



# Standard Test Methods for Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams<sup>1</sup>

This standard is issued under the fixed designation D 3574; 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 ( $\epsilon$ ) 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 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 equivalent ISO 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:<sup>2</sup>

- D 412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension
- D 624 Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
- D 726 Test Method for Resistance of Nonporous Paper to Passage of Air
- D 737 Test Method for Air Permeability of Textile Fabrics
- D 3675 Test Method for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source
- E 162 Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source
- E 662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials

<sup>1</sup> 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

E 691 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.

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.

## 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 which include test procedures for the following:

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

Tests:	Sections
Test A Density Test	9-15
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Test I <sub>1</sub> Static Force Loss Test at Constant Deflection	77-85
Test I <sub>2</sub> Dynamic Fatigue Test by the Roller Shear at Constant Force,	86-94
Test I <sub>3</sub> Dynamic Fatigue Test by Constant Force Pounding	95-103
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Test J Steam Autoclave Aging	113-118
Test K Dry Heat Aging	119-124
Test L Wet Heat Aging	125-130
Test M Recovery Time	131-136

### 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  $23 \pm 2^\circ\text{C}$  and in an atmosphere of  $50 \pm 5\%$  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.

## 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 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 for complete recovery of the thickness across the full width of the specimen.

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 agree upon an acceptable location to take the specimen.

## 8. Measurement of Test Specimens

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

8.2 Measure thickness up to and including 25 mm using a dial-type gage with a minimum foot area of  $650\text{ mm}^2$ . Hold the pressure of the dial foot to  $170 \pm 35\text{ Pa}$  (Note 2). Thicknesses over 25 mm may be measured with a dial gage, a sliding caliper gage, or as specified in 8.1. When a sliding caliper gage is employed, make the gage setting with the gage out of contact with the foam. Pass the specimen through the previously set gage: the proper setting shall be the one when the measuring faces of the gage 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 foot shall not exceed 100 Pa.

8.3 The scale, tape, or gage shall be graduated so as to permit measurements within  $\pm 1\%$  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 uncured 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—ISO 845 is a similar test, but there are technical differences.

## 10. Test Specimen

10.1 *Core Density*—A representative specimen of regular shape, circular or square without skins or densification lines, not less than  $1000\text{ mm}^3$  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  $0.1\text{ m}^2$  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<sup>3</sup>.

### 14. Report

14.1 Report the following information:

14.1.1 Density to the nearest 0.1 kg/m<sup>3</sup>, and

14.1.2 Type of specimen, core or section.

### 15. Precision and Bias

15.1 See Section 137 for Precision and Bias statements.

## TEST B<sub>1</sub> —INDENTATION FORCE DEFLECTION TEST—SPECIFIED DEFLECTION

### 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. (Appendix X3).

NOTE 4—ISO 2439 is a similar test, but there are technical differences.

### 17. Apparatus

17.1 An apparatus having a flat circular indenter foot 203 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 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.

### 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 honey-combed, 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.

20.2 Preflex the area to be tested by twice lowering the indenter 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 indenter foot while under a 4.5-N force. Allow the specimen to rest 6 ± 1 min after the preflex.

20.3 Bring the indenter foot into contact with the specimen and determine the thickness after applying a contact force of 4.5 N (Note 5) to the indenter 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.

NOTE 5—For super-soft foam, 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.

### 21. Report

21.1 Report the force in 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 also 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.

### 22. Precision and Bias

22.1 See Section 137 for Precision and Bias statements.