Designation: D 461 – 93

Standard Test Methods for Felt[1]

This standard is issued under the fixed designation D 461; 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 are applicable to all types of felt covered by Specification D 2475 and as defined in Section 3 herein.

1.2 The procedures appear in the following sections:

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

1.4 *This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory 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 risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.*

1.5 *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.* Specific warning statements are given in Note 9 and 25.4.

NOTE 1—The word "weight" is used in these test methods because of common trade practice, in place of the technically correct word "mass."

2. Referenced Documents

2.1 *ASTM Standards:*

D 76 Specification for Tensile Testing Machines for Textiles[2]

D 123 Terminology Relating to Textiles[2]

D 276 Test Method for Identification of Fibers in Textiles[2]

D 629 Test Methods for Quantitative Analysis of Textiles[2]

D 737 Test Method for Air Permeability of Textile Fabrics[2]

D 774 Test Method for Bursting Strength of Paper[3]

D 1388 Test Methods for Stiffness of Fabrics[2]

D 1574 Test Method for Extractable Matter in Wool[2]

D 1776 Practice for Conditioning Textiles for Testing[2]

D 2165 Test Method for pH of Aqueous Extracts of Wool and Similar Animal Fibers[2]

D 2475 Specification for Wool Felt[2]

E 70 Test Method for pH of Aqueous Solutions with the Glass Electrode[4]

2.2 *Other Standards:*

TT-I-563a Federal Specifications for Ink, Writing[5]

U. S. Military Standard MIL-105D Sampling Procedures and Tables for Inspection by Attributes[5]

3. Terminology

3.1 *Definitions:*

3.1.1 *acid content, n—of felt*, the number of milliequivalents of acid present per unit weight of felt, measured under prescribed conditions.

3.1.2 *dimensional change in boiling water in felt, n*—the change in length and width with any associated change in thickness produced by immersion in boiling water under specified conditions.

[1] These test methods are under the jurisdiction of ASTM Committee D-13 on Textiles and are the direct responsibility of Subcommittee D13.13 on Felt.

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[2] *Annual Book of ASTM Standards*, Vol 07.01.

[3] *Annual Book of ASTM Standards*, Vol 15.09.

[4] *Annual Book of ASTM Standards*, Vol 15.05.

[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

3.1.3 *extractable matter*, *n*—nonfibrous material in or on a textile, not including water, which is removable by a specified solvent or solvents, as directed in a specified procedure.

3.1.3.1 *Discussion*—Nonfibrous material is usually oily, waxy, resinous, or polymeric in nature, but may also include other material such as protein, particularly if ethyl alcohol is used as, or in, the extracting solvent.

3.1.4 *flame resistance*, *n*—the property of a material whereby flaming combustion is prevented, terminated, or inhibited following application of a flaming or nonflaming source of ignition, with or without subsequent removal of the ignition source.

3.1.5 *part wool felt, n*—a felt composed of any one of or a combination of new and recycled wool fibers mixed with one or more man-made fibers, vegetable fibers, or animal fibers other than wool.

3.1.6 *pH*, *n—in common usage*, a measure of acidity or alkalinity of a solution, on a logarithmic scale, with neutrality represented by a value of 7, with increasing acidity represented by decreasingly smaller values, and with increasing alkalinity represented by increasingly larger values.

3.1.7 *shrinkage*, *n*—a decrease in one or more dimensions of an object or material.

3.1.8 *splitting resistance*, *n—of felt*, the force required to overcome the interfacial strength of a material and specifically to separate a felt into two layers (of approximately equal thickness).

3.1.9 *supported needled felt*, *n*—a needled felt that is composed entirely of fibers physically interlocked and reoriented in combination with interlay, scrim, or foundation of knitted, stitched, bonded, or extruded structure.

3.1.10 *unsupported needled felt*, *n*—a needled felt that is composed entirely of fibers physically interlocked and reoriented with, and of themselves without an interlay, scrim, or foundation of knitted, stitched, bonded, or extruded structure.

3.1.11 *water retained*, *n—in textiles*, the amount of water absorbed by the fibers, adsorbed on the surface of the fibers, and held within the voids of the fabric after immersion, measured under specified conditions.

3.1.12 *wool felt, n*—a felt composed wholly of any one of or a combination of new or recycled wool fibers.

3.1.13 For definitions of other textile terms used in these test methods, refer to Terminology D 123.

4. Summary of Test Methods

4.1 These test methods include a number of specific test procedures designed to measure specific properties. Individual summaries are included in specific sections where pertinent (see, for example, 20.2).

5. Significance and Use

5.1 Except where specifically noted, these test methods cannot be formally recommended for acceptance testing of commercial shipments, because reliable data on the between-laboratory precision has not been established. The test methods are nevertheless used extensively in the trade to rate materials with respect to their conformance with Specification D 2475. In cases of dispute, the statistical bias, if any, between the laboratory of the purchaser and the laboratory of the seller should be determined with each comparison based on testing randomized specimens from one sample of material.

5.2 Unless otherwise specified, no justifiable statements on the bias of the procedures in these test methods can be made since the true values of the properties cannot be established by accepted referee methods.

6. Sampling Lots and Test Specimens

6.1 Take a lot sample as directed in an applicable material specification, or as agreed upon by the purchaser and the seller. In the absence of a material specification or other agreement, take a lot sample and laboratory samples as follows:

Lot Size in Yards or Sheets[A]	Sample size in Rolls l/lot	Sample size in Sheets l/lot
Up to 1200	3	7
1201 up to and including 3200	5	10
3201 up to and including 10 000	7	15
10 001 up to and including 35 000	10	25
35 001 up to and including 150 000	15	35
150 001 and over	25	50

[A] If a lot contains fewer than the required number of rolls or sheets, sample each role or sheet in the lot.

6.2 Take three samples, mark them “edge No. 1,” “center,” and “edge No. 2,” but do not take samples from areas within 6 in. (150 mm) from the edges of the roll, piece, or sheet; in the case of roll felt, omit the area within a distance from the end of the roll equal to the width of the roll. Mark the sampling areas with indelible ink, or by other means, to indicate the lengthwise direction of the original piece. The size and number of specimens cut will be determined by the number of tests to be run.

NOTE 2—In some cases the same specimens may be used for more than one test. For example, the specimens tested for thickness may also be used for weight, air permeability, wool content, or ash tests.

7. Conditioning

7.1 Bring the samples or specimens from the prevailing atmosphere to moisture equilibrium for testing in the standard atmosphere for testing textiles as defined in Practice D 1776, for tests made as directed in the following sections:

	Sections
Bursting Strength	13
Fire Retardance	20
Oil Retention	21
Splitting Resistance	14
Stiffness	19
Tensile Strength, “Breaking Load,” and “Specific Strength”	12
Thickness Change After Exposure to Boiling Water and Subsequent Drying	16
Thickness of Conditioned Specimens	10
Water Retained	17
Weight per Unit Area	11

7.2 Specimens need not be conditioned for the following tests:

	Sections
Air Permeability	18
Ash	26
Dimensional Change in Boiling Water-Length and Width	15
Fiber Identification	24
Matter Extracted by 1,1,1-Trichloroethane	22
Matter Extracted by Water	23
pH	28
Wool Content	25

8. Length of Roll

8.1 *Apparatus*—Measuring drum of known circumference driven by a chain or other positive nonslip mechanism that registers the yardage on a dial or counter.

8.2 *Procedure*—Measure the length of a roll or piece by running it over the measuring drum, applying just enough tension uniformly to keep the felt running flat and true. Record the indicated length to the nearest 0.1 m or ⅛ yd.

8.3 *Report*:

8.3.1 State that the specimens were tested as directed in Section 8 of ASTM Test Methods D 461. Describe the material or product sampled and the method of sampling used.

8.3.2 Report the length to the nearest 0.1 m or ⅛ yd.

8.4 *Precision and Bias*:

8.4.1 *Precision*—The precision of the test method for length of roll is being established.

8.4.2 *Bias*—See 5.2.

9. Width of Roll or Sheet

9.1 *Apparatus—Steel Rule*, graduated in 1 mm or ⅛ in.

9.2 *Procedure*—Measure the width of a roll, piece, or sheet to the nearest 5 mm or 0.25 in. at five different places uniformly distributed along its full length, but in the case of a roll or piece, omit the ends for a distance equal to the width of the roll.

9.3 *Calculation*—Average the five width measurements.

9.4 *Report*:

9.4.1 State that the specimens were tested as directed in Section 9 of ASTM Test Methods D 461. Describe the material or product sampled and the method of sampling used.

9.4.2 Report the average width to the nearest 5 mm or 0.25 in. In the case of sheet felt, report both directions as width.

9.5 *Precision and Bias*:

9.5.1 *Precision*—Since the procedures in Test Methods D 461 for testing the width of felt involve only the reading of a steel rule, the precision of the procedure has not been established.

9.5.2 *Bias*—The procedures in Test Methods D 461 for testing the width of felt have no known bias and are generally used as a referee method.

10. Thickness of Conditioned Specimens

10.1 *Significance and Use*—This test is used to determine if the sample felt in roll, sheet and cut part form meets specific tolerances for thickness. Thickness is a critical dimensional characteristic of felt.

10.2 *Apparatus*:

10.2.1 *Dial Micrometer*, consisting of an anvil for supporting the specimen, a circular presser foot acting under a dead-weight load and a dial graduated to read 0.02 mm (0.001 in.) in increments of 0.02 mm.

10.2.2 *Supporting Anvil*—A flat horizontal surface with a minimum diameter of 50 mm (2 in.).

10.2.3 *Presser Foot*—The lower surface of the presser foot shall be parallel to the plane of the anvil and have an area of 6.45 ± 2 mm^2 (1 ± 0.0025 $in.^2$), that is 28.6 mm (1.129 in.) in diameter. It shall be sufficiently thick to ensure rigidity, and the edges shall be rounded off with a radius of 0.40 mm ± 0.02 mm (0.016 ± 0.001 in.). The surface of the presser foot shall be actuated by a freely acting total dead weight of 283 ± 14 g (10 ± 0.5 oz), except that when the felt has a density less than 0.14 g/cm^3 (0.08 $oz/in.^3$) the dead weight load shall be 57 ± 2.8 g (2 ± 0.1 oz).

10.3 *Sampling*—Use specimens having an area of at least 258 cm^2 (40 $in.^2$) taken from the center and side areas described in Section 6.

10.4 *Procedure for Roll and Sheet Specimens*—Place the conditioned specimen on the supporting anvil of the dial micrometer in a flat and relaxed condition. For large, heavy or stiff felts, provide large additional supports at the same level as the anvil to avoid tendencies for the felt to curve or buckle. Apply the load to the specimen gradually and without shock. After approximately 10 s read the thickness on the dial to the nearest 0.025 mm (0.001 in.). Measure the thickness in five locations evenly distributed over each specimen.

10.5 *Calculation and Report for Roll and Sheet Specimens*:

10.5.1 Calculate the average of the five thickness readings on each specimen of roll and sheet felt.

10.5.2 State that the specimens were tested as directed in Section 10 of ASTM Test Methods D 461. Describe the material or product sampled and the method of sampling used.

10.5.3 Report the average thickness of all specimens to the nearest 0.025 mm (0.001 in.).

10.6 *Precision and Bias for Roll and Sheet Specimens*:

10.6.1 *Precision*—The precision of the test method for thickness is being established.

10.6.2 *Bias*—See 5.2.

10.7 *Procedure for Cut Parts*:

10.7.1 Take samples of cut felt parts at random from throughout the entire lot. Take a lot size of the sample as directed in MIL-STD-105D, General Inspection Level II, Multiple Sampling Plan for Normal Inspection.

10.7.2 When the cut part is large enough to provide a continuous flat felt surface under the 28.66-mm (1.129-in.) diameter foot, proceed as in 10.4.

10.7.3 When the area of the cut part is insufficient to provide completely a continuous flat felt surface under the 28.66-mm (1.129-in.) diameter presser foot, adjust the weight of the freely acting total dead weight made to provide a constant loading of 4300 ± 215 Pa (10 ± 0.5 $ozf/in.^2$) on the individual cut felt part (see Table 1). Proceed to measure the individual cut part thickness as directed in 10.4, except take only a single reading.

10.8 *Calculation and Report for Cut Parts*:

10.8.1 Use an Allowable Quality Level (AQL) of 4.0 for all felt whose classification is listed in Table 1 of Specification D 2475.

10.8.2 Also use the appropriate cut part thickness tolerances

TABLE 1 Load Adjustments for Cut Part Thickness

Area Under Presser Foot		Required Loading on Felt	
in.^{2}	mm^2	ozf	N
0.000 to 0.200	0 to 130	2.00 ± 0.10	0.556
0.201 to 0.300	130 to 194	3.00± 0.15	0.834
0.301 to 0.400	195 to 258	4.00± 0.20	1.112
0.401 to 0.500	259 to 323	5.00± 0.25	1.390
0.501 to 0.600	324 to 387	6.00± 0.30	1.668
0.601 to 0.700	388 to 452	7.00± 0.35	1.946
0.701 to 0.800	453 to 516	8.00± 0.40	2.224
0.801 to 0.900	517 to 580	9.00± 0.45	2.502
0.901 to 1.000	581 to 645	10.00± 0.50	2.780

as listed in Table 1 for Specification D 2475 under cut felt part tolerances.

10.8.3 Determine if the lot is acceptable or rejectable from the appropriate table in MIL-STD-105D under Normal Inspection, General Inspection Level II, Multiple Sampling Plan for Normal Inspection.

10.8.4 State that the specimens were tested as directed in Section 10 of ASTM Test Methods D 461 and in the Sampling Procedures and Tables for Inspection by Attributes, MIL-STD-105D. Describe the material or product sampled and the method of sampling used.

10.8.5 Report that the lot is either accepted or rejected on the basis of observed thickness and applicable thickness tolerances.

10.9 *Precision and Bias for Cut Parts*—The acceptance or rejection of a lot for the thickness of cut parts is an attribute, and the usual statements on precision and bias do not apply.

11. Weight per Unit Area

11.1 *Significance and Use*—This test is used to determine if the felt meets specifications for weight per unit area.

11.2 *Test Specimens*—Cut rectangular specimens of not less than 250 cm^2 (40 in.^{2}) from the three sampling areas described in Section 6.

11.3 *Procedure*—Weigh each conditioned specimen separately in grams or ounces to the nearest 0.1 % of its weight.

11.4 *Calculation*—Calculate the weight of each specimen in ounces per square yard using Eq 1.

$$\text{Weight, oz/yd}^2 = \frac{\text{weight of specimen in g} \times 45.72}{\text{length of specimen in in.} \times \text{width in in.}} \quad (\text{oz/yd}^2 \times 33.9 = \text{g/m}^2) \quad (1)$$

11.5 *Report*:

11.5.1 State that the specimens were tested as directed in Section 11 of ASTM Test Methods D 461. Describe the material or product sampled and the method of sampling used.

11.5.2 Report the average weight of the three specimens tested to the nearest 3 g (0.1 oz).

11.6 *Precision and Bias*:

11.6.1 *Precision*—The precision of the test method for weight per unit area is being established.

11.6.2 *Bias*—See 5.2.

12. Tensile Strength, "Breaking Load," and "Specific Strength"

12.1 *Scope*—The same procedure is used for both properties, but the results are calculated and reported in two different ways: first as breaking load expressed as N (lbf)/2 in. width of specimen, and second as specific strength (Note 3) expressed as pounds-force per square inch of cross section of the original specimen.

NOTE 3—In the table in Specification D 2475, specific strength is referred to as "tensile strength, psi."

12.2 *Significance and Use*—Strength is a measure of the ability of the felt to withstand tensile stresses in handling and in use. Strength and elongation are frequently related to the felt density, fiber quality, and fiber length. Strength measurements may also serve as a measure of the degree of felting.

12.3 *Apparatus—Tensile Testing Machine*, conforming to Specification D 76 CRT, CRE, and CRL type.

12.4 *Test Specimens*—Cut two specimens 50 by 150 mm (2 by 6 in.) from the center and from both sides of sampling areas described in Section 6 with the long dimension parallel to the length of the piece. Cut two specimens of the same size from each of the three areas with the long dimension crosswise of the piece.

12.5 *Procedure*:

12.5.1 Adjust the testing machine, if necessary, so that the breaking load will be between 20 and 90 % of its scale capacity. Use clamps having jaws not less than 64 mm (2.5 in.) in width. Set the speed of the pulling clamp at 305 mm ± 10 mm (12 ± ½ in.)/min in the CRE and CRT-type machine. Adjust the CRL-type testing machine so that the time-to-break is within 90 % of the machine's rated time to full-load. Set the distance between the clamps at the start of the test at 75 ± 1 mm (3 ± 0.05 in.). Insert the conditioned specimen in the central part of the clamps with approximately the same length of fabric extending beyond the jaws at each end. Activate the testing machine and apply an increasing load to the specimen until it breaks. Record the indicated load to the nearest 0.44 N (0.1 lbf).

12.5.2 Test the remaining specimens as directed in 12.5.1.

12.5.3 Determine the thickness of each specimen as directed in Section 10.

12.6 *Calculation*:

12.6.1 Calculate the average thickness of all the specimens.

12.6.2 Calculate the "specific strength" using Eq 2 or Eq 3.

$$\text{Specific strength, kgf/cm}^2 = B/5T \quad (2)$$

where:

B = average breaking load (strength) in N/5 cm width of test specimen, and

T = average thickness of test specimen, cm.

$$\text{Specific strength, psi} = B/2T \quad (3)$$

where:

B = average breaking load (strength) in lbf/2 in. width of test specimen, and

T = average thickness of test specimen, in.

12.7 *Report*:

12.7.1 State that all specimens were tested as directed in Section 12 of ASTM Test Methods D 461. Describe the material or product sampled and the method of sampling used.

12.7.2 Report the "breaking load" and the "specific

strength" of the lengthwise and crosswise specimens separately. Report the breaking load in N/50 mm (lbf/2 in.) of width to the nearest 2.2 N (0.5 lbf). Report the specific strength to the nearest 3.5 kPa (0.51 psi).

12.8 *Precision and Bias*:

12.8.1 *Precision*—The precision of the test method for breaking load and specific strength is being established.

12.8.2 *Bias*—See 5.2.

13. Bursting Strength

13.1 *Significance and Use*—Bursting strength may be important in certain end use applications such as filtration.

13.2 *Apparatus—Bursting Tester of the Diaphragm Type*,[6] having a 30.5-mm (1.2-in.) orifice commonly referred to as a Mullen tester and used in testing paper and knitted fabric. The tester runs at a constant rate of 98 ± 4 cm^3/min (6 ± 0.25 $in.^3$/min) to ensure a uniform displacement of the pressure medium. The tester should be furnished with a gage such that the bursting point of the specimens falls within 10 to 90 % of full gage capacity.

13.3 *Test Specimens*—From each of the three sampling areas described in Section 4, cut two specimens of sufficient size that the smallest dimension will be at least 13 mm (0.5 in.) greater than the outside diameter of the ringclamp mechanism of the testing machine.

13.4 *Procedure*:

13.4.1 Place the conditioned specimen smoothly and without tension between the diaphragm and the upper clamp. Clamp the specimen securely, and start the machine.

13.4.2 Turn off the machine as soon as the specimen is ruptured. Record the final bursting pressure indicated on the gage to the nearest 6.9 kPa (1.0 psi).

13.5 *Calculation*—Calculate the average bursting pressure of the six specimens.

13.6 *Report*:

13.6.1 State that the specimens were tested as directed in Section 13 of ASTM Test Methods D 461. Describe the method or product sampled and the method of sampling used.

13.6.2 Report the average bursting pressure (bursting strength) of the six specimens to the nearest 6.9 kPa (1.0 psi).

13.7 *Precision and Bias*:

13.7.1 *Precision*—The precision of the test method for bursting strength is being established.

13.7.2 *Bias*—See 5.2.

14. Splitting Resistance

14.1 *Scope*—This test method covers the determination of the resistance to splitting and is applicable to felts thicker than 5 mm (3⁄16 in.).

14.2 *Significance and Use*—Splitting resistance is a measure of the internal strength of a felt, which may be important in certain end uses, such as shock mounts and polishing pads. For material thinner than 5 mm (3⁄16 in.), breaking strength is considered adequate.

14.3 *Apparatus—Tensile Testing Machine*, A CRE or CRT machine as specified in 12.3.

14.4 *Test Specimens*—Prepare specimens as directed in 12.4.

14.5 *Procedure*—Split the conditioned specimen within the middle third of the thickness for a distance of approximately 50 mm (2 in.) from one end only to form two lips. Secure one of these lips in each clamp of the testing machine, bringing the clamps close enough together for the purpose. Start the machine and record the force required to continue the splitting process. Lay a fine thread or transparent rule over the recorded tension on the chart as an aid in reading the average tension.

14.6 *Calculation*—Calculate the average force for the six lengthwise and the six widthwise specimens, separately.

14.7 *Report*:

14.7.1 State that the specimens were tested as directed in Section 14 of ASTM Test Methods D 461. Describe the material or product sampled and the method of sampling used.

14.7.2 Report separately the average splitting resistance of the lengthwise and crosswise specimens in N/50 mm (lbf/2 in.) of width to within 5 % of the average resistance.

14.8 *Precision and Bias*:

14.8.1 *Precision*—The precision of the test method for splitting resistance is being established.

14.8.2 *Bias*—See 5.2.

15. Dimensional Changes (Relaxation Shrinkage) in Boiling Water-Length and Width

15.1 *Significance and Use*—Shrinkage of felt in water is important in predicting dimensional changes which may occur during certain end uses, for example, when a felt is exposed to moist conditions for a prolonged time, or when immersed in water.

15.2 *Apparatus*:

15.2.1 *Stainless Steel Wire Screen*, 150 by 150 mm (6 by 6 in.) with openings approximately 6 mm (0.25 in.).

15.2.2 *Anionic Wetting Agent*.[7]

15.2.3 *Blotting Paper*, meeting the following requirements:

15.2.3.1 *Absorbency*, 1 mL of standard Government ink in 40 to 50 s. This ink shall conform to Federal Specification TT-I-563a.

15.2.3.2 *Size Sheets*, 200 by 200 mm (8 by 8 in.).

15.2.3.3 *Thickness* (Caliper), 26 to 26.5 points.

15.2.3.4 *Bursting Strength* (Mullen), 276 to 310 kPa (40 to 45 psi) determined as directed in Test Method D 774.

15.2.4 *Container*, large enough to hold a 300-mm (12-in.) square specimen of felt under water with means for boiling the water.

15.3 *Test Specimens*—Cut one specimen approximately 300 mm (12 in.) square from the center and from both side areas described in Section 6.

15.4 *Preparation of Specimens*—Lay the specimens without tension on a flat horizontal surface, taking care that there are no wrinkles or creases. Place a staple in the specimen or place on it a waterproof mark about 25 mm (1 in.) from one edge. Measure 250 mm (10 in.) directly lengthwise of the specimen

[6] A suitable testing machine is made by B. F. Perkins and Sons Inc., Mullen Tester Div., P.O. Box 388, Holyoke, MA 01040.

[7] Deceresol Surfactant O.T. (American Cyanamid Co.) Dyes and Textile Chemicals Department, Bound Brook, NJ 08805, and Nacconal 90 F. (Allied Chemical Co.) Specialty Chemicals Divisions, P.O. Box 70, Morristown, NJ 08057, have been found satisfactory.

and place a second staple or mark. Repeat this procedure in the widthwise direction.

15.5 *Procedure*:

15.5.1 Measure and record the distance between each pair of staples or marks to the nearest 1 mm or 1⁄16 in. on each specimen, noting whether the measurements were made in the lengthwise or crosswise direction.

15.5.2 Place a specimen on the wire screen and immerse both in the boiling water. Withdraw the screen and specimen after 2 min and place the specimen in a flat position between sheets of blotting paper to remove excess moisture. Use care to avoid distorting the wet specimen in either direction. Do not use squeeze rolls. Measure the distance between the staples or marks as soon as practicable and, while still wet, with the same precision as before immersion. On hard felts which are difficult to wet out, use a water bath containing 0.05 % of an anionic wetting agent.

NOTE 4—Anionic types are recommended because many surfactants, particularly the nonionic types, are thrown out of solution below the boiling point of water.[7]

15.6 *Calculation*—Average the measurements of the distances between the marks for each direction of the specimen before and after treatment. Calculate the dimensional change in percent using Eq 4 and Eq 5.

$$\text{Length change, percent} = [(L - F)/L] \times 100 \quad (4)$$

$$\text{Width change, percent} = [(W - D)/W] \times 100 \quad (5)$$

where:
L = average original length,
F = average final length,
W = average original width, and
D = average final width.

15.7 *Report*:

15.7.1 State that the specimens were tested as directed in Section 15 of ASTM Test Methods D 461. Describe the material or product sampled and the method of sampling used.

15.7.2 Report the average percent change in length and the average percent change in width to the nearest 0.1%.

15.7.3 State whether the dimensional change was in the form of shrinkage or growth.

15.8 *Precision and Bias*:

15.8.1 *Precision*—The precision of the test method for dimensional changes in boiling water is being established.

15.8.2 *Bias*—See 5.2.

16. Thickness Change After Exposure to Boiling Water and Subsequent Drying

16.1 *Significance and Use*—Dimensional change in thickness is important in determining thickness changes that may occur during certain end uses, for example, under prolonged moist conditions or immersion in water.

16.2 *Apparatus*:

16.2.1 *Wire Screen*, as specified in 15.2.1.

16.2.2 *Anionic Wetting Agent*.

16.2.3 *Container*, as specified in 15.2.4.

16.3 *Test Specimens*—Cut specimens 50 by 50 mm (2 by 2 in.) square from the center and both side areas described in Section 6.

16.4 *Procedure*:

16.4.1 Measure the thickness of each conditioned specimen in four places as directed in Section 10.

16.4.2 Place the specimens on a wire screen and immerse in boiling water for 2 min, as directed in 15.5.

16.4.3 Remove the specimens and dry them at 105 to 110°C until they are dryer than the moisture equilibrium reached in the standard atmosphere for testing textiles, or until they feel dry to the bare hand; however, do not desiccate completely. Recondition specimens as directed in Section 7.

16.4.4 Remeasure the thickness in four places on each specimen as directed in 16.4.1.

16.5 *Calculation*:

16.5.1 For each specimen, calculate the average thickness before immersion and after immersion, drying and reconditioning.

16.5.2 Calculate the dimensional change in thickness using Eq 6.

$$\text{Dimensional change in thickness, percent} = [(B - A)/A] \times 100 \quad (6)$$

where:
A = specimen thickness before immersion (see 16.4.1), and
B = specimen thickness after immersion (see section 16.4.5).

16.6 *Report*:

16.6.1 State that the specimens were tested as directed in Section 16 of ASTM Test Methods D 461. Describe the material or product sampled and the method of sampling used.

16.6.2 Report the thickness change after exposure to boiling water to the nearest 0.5 %.

16.7 *Precision and Bias*:

16.7.1 *Precision*—The precision of the test method for thickness change after exposure to boiling water is being established.

16.7.2 *Bias*—See 5.2.

17. Water Retained

17.1 *Significance and Use*—Water retained is a measure of the moisture-holding capacity of a felt. This characteristic is important in end uses such as reservoirs for ink.

17.2 *Apparatus*:

17.2.1 *Immersion Tank*, at least 210 mm (8 in.) deep and 160 mm (6 in.) wide as illustrated in Fig. 1.

17.2.2 *Sinkers*, to pull the specimen under water. Maximum height 90 mm (3.5 in.). See Fig. 1.

17.2.3 *Hooks*, to attach the weight to the felt.

17.2.4 *Blotters*, meeting the requirements of 15.2.2.

17.2.5 *Hand Roller*, weighing 1 kg (2.2 lb) meeting the specifications in Fig. 2.

17.3 *Test Specimens*—Cut a square specimen measuring 76 mm (3 in.) along each side from each of the three sample areas described in Section 6.

17.4 *Procedure*:

17.4.1 Weigh the individual conditioned specimens in grams to the nearest 5 mg (Weight A).

17.4.2 Prepare the immersion tank with distilled water maintained at a temperature of 21 ± 0.5°C (70 ± 1°F). Attach the hook and sinker to the weighed specimen at a point midway