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Standard Test Methods for Semi-Flexible Cellular Urethanes for Automotive and Similar Energy Absorption Applications¹

This standard is issued under the fixed designation D 5308; 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.

1. Scope

1.1 These test methods apply to slab, bonded, and molded semi-flexible cellular products. Applications include arm rest, instrument panel, A-post, etc.

1.2 Urethane foam may be generally defined as an expanded cellular product produced by the interaction of active hydrogen compounds, water, and isocyanates.

1.3 Unless specifically stated otherwise between the supplier and the purchaser, all tests shall be made in accordance with the test methods specified in the following sections:

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- X1 Definitions of Terms Used to Describe the Force-Deflection Curve of Flexible Urethane Foam
- X2 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.)

1.4 The values stated in SI units are to be regarded as the standard. Values given in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety problems, 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 This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.22 on Cellular Plastics. Current edition approved Nov. 15, 1992. Published March 1993.

2. Referenced Documents

2.1 ASTM Standards:

- D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension²
- D 3574 Test Method for Testing Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams³
- D 4205 Guide for Flammability and Combustion Testing of Rubber and Rubber-Like Materials³
- D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries²

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 *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 1 lap in 5 s at a temperature between 18 and 29°C.

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

3.1.5 *semi-flexible foam*—foams that usually have higher load bearing, lower elongation, and lower resilience than flexible foams used for seating or bedding at the same density.

3.1.5.1 *Discussion*—Semi-flexible foam may or may not meet the requirements of 3.1.3.

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

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

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

4. Significance and Use

4.1 The test procedures provide a standard method of obtaining data for research and development, quality control,

² Annual Book of ASTM Standards, Vol 09.01.

³ Annual Book of ASTM Standards, Vol 09.02.

acceptance and rejection under specifications, and special purposes.

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

5. General Test Conditions

5.1 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.

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

5.3 Preflexing, if required, shall be specified by the purchaser.

6. Sampling

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

6.2 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. 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.

6.3 When the finished molded product does not lend itself to testing or to the taking of specimens because of a 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.

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

7. Measurement of Test Specimens

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

7.2 Measure thicknesses up to and including 25 mm (1 in.) using a dial-type gage with a minimum foot area of 65 mm^2 (1 in.²). Hold the pressure on the dial to $170 \pm 35\text{ Pa}$ ($11 \pm 2\text{ g}$). Thicknesses over 25 mm (1 in.) may be measured with a dial gage, a sliding caliper gage, or as specified in 7.1. When a sliding gage is used, take care not to compress the sample when measuring dimensions.

7.2.1 Pass the specimen through the previously set gage. The proper setting shall be the one at which the measuring

faces of the gage contact the surfaces of the specimen without compressing it.

7.3 The scale, tape, or gage shall be graduated so as to permit measurements within $\pm 1\%$ of the dimensions to be measured.

7.4 Results reported shall be the median of a minimum of three measurements.

TEST METHOD A—DENSITY TEST

8. Scope

8.1 This test method covers determination of the density 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.

9. Test Specimen

9.1 *Core Density*—Cut a representative sample of regular shape, circular, or square without skins or densification lines, not less than 100 cm^3 (6 in.³) in volume, from a portion free of voids and defects and as near as possible to the section where the tension and tear specimens were taken.

9.2 *Section Density*—Cut a representative specimen, with skins on top and bottom surfaces measuring at least 50 cm^2 (8 in.²) in area by full part thickness, 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, use the largest representative portion as agreed upon between the supplier and the purchaser.

10. Number of Specimens

10.1 Test one specimen.

11. Procedure

11.1 Determine the mass of the specimen within 1 %.

11.2 Determine the dimensions of the specimen in accordance with Section 7, and calculate the volume.

12. Calculation

12.1 Calculate the density of kg/m or lb/ft as follows:

$$\text{Density} = M/V \quad (1)$$

where:

M = mass, kg, and
 V = volume, m³.

Or:

$$\text{Density} = 3.81 M/V \quad (2)$$

where:

M = mass, g, and
 V = volume, in.³.

13. Report

13.1 Report the following information:

13.1.1 Density in kg/m³ or lb/ft³, and

13.1.2 Type of specimen (core or section).

14. Precision and Bias

14.1 Precision statements are being prepared in the form

specified by Practice D 4483.

TEST METHOD B—INDENTATION FORCE DEFLECTION TEST—SPECIFIED DEFLECTION

15. Summary of Test Method

15.1 This test method consists of measuring the force necessary to produce 25 % and 65 % or other designated indentations in the foam product (see Appendix X1). The results will be known as IFD values.

16. Apparatus

16.1 *Indentor*, circular, rectangular, or hemispherical, connected to a force-measuring device and mounted in such a manner that the product or specimen can be deflected at a speed of 25 to 375 mm/min (1 to 15 in./min). The apparatus shall support the specimen on a level horizontal plate. Special support for contoured molded pads shall be perforated and agreed upon between the supplier and the purchaser. Pads no longer than the base plate shall be supported from distortion at the 4.5 N (1 lb) contact force.

16.1.1 The indentors commonly in use are circular flat 1 in.²; rectangular flat 0.5 by 2.0 in. or 0.75 by 3.0 in.; and hemispherical 0.75 in. diameter.

17. Test Specimen

17.1 The test specimen shall consist of the entire product sample or a suitable portion.

NOTE 1—See Method D 3574 for a description of the IFD for seating and bedding foam.

18. Number of Specimens

18.1 Test one specimen.

19. Procedure

19.1 Place the test specimen in position on the supporting plate of the apparatus. 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.

19.2 Unless otherwise specified, preflex the area to be tested by twice lowering the indentor foot 75 to 80 % of the full part thickness at a rate of 25 to 375 mm/min (1 to 15 in./min). Mark the location of the test area by circumscribing the indentor foot with a pen while under a 4.5 N (1 lb) contact force. Allow the specimen to rest 6 ± 1 min before testing.

19.3 Bring the indentor foot into contact with the specimen and determine the thickness after applying a force of 4.5 N (1 lb). Indent the sample 25 % of this thickness at a rate of 50 ± 5 mm/min (2 ± 0.2 in./min). Record the force in N (lb) after 60 ± 3 s. Without removing the sample, continue indenting to the 65 % deflection. Again record the load in N (lb) after 60 ± 3 s.

20. Report

20.1 Report the following information:

20.1.1 Force in N (lb) required for 25 % and 65 % indentation. These figures are known as the 25 % and 65 % IFD values, respectively.

20.1.2 Length, width, and thickness of the specimen.

20.1.3 Length and width of the indentor.

20.1.4 Whether the specimen was preflexed.

21. Precision and Bias

21.1 Precision statements are being prepared in the form specified by Practice D 4483.

TEST C—COMPRESSION FORCE DEFLECTION TEST

22. Summary of Test Method

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

NOTE 2—Compression deflection tests other than at 50 % may be specified as agreed upon between the supplier and the purchaser.

23. Apparatus

23.1 *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 25 to 375 mm/min (1 to 15 in./min). The apparatus shall be arranged to support the specimen on a horizontal plate.

24. Test Specimens

24.1 The slab test specimen shall have parallel top and bottom surfaces and essentially vertical sides. The thickness shall be no greater than 75 % of the minimum top dimension.

24.2 Specimens shall be a minimum of 2500 mm² (4 in.²) in area and a minimum thickness of 20 mm (0.8 in.). Specimens less than 20 mm (0.8 in.) shall be plied up, without use of cement, to a minimum of 20 mm (0.8 in.).

24.3 The test specimen from molded parts shall have parallel top and bottom surfaces and perpendicular sides. Preferably the specimen should include both top and bottom molded skins. If a test specimen with parallel top and bottom surfaces including both molded skins cannot be obtained because of the shape of the molded part, at least one of the molded skin surfaces should be retained. Both surface skins should be removed only in cases where the shape of the original sample makes this absolutely necessary.

24.4 Maximum molded specimen thickness shall not be greater than the minimum top dimension. Specimens shall have a minimum length and width of 50 mm (2 in.) and a minimum thickness of 20 mm (0.8 in.). Specimens less than 20 mm (0.8 in.) shall be plied up to a minimum of 20 mm (0.8 in.) without the use of cement.

25. Number of Specimens

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

26. Procedure

26.1 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 honeycombed, rest this face on the perforated plates.

26.2 Bring the compression foot into contact with the specimen and determine the thickness after applying a 4.5 N (1 lb) contact load. Compress the specimen 50 % of this thickness at a rate of 50 ± 5 mm/min (2 ± 0.2 in./min). Record the load after 60 ± 3 s.

27. Report

27.1 Report the thickness after contact load and the 50 % compression load deflection value in Pa (psi).

28. Precision and Bias

28.1 Precision statements are being prepared in the form specified by Practice D 4483.

TEST D—CONSTANT DEFLECTION COMPRESSION SET TEST

29. Summary of Test Method

29.1 This test method consists of deflecting the foam specimen under specified conditions of time and temperature and noting the effect on the thickness of the specimen.

30. Apparatus

30.1 *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.

31. Test Specimens

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

31.2 Specimens shall be 50 by 50 by 25 mm (2 by 2 by 1 in.) unless otherwise specified. Specimens less than 25 mm (1 in.) thick shall be plied up to 25 mm (1 in.) without the use of cement.

31.3 Specimens from molded products 25 to 50 mm in thickness shall be cut 50 mm by 50 mm by full part thickness with top and bottom skins intact.

31.4 Specimens greater than 50 mm in thickness shall be cut to 50 mm thickness and the sample containing the top skin shall be used for testing.

32. Number of Specimens

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

33. Procedure

33.1 Perform the entire test procedure under the following conditions:

33.1.1 Conduct all measurements, conditioning, and recovery of the specimen at $23 \pm 2^\circ\text{C}$ and in an atmosphere of 50 ± 2 % relative humidity.

33.1.2 The oven conditions shall be $70 \pm 2^\circ\text{C}$ and 5 ± 1 % relative humidity.

NOTE 3—The condition of relative humidity may be achieved by placing an oven at $70 \pm 2^\circ\text{C}$ in an atmosphere maintained at $23 \pm 2^\circ\text{C}$ and 50 ± 2 % relative humidity.

33.2 Measure the test specimen in accordance with the procedure described in Section 7.

33.3 Place the test specimen in the compression set jig and deflect it to 50 ± 1 % of its thickness, or to any other deflection agreed upon between supplier and purchaser.

33.4 Within 15 min, place the deflected specimen and the apparatus in the mechanically convected air oven for a period of 22 h; then remove the apparatus. The oven temperature shall be $70 \pm 2^\circ\text{C}$.

33.5 Remove the specimen immediately from the apparatus and measure it in accordance with the procedure described in Section 7 after 30 to 40 min recovery.

34. Calculation

34.1 Calculate two compression set values as follows:

34.1.1 Calculate the constant deflection compression set, expressed as a percent of the original thickness, as follows:

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

where:

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

t_o = original thickness of test specimen, and

t_f = final thickness of test specimen 30 min + 10 or - 0 min after removal from the apparatus.

34.1.2 Calculate the constant deflection compression set, expressed as a percent of the original deflection, as follows:

$$C_d = [(t_o - t_f)/(t_o - t_s)] \times 100 \quad (4)$$

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 30 min + 10 or - 0 min after removal from the apparatus.

35. Report

35.1 Report compression set as C_t or C_d , and deflection used.

36. Precision and Bias

36.1 Precision statements are being prepared in the form specified by Practice D 4483.

TEST E—TENSION TEST

37. Scope

37.1 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.

38. Apparatus

38.1 *Dies*—The specimen for tension testing shall be stamped out with a die of the shape and dimensions shown in Fig. 1 or Die A of Test Methods D 412. The die shall be sharp and free of nicks to prevent leaving ragged edges on the specimen.

38.2 *Bench Marker*, having two parallel marking edges 1.6 mm in thickness and spaced 20 or 25 mm apart on centers.