen, if non-standard, and the ratio (support factor Appendix X3) of 65 % to 25 % IFD values.

NOTE 6—Indentation deflection tests, other than 25 and 65 %, as well as a 25 % return value (25 % RT), may be specified as agreed upon between the supplier and the purchaser. Alternative or additional deflections shall be performed as described in 20.3.

22. Precision and Bias

22.1 See Section ~~137~~ 146 for Precision and Bias statements.

TEST B_2 —INDENTATION RESIDUAL GAUGE LENGTH TEST—SPECIFIED FORCE (IRGL)

23. Scope

23.1 Cellular foam products have been traditionally checked for indentation force deflection by determining the force required to effect a 25 % deflection. In seating, on the other hand, the interest is in determining how thick the padding is under the average person. Two measurements are called for to meet the requirements of this test method. The force deflection is determined by measuring the thickness of the pad under a fixed force of 4.5 N, 110 N, and 220 N, ~~on~~with a ~~323-cm^2~~ 200 +3/–0 mm circular ~~indentor~~indenter foot.

23.2 This determination shall be known as the Indentation Residual Gauge Length and the measurements as the IRGL values.

NOTE 7—This standard and ISO 2439 address the same subject matter, but differ in technical content; and results cannot be directly compared between the two methods.

24. Apparatus

24.1 An apparatus having a flat circular ~~indentor~~indenter foot 200 +3/–0 mm in diameter, connected with a swivel joint for applying forces of 4.5 N, 110 N, 220 N and 330 N, shall be mounted over a level horizontal platform that is perforated with approximately 6.5-mm holes on approximately 20-mm centers to allow for rapid escape of air during the test. The distance between the ~~indentor~~indenter foot and the platform shall be variable to indent the specimen at a speed of 50 to ~~200~~250 mm/min for thickness measurements. The apparatus shall be equipped with a device for measuring the distance between plates.

24.2 Special support for contoured molded pads shall be perforated and agreed upon between the supplier and the purchaser. Pads longer than the base plate shall be supported from distortion at the 4.5-N contact force.

25. Test Specimen

25.1 When possible the completed manufactured product shall be used. In the case of tapered cushions, the location of the area for measurement is to be agreed upon between the supplier and the purchaser. In the case a finished part is not feasible for test, 380 by 380-mm specimens of an average thickness are to be cut from the cushion.

25.2 The IRGL values for molded products are dependent on the specimen dimensions. Different values are generally obtained for specimens that retain all molded surfaces.

26. Number of Specimens

26.1 One specimen shall be tested, unless otherwise agreed upon by the supplier and the purchaser.

27. Procedure

27.1 Test the whole test specimen or a minimum area of 380 by 380 mm. Preflex the specimen twice with a 330 N force, raising and lowering the indenter foot at 200 ± 20 mm/min, allowing the indenter foot to fully clear the top of the specimen after each

preflex. Allow the specimen to rest for 6 ± 1 min after the final preflex. Position the specimen in the test apparatus with any cored or convoluted surfaces resting against the perforated bottom plate.

27.2 Bring the ~~indentor~~indenter foot into contact and determine the thickness of the specimen, in mm, with the 4.5-N load on the indent~~o~~er foot at 50 ± 5 mm/min.

27.3 Apply the 110-N force at 50 ± 5 mm/min with the ~~indentor~~indenter foot until the force is carried by the specimen. Determine the thickness, in mm, at 110 N after maintaining the force for 60 ± 3 s.

27.4 Without removing the specimen, apply the 220-N force at 50 ± 5 mm/min with the ~~indentor~~indenter foot until the force is carried by the specimen. Determine the thickness, in mm, at 220 N after maintaining the force for 60 ± 3 s.

28. Report

28.1 Report the specimen thicknesses, in mm, at 4.5 N instantaneously and at 110 N and 220 N after 60 ± 3 s. These figures are known as the IRGL values, respectively. Report the length, width, and thickness of the specimen.

29. Precision and Bias

29.1 See Section ~~137~~ 146 for Precision and Bias statements.

TEST C—COMPRESSION FORCE DEFLECTION TEST

30. Scope

30.1 This test consists of measuring the force necessary to produce a 50 % compression over the entire top area of the foam specimen.

NOTE 8—This standard and ISO 3386 address the same subject matter, but differ in technical content; and results cannot be directly compared between the two methods.

NOTE 9—Compression deflection tests other than at 50 % may be specified as agreed upon between the supplier and the purchaser following the procedure in Section 34.

31. Apparatus

31.1 An apparatus 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 at a speed of 50 to 500 mm/min. The apparatus shall be arranged to support the specimen on a level horizontal plate that is perforated with approximately 6.5-mm holes on approximately 20-mm centers to allow for rapid escape of air during the test.

32. Test Specimens

32.1 The test specimens shall have parallel top and bottom surfaces and vertical sides. The thickness shall be no greater than 75 % of the minimum top dimension. The standard specimen shall be 50 mm by 50 mm by 25 mm in thickness. Larger specimens are preferable, where possible.

32.2 Specimens shall be a minimum of ~~2000~~2500 mm^2 in area and have a minimum thickness of 20 mm.

32.3 Unless otherwise agreed upon by contractual parties, specimens from molded parts shall be cut from the core material at least 10 mm below the molded surface. Note in the report if the specimens have one or more molded surfaces resulting from insufficient core material or contractual agreement.

33. Number of Specimens

33.1 Three specimens per sample shall be tested. The value reported shall be the mean value of those observed.

34. ~~Procedure~~

~~34.1Preflex the specimen twice, 75 to 80% of its original thickness at 250 ± 25 mm/min. Then allow the specimen to rest for a period of 6 ± 1 min.~~ Procedure

34.1 Preflex the specimen twice, 75 to 80 % of its original thickness raising and lowering the compression foot at 250 ± 25 mm/min, allowing the compression foot to fully clear the specimen after each preflex. Then allow the specimen to rest for a period of 6 ± 1 min after the final preflex.

34.2 Place the specimen centered in the line of the axial load on the supporting plate of the apparatus. If the product has one side cored or convoluted, rest this face on the perforated plates.

34.3 Bring the compression foot into contact with the specimen and determine the thickness after applying a contact load of 140 Pa to the specimen area (Note 2). Compress the specimen 50 % of this thickness at 50 ± 5 mm/min and determine the final force, in N, after 60 ± 3 s. (See Note ~~9~~8.)

$$\textit{Compression Force Deflection, kPa} = [\textit{force, in N} \times 10^3]/\textit{specimen area, in mm}^2$$

35. Report

35.1 Report the thickness after contact force, the 50 % compression deflection value in kilopascals, and the dimensions of non-standard specimens. Indicate if the sample was cored or convoluted. Report any molded surfaces that were on the specimens.

36. Precision and Bias

36.1 See Section ~~137~~ 146 for Precision and Bias statements.

TEST D—CONSTANT DEFLECTION COMPRESSION SET TEST

37. Scope

37.1 This test method consists of deflecting the foam specimen to a specified deflection, exposing it to specified conditions of time and temperature and measuring the change in the thickness of the specimen after a specified recovery period.

NOTE 10—This standard and ISO 1856 address the same subject matter, but differ in technical content and results cannot be directly compared between the two methods.

38. Apparatus

38.1 *Compression Device*~~, consisting of two or more flat plates arranged so 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.~~ , consisting of two or more flat plates arranged so 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. The plates shall have sufficient stiffness to ensure that they are not deflected under the force necessary to compress all of the specimens.

38.2 Mechanically convected air oven capable of maintaining the conditions of 70 ± 2°C and 6 % maximum relative humidity.

NOTE 11—This condition of relative humidity can be achieved by placing an oven at 70 ± 2°C in an atmosphere maintained at 23 ± 2°C and 50 ± 5 % relative humidity.

39. Test Specimens

~~39.1The test specimens shall have parallel top and bottom surfaces and essentially perpendicular sides.~~

39.1 The test specimens shall have parallel top and bottom surfaces and essentially perpendicular sides. It is recommended that the specimens be cut with a band knife or band saw. Die cut specimens have a greater tendency to exhibit edge sticking (pillowing) after being removed from the compression device. Specimens shall be cut at least 13 mm from any edge that has been exposed to the light (see Note 13).

39.2 Specimens shall be 50 by 50 by 25 mm unless otherwise specified. Specimens less than 25 mm in thickness shall be plied up, without the use of cement, to a 25-mm thickness.

39.3 Specimens from cored foams shall have a minimum top surface area of 100 cm^2. The thickness shall be no greater than 75 % of the minimum top dimension.

39.4 Specimens from uncored molded products 25 mm or less in thickness shall be 50 by 50 mm by full-part thickness and shall contain the top and bottom skin.

39.5 Specimens greater than 50 mm in thickness shall be cut to 25 mm thickness from the core. (see ~~Note 11~~Note 12)

NOTE 1~~1~~2—Specimens from molded products may be tested with one or both skins by agreement between the purchaser and the supplier.

NOTE~~12—Care~~ 13—Care should be taken to minimize the exposure of compression set specimens to visible light. Studies have shown that light can have a deleterious effect on compression sets.[3] If the specimens are not to be tested within 24 hours of being cut from the part or block, they should be covered or be placed in an opaque container or bag.

40. Number of Specimens

40.1 Three specimens per sample shall be tested. The value reported shall be the mean of those observed.

41. Procedure

41.1 ~~Perform the entire test procedure under the following conditions: Conduct all measurements, conditioning, and recovery of the specimen at 23 ± 2°C and in an atmosphere of 50 ± 5% relative humidity. The oven conditions shall be 70 ± 2°C and 6% maximum relative humidity.~~

~~NOTE13—This condition of relative humidity may be achieved by placing an oven at 70 ± 2°C in an atmosphere maintained at 23 ± 2°C and 50 ± 5% relative humidity.~~ Perform the entire test procedure under the following conditions: Conduct all measurements, conditioning, and recovery of the specimen at 23 ± 2°C and in an atmosphere of 50 ± 5 % relative humidity.

41.2 Measure the original thickness of the test specimen in accordance with the procedure described in Section 8.

41.3 Place the test specimen in the apparatus and deflect it to 50 ± 1, 75 ± 1, or 90 ± 1 % of its thickness, or any other deflection agreed upon between the supplier and the purchaser. Space the specimens in the compression device in such a manner that there is at least 6 mm of separation between specimens in all directions.

41.4 Within 15 min, place the deflected specimen and the apparatus in the mechanically convected air oven for a period of 22 h, and then remove the apparatus.

[3] Blair, G.R., Dawe, B., McEvoy, J., Pask, R., Rusan de Priamus, M., Wright, C. "The Effect of Visible Light on the Variability of Flexible Foam Compression Sets" Center for the Polyurethanes Industry of the American Chemistry Council 2007 Conference Proceedings.

41.5 Remove the specimen immediately from the apparatus and measure the final thickness in accordance with the procedure described in Section 8 after allowing it to recover 30 to 40 min at the temperature and humidity conditions specified in 41.1.

NOTE 14—Recovery periods greater than 30 to 40 min may be agreed upon by the supplier and the purchaser.

42. Calculation

42.1 Calculate the compression set value by one of the following formulas:

NOTE 15—The C_t calculation is preferred and shall be the calculation used when neither C_t nor C_d are specified.

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

$$C_t = [(t_o - t_f)/t_o] \times 100 \quad (2)$$

where:
C_t = compression set expressed as a percentage of the original thickness,
t_o = original thickness of test specimen, and
t_f = final thickness of test specimen.

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

$$C_d = [(t_o - t_f)/(t_o - t_s)] \times 100 \quad (3)$$

where:
C_d = compression set expressed as a percent of the original deflection,
t_o = original thickness of test specimen,
t_s = thickness of spacer bar used, and
t_f = final thickness of test specimen.

NOTE 16—Approximate conversion of C_t to C_d can be calculated by multiplying the 50 % C_t by 2, the 75 % C_t by 1.33, and the 90 % C_t by 1.11.

43. Report

43.1 Report compression set as C_t or C_d, and deflection used. Also report any non-standard recovery periods or sample sizes and whether the sample was cored, uncored and/or molded.

44. Precision and Bias

44.1 See Section ~~137~~ 146 for Precision and Bias statements.

TEST E—TENSILE TEST

45. Scope

45.1 This test method determines the effect of the application of a tensile force to foam. Measurements are made for tensile stress, tensile strength, and ultimate elongation.

NOTE 17—This standard and ISO 1798 address the same subject matter, but differ in technical content and results cannot be directly compared between the two methods.

46. Apparatus

46.1 *Specimens*—The specimen for tensile tests shall be stamped out with a die of the shape and dimensions shown in Fig. 1, or Die A of Test Methods D412. The die shall be sharp and free of nicks in order to prevent leaving ragged edges on the specimen. The D412 Die is the preferred die and is identical in dimensions to the ISO 1798 Die.

46.2 *Bench Marker*—The marker shall have two parallel marking edges 1 to 3 mm in thickness and spaced 20 or 25 mm apart on centers.

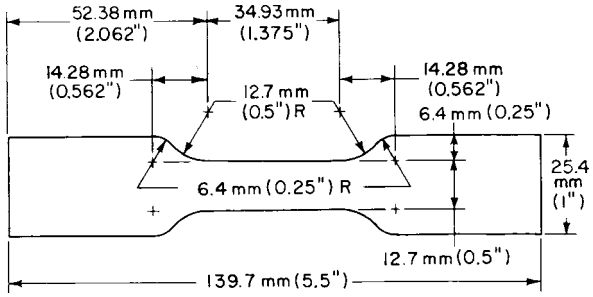

FIG. 1 Die for Stamping Tension Specimens

46.3 *Measurements*—The dimensions of the test specimen shall be determined with a suitable gauge in accordance with Section 8.

46.4 Machine—Tensile tests shall be made on a power-driven machine complying with the following requirements:

46.4.1 The machine shall be equipped with a load cell or force measuring device that can measure the maximum applied force. The test speed shall be 500 ± 50 mm/min, and shall be uniform at all times.

~~46.4.2The machine may~~ 46.4.2 Elongation shall be determined by either the machine being equipped with a device graduated to 2.5 mm for measuring the ~~elongation. The~~ elongation, by the use of non-contact ~~extensometers may similarly be used for determining elongation.~~extensometers, or by crosshead travel (also referred to as grip separation). Extensometers that clip on to the specimen generally are unsuitable for flexible foam. For testing dumbbell specimens, the machine shall have either screw-type flat plate grips or a type of grip that tightens automatically and exerts a uniform pressure across the gripping surfaces, increasing as the tension increases to prevent slipping.

47. Test Specimens

47.1 The test specimens shall be cut from flat sheet material 12.5 ± 1.5 mm thick. The foam rise shall be in the thickness direction, unless otherwise agreed upon by customer and supplier. The top and bottom surfaces shall be parallel and free of skin. The cut edges shall be perpendicular to the top surface and be free of ragged edges. The length of the tabs ~~may~~can be adjusted to fit machine conditions provided that all other requirements remain constant.

48. Number of Specimens

48.1 Three specimens per sample shall be tested. The value reported shall be the mean value of those observed.

49. Procedure

49.1 Set the grip separation at a minimum of 62.5 mm for the D3574 Die and at a minimum of 75 mm for the D412 Die A. Place the dumbbell tabs in the grips of the testing machine, using care to adjust them symmetrically, in order that the tension will be distributed uniformly over the cross section. The test shall be run at a speed of 500 ± 50 mm/min, unless otherwise specified by agreement between customer and supplier. Start the machine and note continuously the distance between the two bench marks. Record the stress at the corresponding elongation or if an automatic recording device is used, it will record the data continuously. At rupture, measure or record elongation to the nearest 10 %.

50. Calculation

50.1 Calculate the tensile strength by dividing the maximum breaking force by the original cross-sectional area of the specimen.

50.2 Calculate the stress by dividing the force at a predetermined elongation by the original cross-sectional area of the specimen.

50.3 Calculate the ultimate elongation, *A*, by subtracting the original distance between the bench marks from the total distance between the bench marks at the time of rupture and expressing the difference as a percentage of the original distance, as follows, or use the grip separations in a similar calculation.

$$A, \% = [(d_f - d_o)/d_o] \times 100 \quad (4)$$

where:

d_o = original distance between bench marks, and

d_f = distance between bench marks at the break point.

50.4 The value reported shall be the mean value of all specimens tested.

51. Report

51.1 Report the following information:

51.1.1 Tensile strength in kilopascals,

51.1.2 Stress in kilopascals at a predetermined elongation, and

51.1.3 Ultimate elongation, in percent, and whether bench marks, grip separation or extensometers were used to measure elongation.

51.1.4 Crosshead speed, if other than 500 mm/min.

52. Precision and Bias

52.1 See Section ~~137~~ 146 for Precision and Bias statements.

TEST F—TEAR RESISTANCE TEST

53. Scope

53.1 This test method covers determination of the tear propagation resistance of foam. The block method, as described, measures the tear resistance under the conditions of this particular test.

NOTE 18—This standard and ISO 8067 address the same subject matter, but differ in technical content and results cannot be directly compared between the two methods.

54. Apparatus

~~54.1Tear resistance shall be measured on a power-driven apparatus which will indicate the force at which rupture of the specimen takes place. An automatic machine may be used which draws the actual curve, or, a style or scale shall be used, which has an indicator that remains at the point of maximum force after rupture.~~

54.1 Tear resistance shall be measured on a power-driven apparatus which will indicate the maximum force, by mechanical or electronic means, at which rupture of the specimen takes place.

55. Test Specimens

55.1 The test specimens shall be a block shape free of skin, voids, and densification lines, as shown in Fig. 2. They ~~may~~shall be cut on a saw ~~or die cut~~ from sheet material ~~so~~ensuring that the sides are parallel and perpendicular to each other. A nominal 40-mm cut shall be placed in one side as shown in Fig. 2. Dimension *A-B* can be reduced to the pad thickness. The thickness shall be determined in accordance with Section 8.

56. Number of Specimens

56.1 Three specimens per sample shall be tested. The values reported shall be the mean of those tested.

57. Procedure

57.1 Clamp the test specimen in the jaws of the testing machine, taking care that the jaws grip the specimen properly. Spread the block so that each tab is held in the jaw to pull across the specimen. The test shall be run at a speed of 500 ± 50 mm/min, unless otherwise specified by agreement between purchaser and supplier. Aid the cut in the specimen with a razor blade or knife, so as to keep it in the center of the block (Note 19). After the rupture of the specimen, or after at least a 50-mm length is torn, record the maximum force in ~~newtons~~Newtons and note also the thickness of the specimen (direction *A-B*).

NOTE 19—For foams that will not tear by this method, side by side tear strength comparisons can be made by testing in accordance with Test Method D624. It ~~should~~shall be noted that the D624 test is a tear initiating measurement, as opposed to a tear propagating measurement in this block tear test.

58. Calculation

58.1 Calculate the tear strength from the maximum force registered on the testing machine and the average thickness of the specimen (direction *A-B*), as follows:

$$\text{Tear strength, N/m} = F/T \times 10^3 \tag{5}$$

where:
F = force, N, and
T = thickness, mm.

59. Report

59.1 Report the following information:
59.1.1 Tear strength in ~~newtons~~Newtons per metre,
59.1.2 Orientation of specimen, and
59.1.3 Crosshead speed, if other than 500 mm/min.

60. Precision and Bias

60.1 See Section ~~137~~ 146 for Precision and Bias statements.

TEST G—AIR FLOW TEST

61. Scope

61.1 The air flow test measures the ease with which air passes through a cellular structure. Air flow values ~~may~~can be used as an indirect measurement of certain cell structure characteristics. The test consists of placing a flexible foam core specimen in a

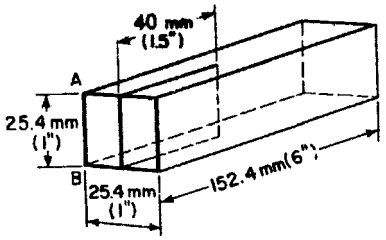

FIG. 2 Tear Resistance Test Specimens

cavity over a chamber and creating a specified constant air-pressure differential. The rate of flow of air required to maintain this pressure differential is the air flow value. This test is normally for slab foam products or for the core materials of molded products. Measurements of air flow through molded skins or extremely high air flow products ~~may~~can require alternative methods (see Note 21).

NOTE 20—This standard is identical to ISO 7231.

NOTE 21—For measuring air flow of products, such as very tight viscoelastic foams or very high air flow foams, which can have air flows beyond the range of this method, very good success has been achieved using the equipment specified in Test Method D737. Direct correlations between Test Method D737 and this method have been established, although some modification of the D737 equipment ~~may~~can be necessary.[4] Test Method D3574 air flow ~~in cfm~~ times 36 will give an approximate value for Test Method D737 ~~air flow in cfm/ft^2. For surface porosity of molded foams, see Test Method D726.~~ air flow.

62. Terminology

62.1 *Definitions of Terms Specific to This Standard:*

62.1.1 *air flow value*—the volume of air per second at standard temperature and atmospheric pressure required to maintain a constant pressure differential of 125 Pa across a flexible foam specimen approximately 50 by 50 by 25 mm.

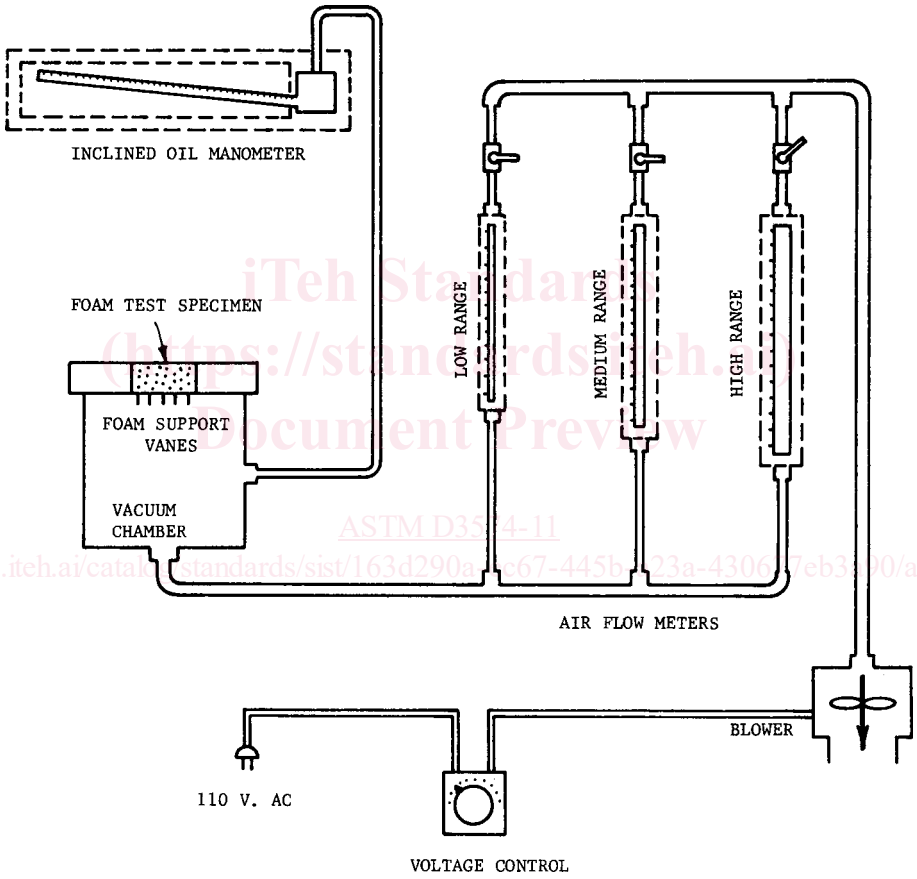

FIG. 3 Air Flow Apparatus Schematic Diagram

62.1.2 *air flow parallel to foam rise*—the air flow value obtained when the air enters and leaves the mounted specimen parallel to foam rise.

63. Apparatus

63.1 A schematic drawing of the apparatus, including the specimen mounting chamber, manometer, air flowmeters, blowmeters, blower, and voltage control, is shown in Fig. 3.

63.2 *Chamber*, consisting of a pot approximately 130 mm in diameter and 150 mm high, with provision for mounting the foam specimen and fittings for the manometer and air exhaust. The specimen mount cavity shall be 50.0 ± 0.5 by 50.0 ± 0.5 by 25.0

[4] Gummaraju, R.V., Pask, R.F., Koller, H.J., Wujcik, S.E., and Reimann, K.A., "Evaluation, Modification and Adaptation of an Airflow Test Method for Polyurethane Foams," *Journal of Cellular Plastics* , May/June 2001.