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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 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 (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 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 *This standard should be used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire hazard assessment or a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard or fire risk of a particular end use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers— Tension[2]

D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries[2]

E 162 Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source[3]

NOTE 1—The specific dated edition of Practice D 4483 that prevails in this document is referenced in the Precision and Bias section.

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

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

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

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:

Tests:		Sections
Test A	Density Test	9-15
Test B_1	Indentation Force Deflection Test—Specified Deflection	16-22
Test B_2	Indentation Force Deflection Test—Specified Force	23-29
Test C	Compression Force Deflection Test	30-36
Test D	Constant Deflection Compression Set Test	37-44
Test E	Tension Test	45-52
Test F	Tear Resistance Test	53-60
Test G	Air Flow Test	61-67
Test H	Resilience (Ball Rebound) Test	68-75
Test I_1	Static Force Loss Test at Constant Deflection	77-85
Test I_2	Dynamic Fatigue Test by the Roller Shear at Constant Force,	86-94
Test I_3	Dynamic Fatigue Test by Constant Force Pounding	95-103
Test I_4	Dynamic Fatigue Test for Carpet Cushion	104-112
Test J	Steam Autoclave Aging	113-118
Test K	Dry Heat Aging	119-124

Appendixes:

X1. Suggested Method for Specifying Flexible Urethane Foams

[1] These test methods are under the jurisdiction of ASTM Committee D-20 on Plastics and are the direct responsibility of Subcommittee D20.22 on Cellular Plastics.

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

[3] *Annual Book of ASTM Standards*, Vol 04.07.

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 All foams shall be preflexed twice 75 to 80 % of their nominal thickness or as specified by the purchaser.

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 mm^2. Hold the pressure of the dial foot to 170 ± 35 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 70 Pa.

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

8.4 Results reported shall be the median of a minimum of three 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.

10. Test Specimen

10.1 *Interior 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.

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:

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

where:

M = mass of specimen, kg, and
V = volume of specimen, m^3.

14. Report

14.1 Report the following information:
14.1.1 Density to the nearest 1 kg/m^3, and
14.1.2 Type of specimen.

15. Precision and Bias

15.1 Precision statements are in the process of being prepared in the form specified by Practice D 4483 – 85.

TEST B_1 —INDENTATION FORCE DEFLECTION TEST—SPECIFIED DEFLECTION

16. Summary of Test Method

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 25 and 65 % or other designated indentations in the foam product (Appendix X3).

17. Apparatus

17.1 An apparatus having a flat circular indentor foot 323 cm^2 in area 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 0.4 to 6.3 mm/s. 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 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.

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 20 mm. Specimens less than 20 mm thick shall be plied up, without the use of cement, to a minimum of 20 mm.

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.

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 indentor foot to a total deflection of 75 to 80 % of the full-part thickness at a rate of 4 ± 0.4 mm/s. 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.

20.3 Bring the indentor foot into contact with the specimen and determine the thickness after applying a contact force of 4.5 N (Note 3) to the indentor foot. Indent the specimen at 0.83 ± 0.08 mm/s 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 3—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 pressure to make contact is normal.

21. Report

21.1 Report the force in newtons required for 25 and 65 % indentation (Note 4). These figures are known as the 25 % and 65 % IFD values, respectively. Report also length, width, and thickness of the specimen and the ratio (comfort factor Appendix X3) of 65 % to 25 % IFD values.

NOTE 4—Indentation deflection tests, other than 25 and 65 %, as well as a 25 % return value, may be specified as agreed upon between the supplier and the purchaser.

22. Precision and Bias

22.1 Precision statements are in the process of being prepared in the form specified by Practice D 4483 – 85.

TEST B_2 —INDENTATION FORCE DEFLECTION TEST—SPECIFIED FORCE

23. Summary of Test Method

23.1 Cellular foam products have been traditionally checked for force deflection by determining the force required to effect a 5 % 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 a 323-cm^2 circular indentor foot.

23.2 This determination shall be known as the Indentation Residual Deflection Force and the measurements as the IRDF values.

24. Apparatus

24.1 An apparatus having a flat circular indentor foot 323 cm^2 in area and equipped with a swivel joint for applying forces of 4.5 N, 110 N, and 220 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 foot and the platform shall be variable to indent the specimen at a speed of 0.83 ± 0.08 to 3.3 ± 0.3 mm/s for deflection 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 Conditions

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 IRDF values for molded products are dependent on the specimen dimensions. Difference values are generally obtained for specimens that retain all molded surfaces.

26. Number of Specimens

26.1 One specimen shall be tested.

27. Procedure

27.1 Test the whole test specimen or a minimum area of 380 by 380 mm. Preflex twice to a 10-kPa pressure. This corresponds to 330 N on a 320-cm^2 indentor foot at 3.3 mm/s. Allow to rest 6 ± 1 min. Position in the test apparatus with any coring, honeycombing, or slotting resting on the perforated bottom plate.

27.2 Bring the indentor foot into contact and determine the thickness of the specimen with the 4.5-N load on the indentor foot.

27.3 Apply the 110-N force at 0.83 ± 0.08 mm/s to the indentor foot and indent the specimen until the force is carried by the specimen. Determine the thickness at 110 N after maintaining the force for 60 ± 3 s.

27.4 Without removing the specimen apply the 220-N force to the indentor foot and further indent the pad until this load is carried. After 60 ± 3 s under load, observe the thickness of the pad.

28. Report

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

29. Precision and Bias

29.1 Precision statements are in the process of being prepared in the form specified by Practice D 4483 – 85.

TEST C—COMPRESSION FORCE DEFLECTION TEST

30. Summary of Test Method

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

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 0.4 to 6.3 mm/s. 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 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.

32.2 Specimens from uncored slab stock shall be a minimum of 2500 mm^2 in area and a minimum thickness of 20 mm. Specimens less than 20 mm thick shall be plied up, without the use of cement, to a minimum of 20 mm.

32.3 Specimens from cored slab stock shall be of such size that the coring does not appreciably affect the compression value.

32.4 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.

32.5 Maximum molded specimen thickness shall be no greater than the minimum top dimensions. Specimens from uncored stock shall have a minimum length of 50 mm, a minimum width of 50 mm, and a minimum thickness of 20 mm. Specimens less than 20 mm thick shall be plied up, without the use of cement, to a minimum of 20 mm.

33. Number of Specimens

33.1 Three specimens per sample shall be tested. The value reported shall be the median of those observed. If any value deviates more than 20 % from this median, two additional specimens shall be tested and the median for all five values shall be reported.

34. Procedure

34.1 Preflex the specimen twice, 75 to 80 % of its original thickness at 4 ± 0.4 mm/s. Then allow the specimen to rest for a period of 6 ± 1 min.

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 honeycombed, 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 0.83 ± 0.08 mm/s and observe the final load after 60 ± 3 s.

35. Report

35.1 Report the thickness after contact load, and the 50 % compression deflection value in pascals.

36. Precision and Bias

36.1 Precision statements are in the process of being prepared in the form specified by Practice D 4483 – 85.

TEST D—CONSTANT DEFLECTION COMPRESSION SET TEST

37. Summary of Test Method

37.1 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.

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.

39. Test Specimens

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

39.2 Specimens from uncored slab stock 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 slab stock shall be of such size that the coring does not appreciably affect the test result. They 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 75 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 50 mm thickness and the sample containing the top skin used for testing.

39.6 Specimens from cored molded products shall be of such size that the coring does not appreciably affect the test results. They shall have a minimum top surface area of at least 100 cm^2. The thickness shall be no greater than 75 mm and shall include the top molded surface. Specimens from molded products may be tested without skins by agreement between the customer and the supplier.

40. Number of Specimens

40.1 Three specimens per sample shall be tested. The value reported shall be the median of those observed. If any value deviates more than 20 % from this median, two additional specimens shall be tested and the median for all five values shall be reported.

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 ± 2 % relative humidity. The oven conditions shall be 70 ± 2°C and 5± 1 % relative humidity.

NOTE 6—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 ± 2 % relative humidity.

41.2 Measure 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 either 50 ± 1, 75 ± 1, or 90 ± 1 % of its thickness, or any other deflection depending on the value agreed upon between the supplier and the purchaser.

41.4 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.

41.5 Remove the specimen immediately from the apparatus and measure it in accordance with the procedure described in Section 8 after 30 to 40 min recovery.

42. Calculation

42.1 Calculate two compression set values as follows:

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

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

NOTE 7—Approximate conversion of C_d to C_t 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.

44. Precision and Bias

44.1 Precision statements are in the process of being prepared in the form specified by Practice D 4483 – 85.

TEST E—TENSION 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.

46. Apparatus

46.1 *Dies*—The specimen for tension tests shall be stamped out with a die of the shape and dimensions shown in Fig. 1, or

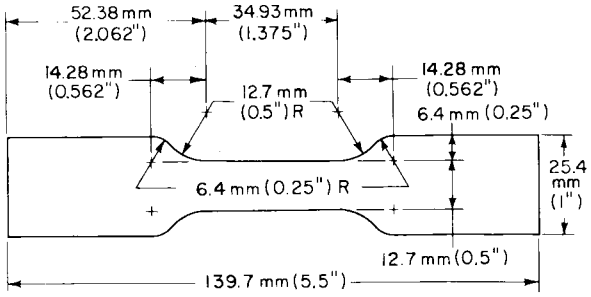

FIG. 1 Die for Stamping Tension Specimens

Die A of Test Methods D 412. The die shall be sharp and free of nicks in order to prevent leaving ragged edges on the specimen.

46.2 *Bench Marker*—The marker shall have two parallel marking edges 1.6 mm in thickness and spaced 20 or 25 mm apart on centers.

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

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

46.4.1 The machine shall be of such capacity as to allow the specimen to break at practically three fourths of machine full-scale force. It shall be equipped with a dial or scale indicator that will remain at the point of maximum load after rupture of the specimen and will measure the applied tension at that point. Rate of travel of a power-actuated grip shall be 8.3± 0.8 mm/s and shall be uniform at all times.

46.4.2 The machine may be equipped with a device graduated to 2.5 mm for measuring the elongation. 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 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 specimens shall be die cut either parallel to or across the direction of rise of the foam and shall be so specified. The length of the tabs may 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 median of those observed. If any value deviates more than 20 % from this median, two additional specimens shall be tested, and the median for all five values shall be reported.

49. Procedure

49.1 Set the grip separation at 65.3 mm minimum. 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. 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 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 median 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 the distance between bench marks or grip separations were used in the calculations.

52. Precision and Bias

52.1 Precision statements are in the process of being prepared in the form specified by Practice D 4483 – 85.

TEST F—TEAR RESISTANCE TEST

53. Scope

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

54. Apparatus

54.1 Tear resistance shall be measured on a power-driven apparatus which will indicate the final load 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 having an indicator that remains at the point of maximum force after rupture.

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 be cut on a saw or die cut from sheet material so that the sides are parallel and perpendicular to each other. A40-mm cut shall be