



Standard Test Methods for Coated and Laminated Fabrics for Architectural Use¹

This standard is issued under the fixed designation D 4851; 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 cover the testing of coated and laminated fabrics made primarily for use in fabric roof systems. These coated and laminated fabrics are generally in either an air supported or tension supported construction of fabric roof systems.

1.2 These methods can be used for most fiber-based, coated and laminated architectural fabrics.

1.3 This standard includes the following sections that provide test procedures for coated and laminated architectural fabrics:

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1.4 These test methods include only testing procedures and do not include specifications or tolerances. They are intended as a guide for specifications. Any of these methods may be used in material specifications to evaluate requirements for a specific end use as related to a particular job.

1.5 The values stated in either SI or inch-pound units are to be regarded separately as the standard. Within the text, the inch-pound units are shown in parentheses. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other.

1.6 *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 appro-*

priate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards:

- C 423 Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method²
- D 123 Terminology Relating to Textiles³
- D 751 Test Methods for Coated Fabrics⁴
- D 1003 Test Method for Haze and Luminous Transmittance of Transparent Plastics⁵
- D 1494 Test Method for Diffuse Light Transmission Factor of Reinforced Plastics Panels⁶
- D 1776 Practice for Conditioning Textiles for Testing³
- D 1777 Method of Measuring Thickness of Textile Materials³
- D 2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data³
- D 2906 Practice for Statements on Precision and Bias for Textiles³
- D 3773 Test Methods for Length of Woven Fabric⁷
- D 3774 Test Methods for Width of Woven Fabric⁷
- D 3775 Test Method for Fabric Count of Woven Fabric⁷
- D 3776 Test Methods for Mass Per Unit Area (Weight) of Woven Fabric⁷
- D 3882 Test Method for Bow and Skewness in Woven and Knitted Fabrics⁷
- D 4848 Terminology of Force, Deformation and Related Properties of Textiles⁷
- D 5035 Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)⁷
- D 5587 Test Method for Tearing Strength of Fabrics by the Trapezoid Procedure⁷
- E 84 Test Method for Surface Burning Characteristics of Building Materials⁸
- E 108 Test Methods for Fire Tests of Roof Coverings⁸

¹ These test methods are under the jurisdiction of ASTM Committee D13 on Textiles and are the direct responsibility of Subcommittee D13.59 on Fabric Test Methods, General.

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² Annual Book of ASTM Standards, Vol 04.06.

³ Annual Book of ASTM Standards, Vol 07.01.

⁴ Annual Book of ASTM Standards, Vol 09.02.

⁵ Annual Book of ASTM Standards, Vol 08.01.

⁶ Annual Book of ASTM Standards, Vol 07.02.

⁷ Annual Book of ASTM Standards, Vol 04.07.

⁸ Annual Book of ASTM Standards, Vol 12.02.

E 136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C⁸

E 424 Test Methods for Solar Energy Transmittance and Reflectance (Terrestrial) of Sheet Material⁸

G 23 Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials⁹

G 26 Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials⁹

G 53 Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials⁹

2.2 *Adjunct:*

TEX-PAC¹⁰

2.3 *Federal Standards:*

Federal Test Method Standard 191b, Method 5903, Vertical Flame Resistance of Cloth¹¹

NFPA 701 National Fire Protection Standards—701 Standard Methods of Fire Tests for Flame Resistant Textiles and Films¹²

3. Terminology

3.1 *Definitions:*

3.1.1 *air-supported roof, n*—a fabric roof-system that is properly secured and primarily supported and held in place by air pressure.

3.1.2 *architectural-use, n*—in the building trade, a descriptive term for fabrics used in fabric roof-systems or similar industrial applications. (See also *fabric roof-system*)

3.1.3 *coated fabric, n*—a flexible material composed of a textile fabric and an adherent polymeric material applied to one or both surfaces. (See also *laminated fabric*)

3.1.4 *fabric roof-system, n*—a system of coated fabric or laminated fabric along with support cables, edge ropes, clamps, neoprene, roof drains, arch wear strips, and anchor bolts that constitutes the outside top covering of a building.

3.1.5 *laminated fabric, n*—in fabric roof-systems, a flexible material composed of superimposed layers of textile fabric firmly united by bonding or impregnating with an adherent polymeric material to one or more surfaces.

3.1.6 *tension-supported roof, n*—a fabric roof-system, that is properly secured and primarily held in place by tensile forces applied across the system.

3.1.7 For terminology of other textile terms used in this standard, refer to Terminology D 123. For definitions related to force and deformation in textiles, refer to Terminology D 4848.

4. Summary of Test Method

4.1 A summary of the directions prescribed for the determination of specific properties is stated in the appropriate sections of specific methods or in the referenced test methods.

5. Significance and Use

5.1 The procedures in this standard can be used for acceptance testing of commercial shipments of coated and laminated fabrics for architectural use since these test methods have been used extensively in the trade for acceptance testing. Caution is advised, however, when testing adhesion of coating to fabric and breaking strength after crease fold because between laboratory precision is known to be poor (see 24.2). For these cases, comparative tests conducted, as directed in 5.1.1, may be advisable.

5.1.1 In cases of a dispute arising from differences in reported test results when using Test Methods D 4851 for acceptance testing of commercial shipments, the purchaser and the supplier should conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens which are as homogeneous as possible and from a lot of material of the type in question. The test specimens should then be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using appropriate statistical analysis for unpaired data and an acceptable probability level chosen by the two parties before the testing is begun. If a bias is found, either its cause must be found and corrected or the purchaser and the supplier must agree to interpret future test results with consideration of the known bias.

5.2 The uses and significance of specific properties are discussed in the appropriate sections of specific test methods.

6. Sampling

6.1 *Lot Size*—The size of an acceptance sampling lot of fabric for architectural use shall be the number of fabric rolls in a shipment or consignment of a single fabric style unless otherwise agreed upon between the purchaser and supplier.

6.2 *Lot Sample*—Unless otherwise agreed upon, as when specified in an applicable order or contract, take as a lot sample the number of rolls in a shipment or consignment of fabric. Specify the number of rolls of fabric in the lot sample for each property of interest. Consider rolls of fabric to be the primary sampling units.

NOTE 1—An adequate specification or other agreement between the purchaser and supplier requires taking into account the variability between rolls of fabric and between specimens from a swatch or roll of fabric to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

6.3 *Laboratory Sample*—As a laboratory sample, take the following samples:

6.3.1 For fabric width, fabric bow, and fabric length, the rolls in the lot sample serve as the laboratory sample.

6.3.2 For noise reduction coefficient, flame resistance other than small scale NFPA 701, solar optical properties, and resistance to accelerated weathering, take as a laboratory sample a full-width swatch 12 m (12 yd) long from the end of each randomly selected roll in the lot sample as determined by agreement between the purchaser and supplier.

NOTE 2—Properties such as noise reduction coefficient, some flame resistance tests, solar optical, and resistance to weathering are dependent

⁹ Annual Book of ASTM Standards, Vol 14.02.

¹⁰ PC Programs on floppy disks are available through ASTM. For a 3½-in. disk request PCN:12-429040-18.

¹¹ Available from U.S. Government Printing Office, North Capital and H Streets, NW, Washington, DC 20401.

¹² Although discontinued by the National Fire Protection Association, this standard continues to be used by the industry.

upon fabric style and manufacturing processes. The extent of the sampling for these properties is usually defined in the applicable order or contract. Among the options available to the purchaser and the supplier is for the purchaser to accept a certification by the manufacturer that the material in question meets the specification agreed upon by the two parties and what the basis for the certification is, such as, historical data generated from material manufactured under the same conditions.

6.3.3 For other properties take as a laboratory sample a full-width swatch 1 m (1 yd) long from the end of each roll in the lot sample.

NOTE 3—The sample swatch, as in the laboratory sample, may be taken from the end of a roll if there is no visual evidence that the fabric is distorted or different from the fabric in other parts of the roll. In cases of dispute or if by visual evidence the outside fabric is not typical, take a sample swatch after excluding fabric from the outer wrap of the roll or the inner wrap of the core.

6.4 *Test Specimens*—For fabric width, fabric bow, and fabric length, the rolls in the lot sample serve as test specimens. For other properties, take test specimens from the swatches in the laboratory sample as directed in the respective test methods in this standard.

6.4.1 Take the specimens for the measurement of the machine direction properties from different positions across the fabric width and the specimens for the measurement of the cross-machine direction properties from different positions along the length of the fabric. Take no specimens nearer the selvage or edge of the fabric than $\frac{1}{10}$ the width of the fabric or 125 mm (5 in.) whichever is smaller.

7. Conditioning

7.1 Bring the specimens to moisture equilibrium in one of the following atmospheres:

7.1.1 *Option 1*—A temperature of $21 \pm 2^\circ\text{C}$ ($70 \pm 4^\circ\text{F}$) and relative humidity of $65 \pm 5\%$.

7.1.2 *Option 2*—A temperature of $23 \pm 2^\circ\text{C}$ ($73 \pm 4^\circ\text{F}$) and relative humidity of $50 \pm 5\%$.

NOTE 4—The intent of the two options for testing atmospheres is to allow testing of architectural fabrics in respective laboratories where products generally manufactured are related to a fabric laminating or coating discipline. In any event, the test atmosphere option shall be agreed upon by the contractual parties and stated in the report.

7.2 Equilibrium is considered to have been reached when the increase in mass of the specimen in successive weighings made at intervals of not less than 2 h does not exceed 0.1 % of the mass of the specimen. In general practice, the industry approaches equilibrium from the “As Received” side.

NOTE 5—It is recognized that in practice, coated and laminated fabrics are frequently not weighed to determine when moisture equilibrium has been reached. While such a procedure cannot be accepted in cases of dispute, it may be sufficient in routine testing to expose the material to the standard atmosphere for testing for a reasonable period of time before the specimens are tested. A time of at least 24 h has been found acceptable in most cases. However, certain fibers and coatings may exhibit slow moisture equalization rates from the “As Received” wet side. When this is known, a preconditioning cycle, as described in Practice D 1776 may be agreed upon between contractual parties.

8. Fabric Count

8.1 Determine the fabric count as directed in Test Method D 3775 making five counts in the machine direction and five

counts in the cross-machine direction on each of the swatches from the rolls in the laboratory sample.

9. Mass Per Unit Area

9.1 Determine the mass per unit area of the fabric as directed in Test Methods D 3776, Option C, using each of the rolls in the laboratory sample.

10. Thickness

10.1 Determine the thickness of the fabric as directed in Method D 1777 using ten test specimens from each roll in the laboratory sample and using the gage with a presser foot with a diameter of 9.5 ± 0.025 mm (0.375 ± 0.001 in.) that is weighted to apply a total force of 1.70 ± 0.03 N (6 ± 0.1 ozf) equivalent in pressure of 23.4 kPa (3.4 psi), unless otherwise specified.

11. Width

11.1 Determine the width of the fabric as directed in Test Method D 3774, Option A (full roll), using the tension free procedure, except make five measurements on each of the rolls in the lot sample.

12. Length

12.1 Measure the length of each roll in the lot sample as directed in Test Method D 3773 using Option B (Drum Method) or Option C (Clock Method). Verify that each sample roll does not contain more than one piece. Total the lengths of the rolls measured. Compare the length for each of the rolls tested to the length specified on the corresponding identification label.

13. Fabric Bow

13.1 Measure the fabric bow of each roll in the lot sample as directed in Test Method D 3882 in three places spaced as widely as possible along the roll length. Make no measurement closer to the ends of the roll than 1 m (1 yd).

14. Adhesion of Coating to Fabric

NOTE 6—**Precaution:** In addition to other precautions, when flammable or toxic adhesives are used for sealing, they should be cured in a well-ventilated area, for example, under a hood, to prevent accumulation of vapors. This is also applicable when sealing techniques that do not require adhesives are used.

14.1 Determine the coating adhesion in both machine direction and cross-machine direction as directed in Test Methods D 751, using two sets of specimens in both the machine direction and the cross-machine direction. Use a constant-rate-of-extension (CRE) type tensile testing machine operated at 50 ± 3 mm/min (2.0 ± 0.1 in./min) and report the rate used.

14.2 The use of hydraulic-pneumatic clamping systems with a minimum of 50 by 75 mm (2 by 3 in.) serrated jaw faces is recommended. Manual clamping is permitted if no slippage of the specimen is observed.

14.3 Run the test with the following exception: Prepare test specimens by sealing two material strips face to back.

14.4 Use the sealing method for seams typical to the material under test as defined in the Annexes or by an applicable contract or order. To facilitate separation later, do

not seal the upper 25 mm (1 in.) of specimen. Condition the specimens as specified in the sealing method before testing.

14.5 After conditioning, cut through a 25 by 200 mm (1 by 8 in.) strip of both layers of fabric from the center of each sealed double-layer strip. Strip the fabric from one layer down for a distance of 50 mm (2 in.).

14.9 *Calculation*—Calculate the average coating adhesion to the nearest 0.2 N/cm (0.1 lbf/in.) of width for each direction of each laboratory sampling unit and for the lot.

14.10 *Report*—Report that the specimens were tested as directed in Test Method D 4851 for adhesion of coating to fabric. Describe the material tested and the method of sam-

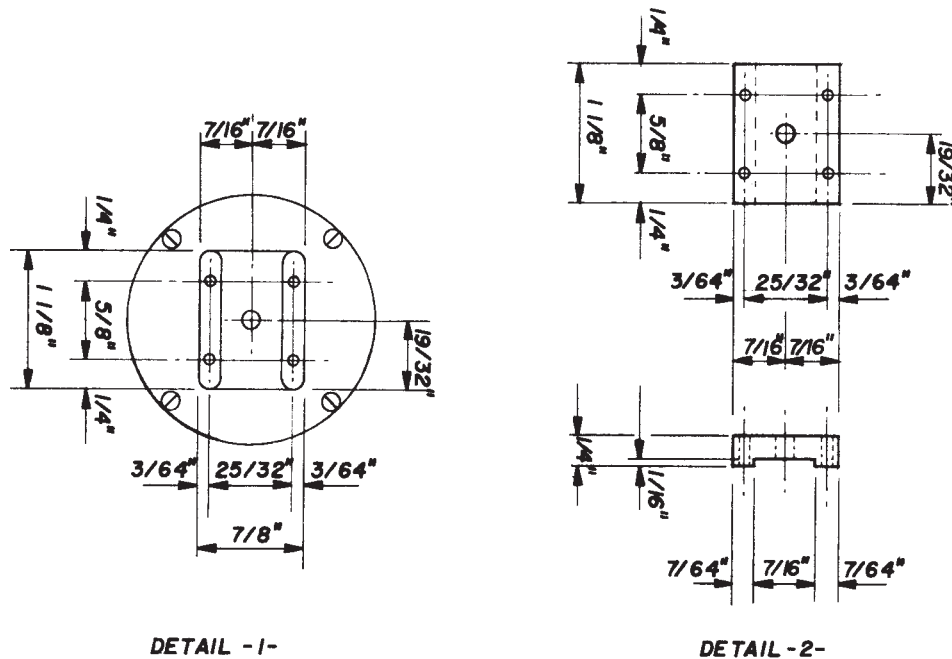


FIG. 1A
 FIG. 1 Adjustable Pin Beam Compass

14.6 Clamp one end of the separated portion of the 25 mm (1 in.) strip in the lower jaw of the tensile testing machine and the other end of the specimen in the upper jaw.

14.7 Activate the crosshead and pull the specimen until a 100-mm (4-in.) separation of the bonded specimen has occurred. This equals 200 mm (8 in.) or crosshead movement.

14.8 Disregard the first inch of bonded specimen separation recorded. Record the average of the five highest force peaks of resistance as the adhesion of each specimen. Report the average value obtained and the type of failure. Note the type failure that occurs as one of the following:

14.8.1 *CAF*—Coating Adhesion Failure defined by separation of the coating and fabric.

14.8.2 *AAF*—Adhesive Adhesion Failure defined by separation of the coating and adhesive.

14.8.3 *AF*—Adhesive Failure defined by separation within the adhesive layer.

14.8.4 *P*—Prefix assigned when two failure conditions are observed in the same specimen.

14.8.5 *CF*—Coating Failure defined by separation within the coating.

14.8.6 *FF*—Fabric Failed in tension, no seam failure.

14.8.7 *DF*—Delamination between the layers of a laminated fabric.

pling. Report the coating adhesion for each laboratory sampling unit and for the lot.

14.11 *Precision and Bias*—The precision and bias of the procedure in Test Methods D 4851 for measuring the adhesion of the coating to the fabric are as specified in Methods D 751.

15. Uniaxial Elongation Under Static Force

15.1 *Scope*—This test method covers the measurement of the uniaxial elongation of fabric when subjected to a specified force. The force applied is dependent on the fabric mass and the end-use requirements.

15.2 *Summary of Test Method*—A unidirectional force is applied to one end of a specimen while the opposite end is fixed in a vertical position. After a fixed time period, the uniaxial elongation and use under the specified force is recorded.

15.3 *Significance and Use*—The property measured is the amount of elongation in a specific weave direction (machine or cross-machine) in a specific roll of fabric when subjected to a specified force. When combined with a knowledge of the biaxial elongation characteristics of a particular style of fabric, the amount of elongation is useful in determining the adjustments of patterns necessary to produce a stressed structure of predetermined dimensions.

15.4 Apparatus and Materials:

15.4.1 Ruler, 1 m with 0.5 mm divisions or 24 in. with 0.01 in. divisions.¹³

15.4.2 Scriber, steel, straight.¹⁴

15.4.3 Knife, razor type.

15.4.4 Adjustable Pin Beam Compass, with dial indicator in accordance with Fig. 1 or other equivalent measuring device.

15.4.5 Static Load Test Rack, in accordance with Fig. 2, or equivalent.

NOTE 7—The dimensions in Fig. 2 are for illustrative purposes. Although the static load test rack using the dimensions in Fig. 2 has been used in the industry, other test rack configurations can be constructed providing they meet the conditions of the uniaxial elongation under static force test procedure in this test method for the specimen size and static load requirements.

15.4.6 Specimen Hold-Down Bar—Fabricate a 380 by 38 mm (15 by 1.5 in.) bar made from 3-mm (1/8-in.) thick steel or aluminum with a 280 mm (11 in.) long by 9.5 mm (3/8 in.) slot in the middle.

15.4.7 Force Gage, 500 × 1.0 N (100 × 0.1 lbf).¹⁵

15.4.8 Force Gage Mounting Bracket—Fabricate a bracket with attached hooks to measure the force at the specimen holders in accordance with Fig. 3.

15.4.9 Force Gage Verification Weight, as specified in an applicable purchase order or contract.

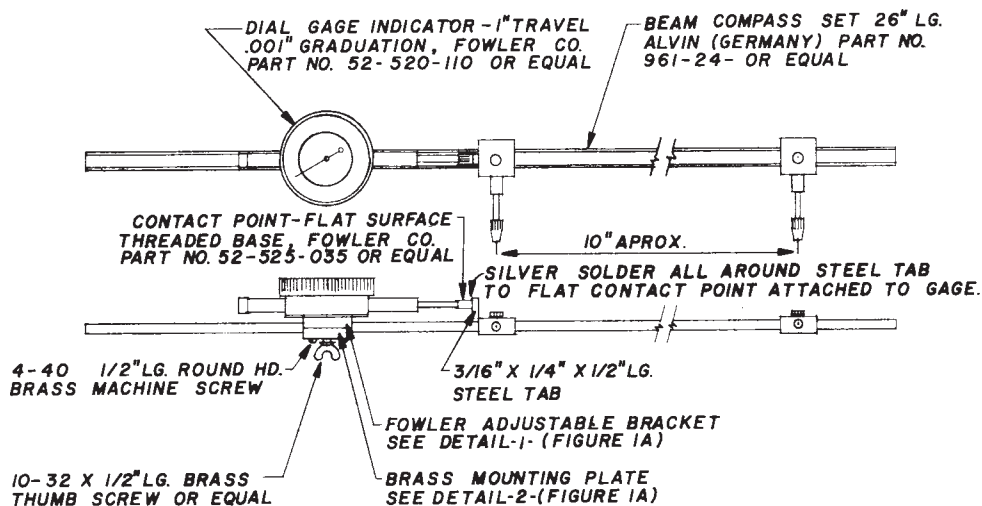
15.4.10 Timer, to measure 8 h ± 10 min.

15.4.11 Pencil, or marking pen.

15.5 Specimen Preparation—Prepare four specimens from each swatch in the laboratory sample with the long dimension in the machine direction and with no two specimens from a swatch containing the same warp ends. Prepare four specimens from each swatch in the laboratory sample with the long dimension in the cross-machine direction and with no two specimens from a swatch containing the same filling ends. Cut four specimens 610 ± 13 by 25 mm (24 ± 1/2 by 1 in.) with the width being plus one yarn, minus zero yarns. If part of a yarn falls under the 25 mm (1 in.) mark, include the complete yarn in the specimen width. Cut the specimens so that yarns along the specimen edges are not nicked or cut. Specimens may not contain a fabric defect. Using a pencil or marking pen, mark each specimen near one end with the sample identification, location, and fabric direction.

NOTE 8—Cutting between yarns along the edges of specimens may be facilitated if a scribe is drawn, with heavy pressure, several times along the path of the intended cut.

15.6 Procedure:



Metric Equivalents			
in.	mm	in.	mm
3/64	1	10/32	15
1/16	2	5/8	16
7/64	3	25/32	20
3/16	5	7/8	22
1/4	6	1	25
7/16	11	1 1/8	29
1/2	13	10	254
		26	660

FIG. 1 Adjustable Pin Beam Compass (continued)

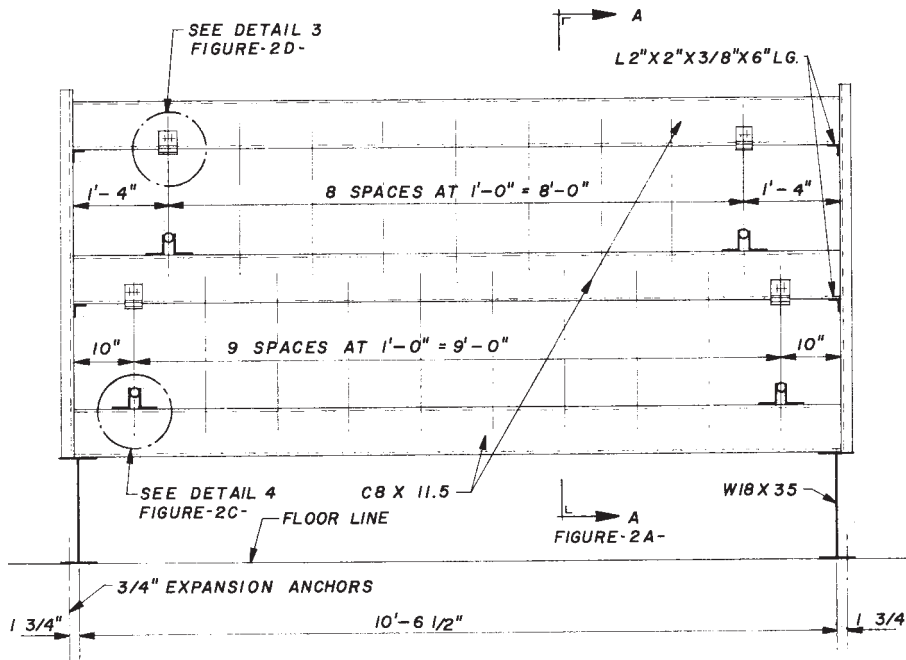


FIG. 2 Static Loading Test Rack

15.6.1 Zero the beam compass and set the span to 250 mm (10 in.) using the steel ruler.

15.6.2 Position the dial indicator about ¼ the distance from one end of the beam, with the measuring foot toward the long section of the beam. Secure the indicator to the beam with the locking screw.

15.6.3 Hold the beam compass in a vertical position with the dial indicator at the top.

15.6.4 Move the adjustable upper pin assembly until the small 0.25 mm (0.1 in.)/division counter dial is on “zero.”

15.6.5 Unlock the dial face and move the outer scale 0.025 mm (0.001 in.)/division to “zero.”

15.6.6 Using care not to move the upper pin, hold the ruler up to the pins and move the lower pin assembly until the distance between the pins is 250 ± 0.25 mm (10 ± 0.01 in.). Tighten the lower pin assembly locking screw.

15.6.7 Using the ruler again, move the upper pin assembly until the distance between the pins is 250 ± 0.25 mm (10 ± 0.01 in.).

15.6.8 Move the dial indicator scale again until the scale is at “zero.” Tighten the dial scale lock.

15.6.9 Check that both dials on the indicator are on zero, then recheck the distance between the pins with the ruler. If not 250 ± 0.25 mm (10 ± 0.01 in.) on the ruler, repeat 15.6.7 and 15.6.8.

15.6.10 Perform the initial (zero force) fabric measurement.

15.6.10.1 With the specimen on a smooth table top, center the specimen hold-down bar lengthwise on the specimen. Center the slot between the sides of the specimen.

15.6.10.2 Place the stationary pin in the center of the slot about 13 mm (0.5 in.) from one end. With the point located between yarns, press it into the fabric far enough to leave a small hole in the coating.

15.6.10.3 With the adjustable pin in the center of the slot, observe where the pin touches the fabric. If it does not fall

between yarns, increase the pin spacing by moving the adjustable pin assembly until that pin reaches the next space between yarns. Press the pin into the fabric, leaving a small hole in the coating and record the measurement to the nearest 0.025 mm (0.001 in.). Make and record a second reading by removing the beam compass, moving the adjustable pin several turns of the thumb wheel, and then making a second measurement. If the readings differ by more than 0.25 mm (0.010 in.), discard both readings and make two new measurements. If the readings still differ by more than 0.25 mm (0.010 in.), determine the cause and correct before continuing. Record the average of the two measurements as M_0 . When making measurements, any force on the pins will cause the pins or beam to deflect or the pinholes to become elongated and cause reading errors.

15.6.10.4 Remove the beam compass and circle both pinholes in the fabric with a marking pen.

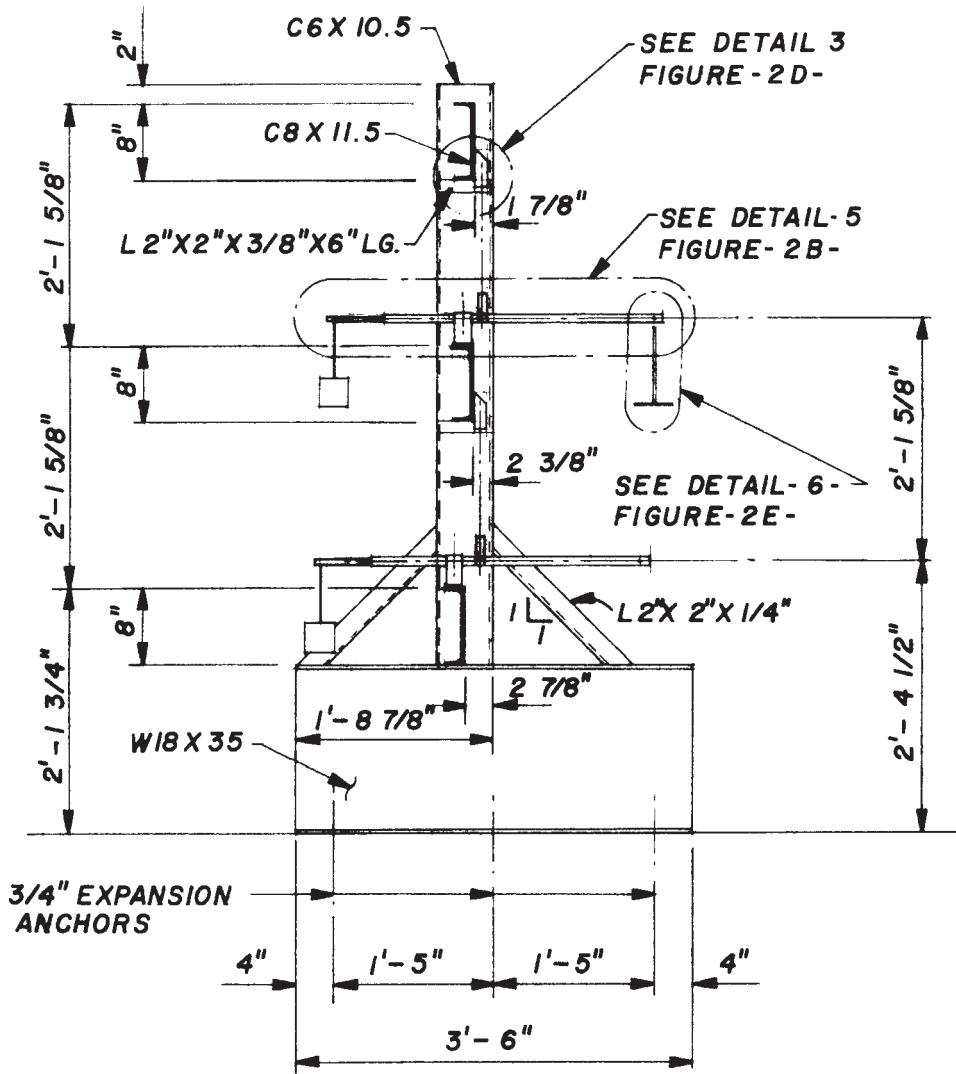
15.6.10.5 Repeat 15.6.10.1-15.6.10.4 for each specimen.

15.6.11 Check the force gage zero and calibration against the verification weight, then check the test rack for force calibration by connecting the force gage from the top specimen holder to the lower holder. Adjust to the specified force.

15.6.12 Mount the specimens in the force rack.

15.6.13 Raise the force arm and insert the locking pin in the mounting bracket to hold the arm in the raised position.

15.6.14 Hold a specimen vertical with the upper pinhole approximately even with the lower bar of the upper specimen holder. Insert the upper end of the specimen over the upper bar and down behind both bars. Pull the inserted end forward, around the lower bar and bring it up behind and over the top bar (from back to front). Check to see that the pinhole is about 6 mm (¼ in.) below the lower bar, align the end with the main portion of the specimen, and center the specimen in the holder. Pull down on the main portion of the specimen to lock the end between the upper bar and the main portion of the specimen (see Fig. 4).



SECTION A-A

FIG. 2A
FIG. 2 Static Loading Rack (continued)

15.6.15 Place the bottom end of the specimen around the lower bar of the bottom specimen holder and up behind both bars. Bring the end forward over the top bar and down around the lower bar (from back to front) and up behind the main portion of the specimen. Pull on the end and feed specimen through the holder until an appropriate amount of slack remains between the upper and lower holders.

NOTE 9—The amount of slack necessary to achieve an acceptable arm angle is estimated according to the fabric direction. Different fabric materials, fabric mass per unit areas, constructions and test forces will affect the amount of slack needed to level the arm assembly.

15.6.16 Raise the arm slightly and remove the locking pin. Slowly lower the arm, allowing more force to be applied until the fabric ceases to elongate and supports the force entirely. Check the arm angle. If the end of the force arm is more than 50 mm (2 in.) above or below an imaginary line drawn at 1.57

radians (90°) to the specimen at the pivot point (see Fig. 4), lift the arm and lengthen or shorten the specimen as needed. Reapply the force very slowly and check the arm angle is within the 50 mm (2 in.) limits. Note the time the force is applied at the correct arm angle.

15.6.17 After 8 ± 0.25 h have passed since the application of the full force, remeasure the length of the specimen between the pinholes by placing the stationary pin of the beam compass in the lower pinhole, and moving the adjustable pin to mate with the upper pinhole. Measure the specimen length while under the fully applied force to the nearest 0.025 mm (0.001 in.). Remove the beam compass, move the adjustable pin to a different reading, and perform a second measurement. If the values are within 0.25 mm (0.010 in.) of each other, report the average of the two measurements as *M*. If not within 0.25 mm (0.010 in.), take two additional measurements and discard the

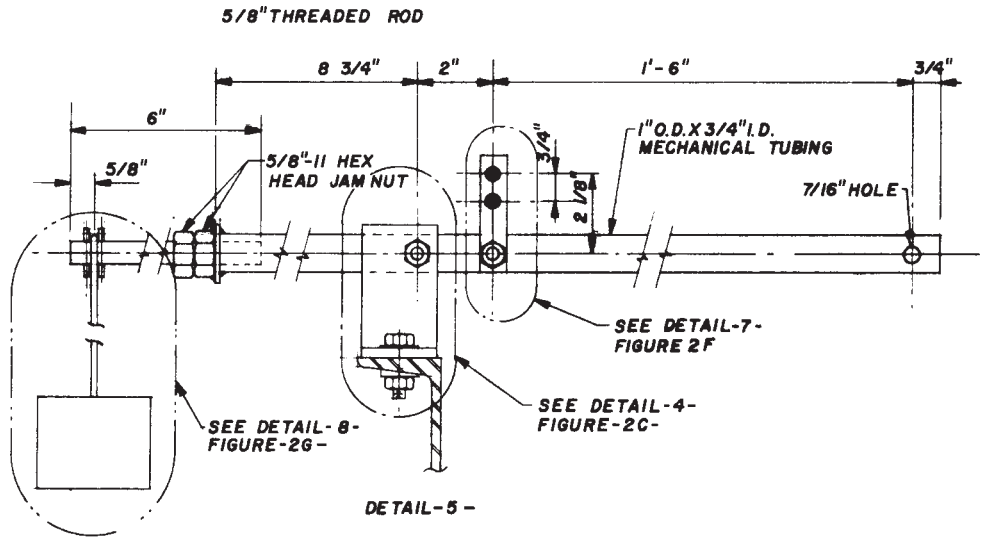


FIG. 2B
FIG. 2 Static Loading Rack (continued)

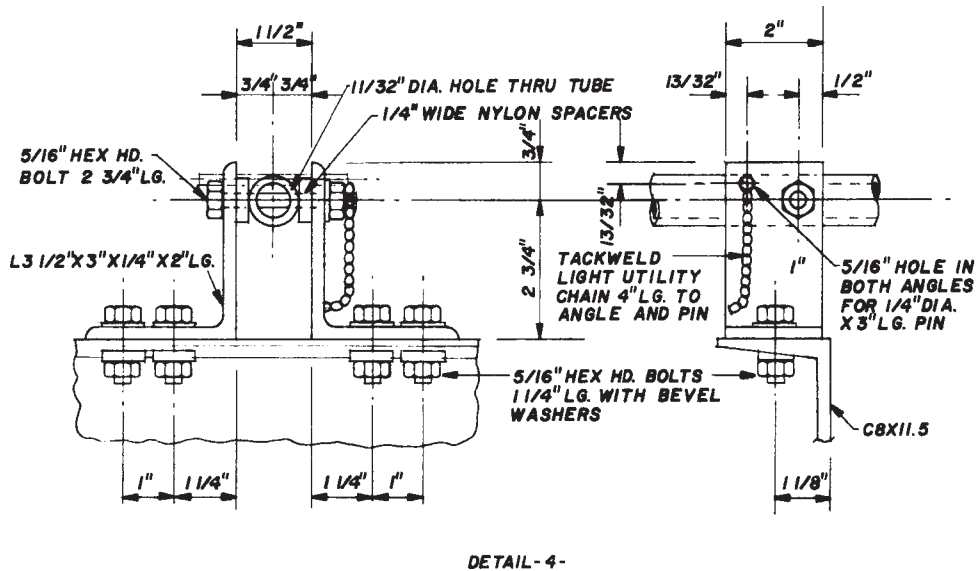


FIG. 2C
FIG. 2 Static Loading Rack (continued)

first two measurements. A measurement may be taken after 1 to 2 min have passed since the application of the full force. When requested, measure at other force/time intervals. Indicate the total time from the original force application with each set of measurements if different than specified.

15.7 Calculation:

15.7.1 Calculate the elongation under static load for each specimen to the nearest 0.01 % by Eq 1:

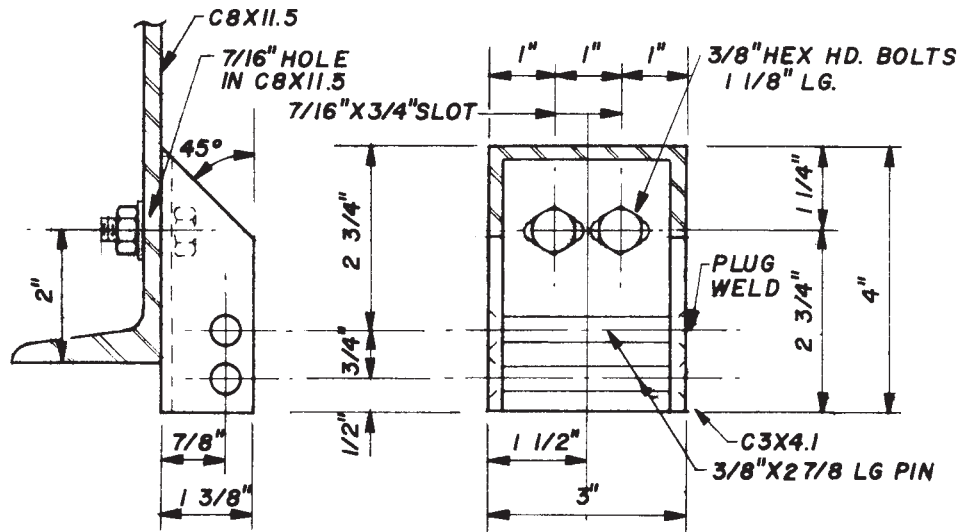
$$\epsilon = \frac{(M - M_0)}{M_0} \times 100 \quad (1)$$

where:

- ϵ = elongation, %,
- M = length measurement after application of full force (15.6.17), mm (in.), and
- M_0 = length measurement before application of force (15.6.10.2), mm (in.).

15.7.2 Calculate the average elongation under static load for each direction of each laboratory sampling unit and for the lot.

15.8 Report:



DETAIL-3-

FIG. 2D

FIG. 2 Static Loading Rack (continued)

15.8.1 State that the specimens were tested as directed in Test Method D 4851 for uniaxial elongation under static load. Describe the material and the method of sampling used.

15.8.2 Report the following information:

15.8.2.1 The force applied and the test duration.

15.8.2.2 The average elongation under static load for each direction of each laboratory sampling unit and for the lot.

15.9 Precision and Bias:

15.9.1 Precision—The precision of Test Methods D 4851 for uniaxial elongation under static force of fabrics for architectural use is given in 24.2.

15.9.2 Bias—The uniaxial elongation under static force of fabrics for architectural use can only be defined in terms of a specified test method. Within this limitation, the procedure for uniaxial elongation under static force in Test Methods D 4851 has no known bias.

16. Breaking Force

16.1 Determine the breaking force in kN/m (lbf/in.) of fabric in both the machine direction and cross-machine direction as directed in Test Method D 5035, 25.4-mm (1-in.) cut strip excluding preconditioning, using five specimens in both the machine direction and cross-machine direction. When required, conduct tests in both the wet and dry condition. Use a CRE type tensile testing machine operated at 50 ± 3 mm/min (2.0 ± 0.1 in./min) unless specified otherwise. The distance between clamps shall be 75 ± 1 mm (3.0 ± 0.05 in.).

16.1.1 The use of hydraulic or pneumatic clamping systems with a minimum of 50 by 75 mm (2 by 3 in.) serrated jaw faces having a clamping force at the grip face of 10 to 14 kN (2000 to 3100 lbf) is recommended. The 75 mm (3.0 in.) dimension of the jaw face is preferred in the direction of test; however, the 50 mm (2.0 in.) dimension is permitted. Manual clamping is

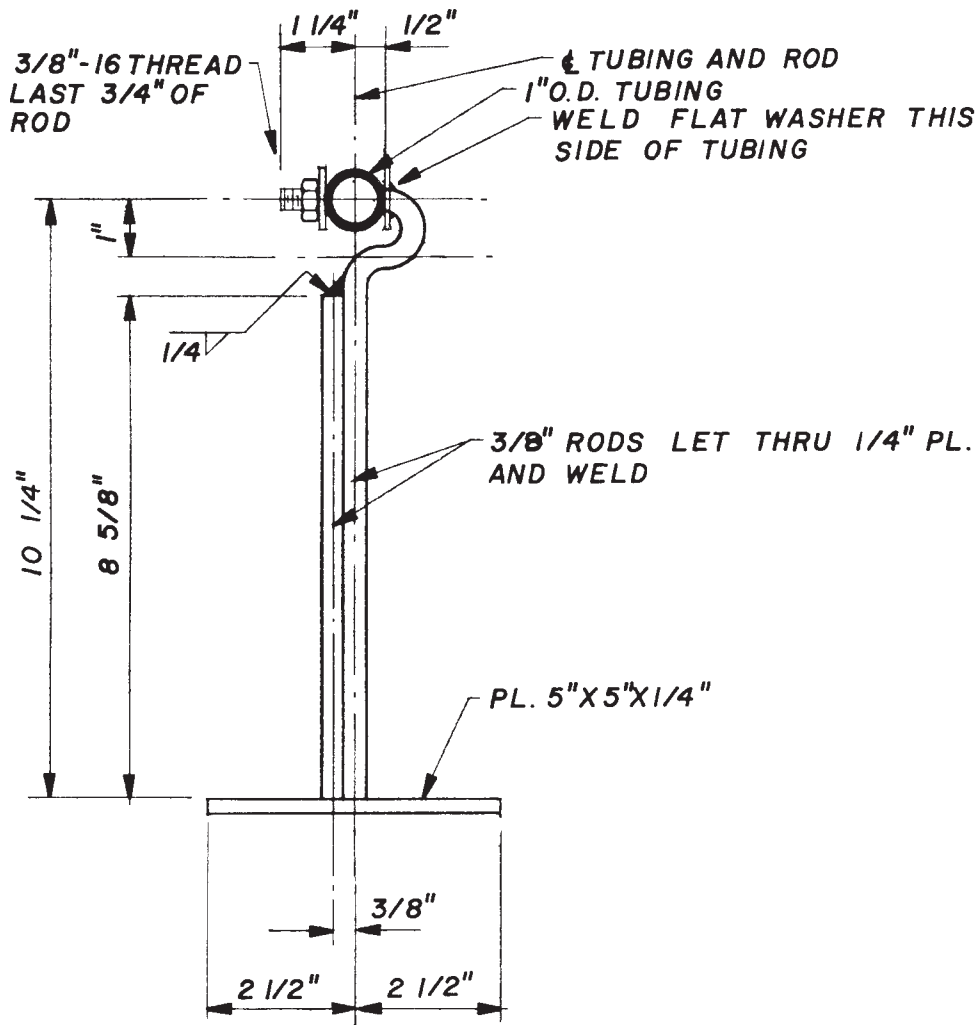
permitted providing no slippage of the specimen is observed. Regardless of the clamp size or jaw orientation, use a gage length of 75 ± 1 mm (3.0 ± 0.05 in.).

16.1.2 When using jaw faces other than serrated, such as rubber-faced jaws, they may be covered with a No. 80 medium grit emery cloth. Secure the emery cloth to the jaw faces with pressure sensitive tape.

16.1.3 From each swatch in the laboratory sample, cut and label five test specimens in the machine direction and five test specimens in the cross-machine direction. Cut the test specimens long enough to extend through the clamps and project at least 10 mm (0.5 in.) at each end. Make the total number of lengthwise yarns in each specimen equal to the yarn count per 25.4 mm (1 in.) in that direction. Take care that the long side of each test specimen follows a yarn component even if the long side of the test specimen is not a straight line. Cut the test specimens in the cross-machine direction adjacent to test specimens cut in the machine direction.

NOTE 10—The use of transmitted light may help to guide the cutting edge along the yarn component. For fabrics with severe weave distortion, it may be necessary to free-hand cut the specimens to permit following the yarn contours and avoiding nicking the outside yarns. The correct number of yarns in the lengthwise direction of the specimen must be maintained even if the width of the specimen varies from 25.4 mm (1 in.).

16.1.4 When both wet and conditioned breaking force of fabric are required, run paired breaks on test specimens containing the same yarns by cutting each test specimen at least twice as long as required for a conditioned test. Number each specimen at each end and then cut crosswise into two parts, one for determining the wet breaking force. Prepare specimens for wet breaking force by soaking 24 ± 1.0 h under 75 to 100 mm (3 to 4 in.) of distilled water at 21 to 27°C (70 to 80°F). After



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FIG. 2E

FIG. 2 Static Loading Rack (continued)

soaking 24 h, remove the specimens, pat dry with an absorbent paper towel, and test within 5 min of removal from the water.

16.2 *Precision and Bias*—The precision and bias of the procedure in Test Methods D 4851 for measuring breaking strength are as specified in Test Method D 5035.

17. Breaking Force After Crease Fold

17.1 *Scope*—This test method determines the resistance to creasing and folding by measuring the breaking force after repeated folding and force applications.

17.2 *Summary of Method*—A strip of fabric is folded and the looped end rolled with a cylinder of specified mass. A specimen containing the fold is cut from the folded strip and broken on a CRE-type tensile testing machine.

17.3 *Significance and Use*—Fabric sections are subjected to repeated folding and force applications to folds during packaging and fabrication. This method is intended to determine the breaking force after these repeated foldings and force applica-

tions. Test Method D 4851 for determining breaking force after crease-fold is useful for judging the compliance of shipments with material specifications.

17.4 Apparatus and Materials:

17.4.1 *Constant-Rate-of-Extension (CRE) Tensile Testing Machine*, with clamp control as prescribed in the breaking force section of this standard.

17.4.2 *Mass*, 4.5 kg (10 lb), cylindrical, approximately 90 mm (3.5 in.) diameter by 100 mm (4 in.) length.

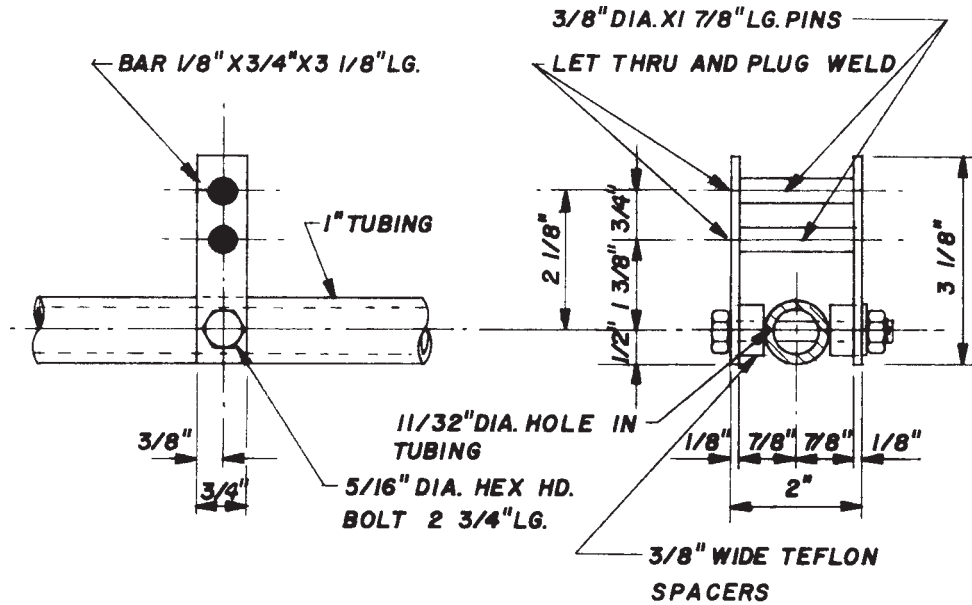
17.4.3 *Knife*, razor type, for specimen cutting.

17.4.4 *Steel Rule*, 300 mm (12 in.) by 25 mm (1 in.) with 2 mm ($\frac{1}{16}$ in.) divisions.

17.5 Sample Preparation:

17.5.1 Unroll the sample on a smooth, flat surface.

17.5.2 Using a steel rule and razor knife, cut five 50 by 200 mm (2 by 8 in.) specimens each in the machine and cross-machine directions. No two specimens shall contain the same warp yarns for the machine direction test or the same filling



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FIG. 2F

FIG. 2 Static Loading Rack (continued)

yarns for the cross-machine direction test. Take no specimen nearer the selvage than $\frac{1}{10}$ of the fabric width.

17.5.3 Loop each specimen end to end and hold on a flat surface. Do not flatten the loop by hand.

17.5.4 Roll the specimen with a 4.5 kg (10 lb) cylindrical mass, unless otherwise specified, by placing the mass near the free ends and roll to and over the looped end. Do not push down on the mass, push horizontally and roll only in one direction, from open end to looped end. The mass must roll perpendicularly to the loop and pass over the fold so that all the mass is passed over the fold at the same instant. Roll the mass at a rate in which it will traverse the specimen in approximately 1 s.

17.5.5 After rolling the mass over the loop of the specimen, pick up the mass and place it back near the end of the specimen. Repeat creasing of the fold nine additional times until a total of ten rolls have been applied.

17.5.6 Unfold the specimens and lay on flat surface. Do not unfold beyond 3.14 rad (180°).

17.5.7 With the razor knife, cut a 200 by 25 mm (8 by 1 in.) specimen from each of the creased specimens as directed in the breaking strength procedure in this standard.

17.6 Procedure:

17.6.1 Determine the breaking force after crease-fold of fabric specimens for both the machine direction and cross-machine direction as directed in the breaking force procedure in this standard.

17.6.2 Position the crease-folded area approximately midway between the upper and lower clamps in the tensile testing machine.

17.7 Report—Report the average breaking force of five specimens after crease-fold to the nearest 5 N/m (1.0 lbf/in.).

17.8 Precision and Bias:

17.8.1 Precision—The precision and bias of Test Methods D 4851 for breaking force after crease-fold of fabrics for architectural use are as specified in 24.2 and 24.3.

18. Elongation at Break

18.1 Determine the elongation at break for each roll in the lot sample as directed in Test Method D 5035 when determining breaking force for both the machine and cross-machine directions.

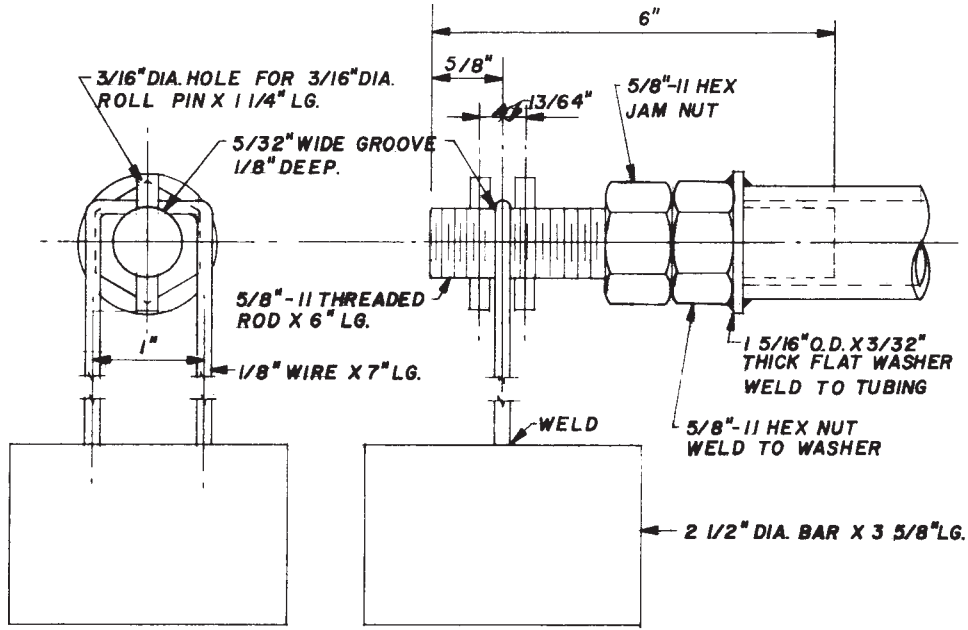
19. Trapezoid Tear Strength

19.1 Determine the trapezoid tear strength of fabric in kilonewtons (pound-force) in both the machine direction and cross-machine direction as directed in Test Method D 5587, using five specimens in both the machine direction and cross-machine direction. Use a CRE type tensile testing machine operated at 300 ± 10 mm (12.0 ± 0.5 in.)/min, unless specified otherwise. The distance between clamps shall be 25 ± 1 mm (1 ± 0.05 in.). Calculate the average tear strength from each of the machine and cross-machine directions, using the five highest peak forces recorded for each tear direction.

19.1.1 The use of hydraulic or pneumatic clamping systems with a minimum of 50 by 75 mm (2 by 3 in.) serrated jaw faces having a clamping force at the grip faces of 10 to 14 kN (2000 to 3100 lbf) is recommended. Manual clamping is permitted providing no slippage of the specimen is observed.

19.1.2 For best results when using jaw faces other than serrated, such as rubber faced jaws, they may be covered with a No. 80 to 120 medium grit emery cloth. Secure the emery cloth to the jaw faces with pressure sensitive tape.

19.1.3 Test specimens cut in the cross-machine direction shall be cut in close proximity to test specimens cut in the machine direction.



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FIG. 2G

Metric Equivalents			
in.	mm	in.	mm
3/32	2	2 3/4	70
1/8	3	2 7/8	73
5/32	4	3	76
13/64	5	3 1/8	79
3/16	5	3 1/2	89
1/4	6	3 5/8	92
5/16	8	4	102
11/32	9	5	127
13/32	10	6	152
3/8	10	7	178
7/16	11	8	203
1/2	13	8 5/8	219
5/8	16	8 3/4	222
3/4	19	10	254
7/8	22	10 1/4	260
1	25	12	305
1 1/8	29	16	406
1 1/4	32	17	432
1 5/16	33	30	457
1 3/8	35	20 7/8	530
1 1/2	38	25 5/8	651
1 3/4	44	25 3/4	654
1 7/8	48	29 1/2	724
2	51	36	1067
2 1/8	54	96	2438
2 3/8	60	108	2743
2 1/2	64	126 1/2	3213

FIG. 2 Static Loading Rack (continued)

20. Resistance to Artificial Weathering

20.1 Expose the fabric by one of the following three test method options as directed by an applicable material specification or contract.

20.1.1 All three test method options for determination of resistance to artificial weathering are considered satisfactory for acceptance testing of fabric for architectural use because they have been used extensively in the trade for acceptance

testing. The decision on which test procedure to use is determined by agreement between the purchaser and supplier based on historical data and experience of the contractual parties. Because the natural environment varies with respect to time, geography, and topography, it may be expected that the effects of natural exposure will vary accordingly. Not all materials are affected equally by the same environment. Results obtained by the use of any of these test method options

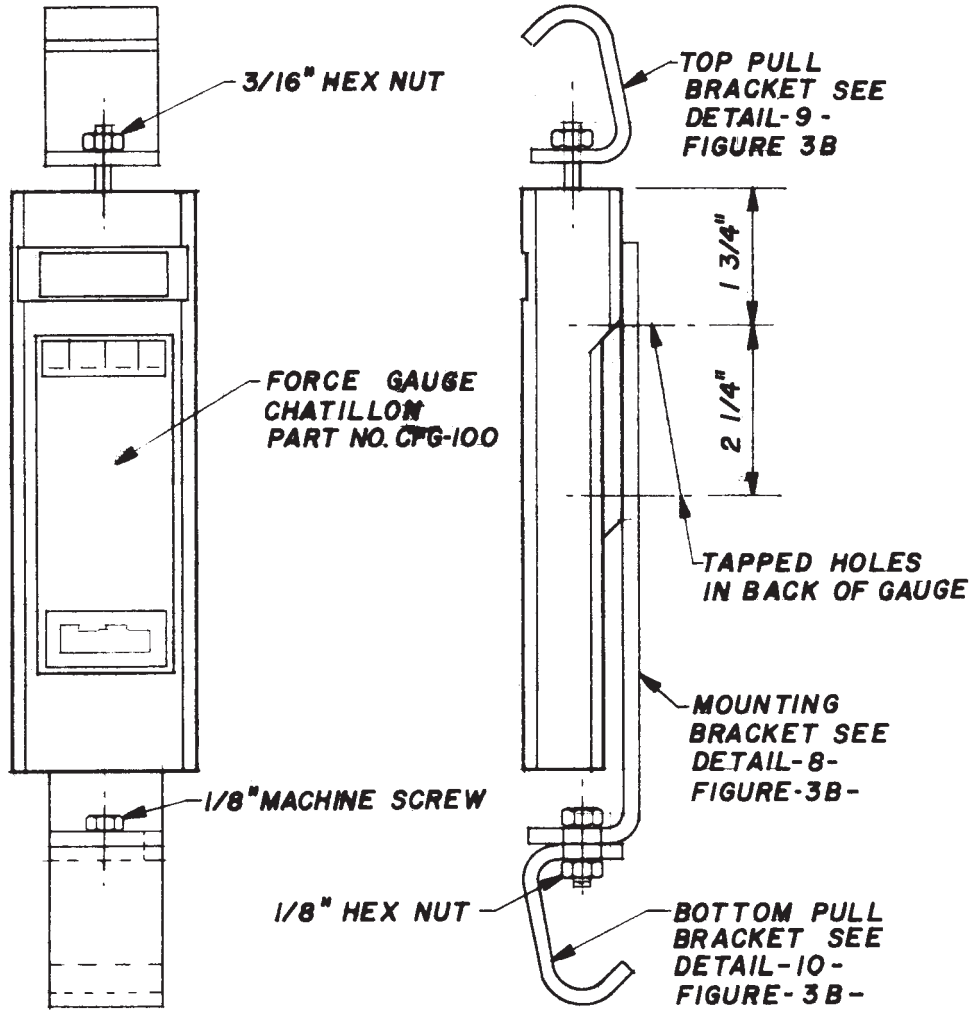
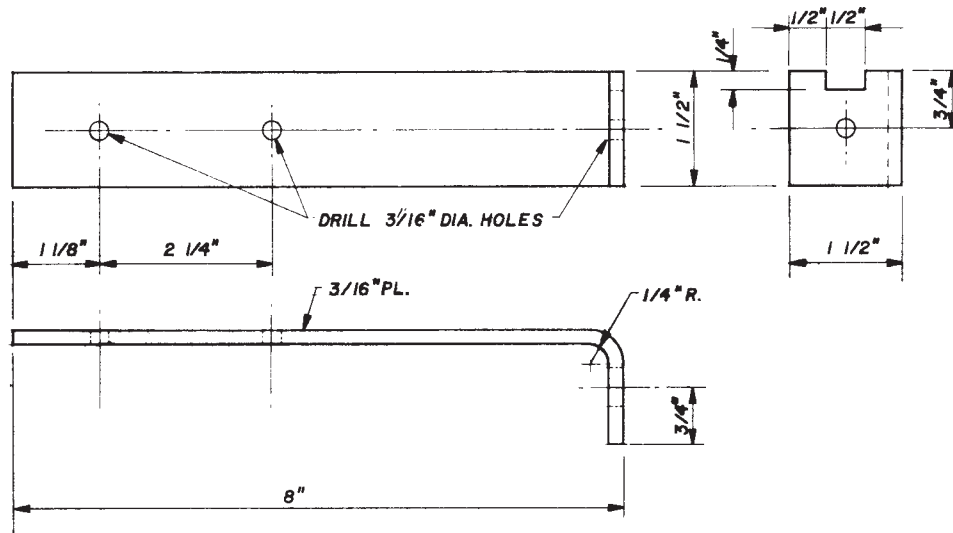


FIG. 3 Force Gage Mounting Bracket



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FIG. 3A

FIG. 3 Force Gage Mounting Bracket (continued)

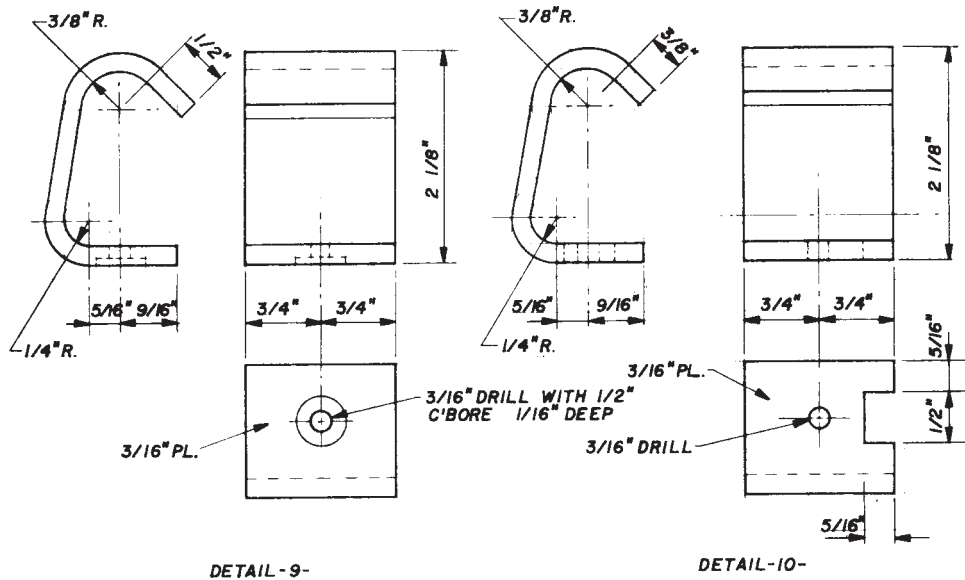


FIG. 3B

Metric Equivalents			
in.	mm	in.	mm
1/16	2	3/4	19
1/8	3	1	25
3/16	5	1 1/8	29
1/4	6	1 1/2	38
5/16	8	1 3/4	44
3/8	10	2 1/8	54
1/2	13	2 1/4	57
9/16	14	8	203

FIG. 3 Force Gage Mounting Bracket (continued)

should not be represented as equivalent to those of any natural weathering test unless the degree of quantitative correlation has been established between the purchaser and supplier. There is a distinct difference in spectral distribution between the xenon lamp, the sunshine carbon arc lamp, and the UV fluorescent lamp test method options. Consequently, they cannot be used interchangeably unless the degree of quantitative correlation has been established between the purchaser and supplier.

NOTE 11—In general, industry has used Option 1, Xenon lamp exposure, for fluoropolymer coated fabrics, and Option 2, Sunshine Carbon Arc lamp exposure, for vinyl coated fabrics. Option 3, UV Fluorescent Condensation, generally used to predict color change, has been used with silicone coated fabric with respect to loss of strength. In any event, these test method options cannot be used interchangeably unless the degree of quantitative correlation has been established between the purchaser and supplier.

20.2 *Test Specimens*—For each selected test method option, expose sufficient material to obtain five breaking strength determinations and three trapezoid tear strength determinations for each, the machine and cross-machine directions unless otherwise specified.

20.3 *Option 1—Xenon Lamp*—Expose the fabric as directed in Practice G 26, Method A. The xenon lamp apparatus shall be a type BH. The apparatus shall be equipped with an inner and outer borosilicate filter glass as described in Practice G 26. Use

the appropriate cycle cam to provide 120-min cycles as follows: 102 min of light only at $63 \pm 3^\circ\text{C}$ ($145 \pm 5^\circ\text{F}$) black panel temperature, and $50 \pm 5\%$ relative humidity, followed by 18 min of light and water spray. When radiometers capable of monitoring discrete portions of a continuous spectrum are available, set the minimum level of irradiance to $0.35 \pm 0.01 \text{ W/m}^2$ controlled at 340 nm. When this capability is not available, wattage settings shall be as defined in Practice G 26.

20.4 *Option 2—Sunshine Carbon Arc*—Expose the fabric as directed in Practice G 23, Method 1. The sunshine carbon arc apparatus shall be a type EH. The apparatus shall be equipped with flat No. 7058 Corex D filter panes or equivalent as described in Practice G 23. Use the appropriate cycle cam to provide 120-min cycles as follows: 102 min of light only at $63 \pm 3^\circ\text{C}$ ($145 \pm 5^\circ\text{F}$) black panel temperature, and $50 \pm 5\%$ relative humidity, followed by 18 min of light and water spray.

20.5 *Option 3—Fluorescent Lamp*—Expose the fabric as directed in Practice G 53. Use an operating cycle to provide 4 h UV exposure at 60°C and 4 h condensation exposure at 40°C .

20.6 Expose the fabrics ensuring that the side of the fabric to be exposed to the elements in actual use is the side exposed to the light source. Expose for time increments of 1000 and

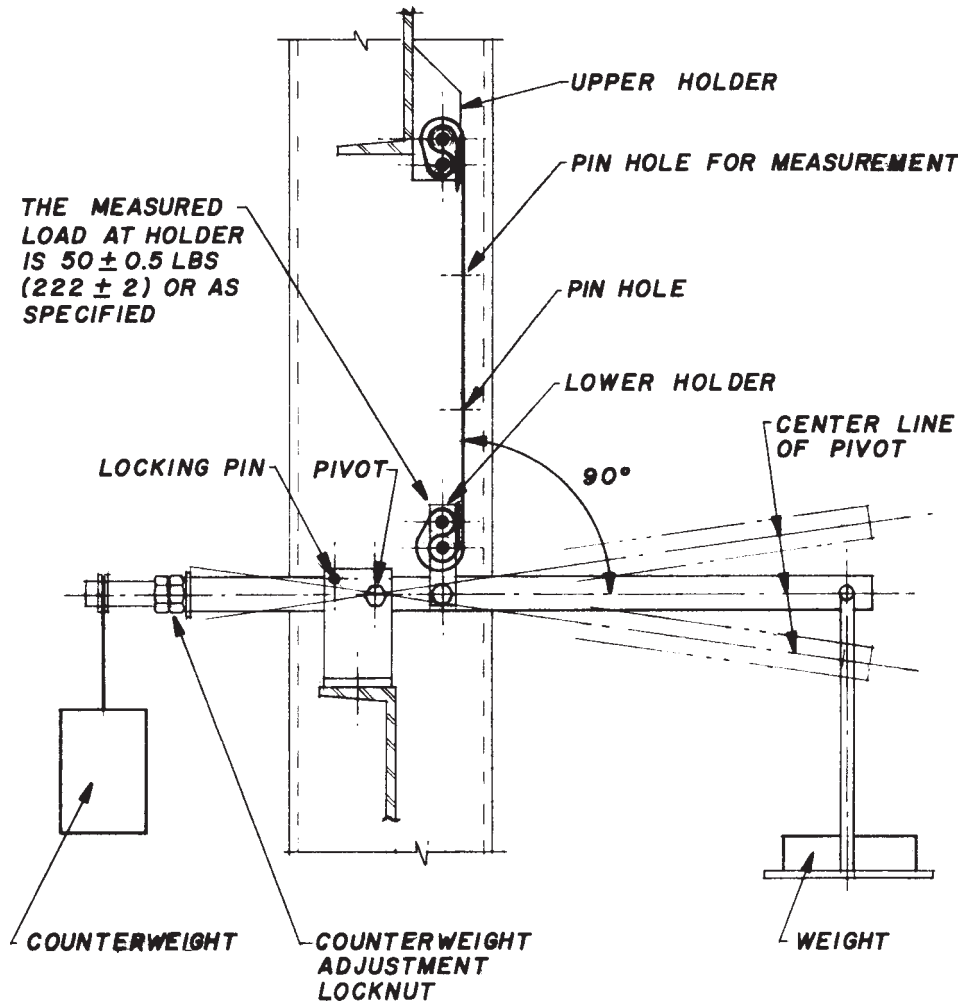


FIG. 4 Uniaxial Elongation Test Set Up

4000 clock hours unless otherwise specified. Record the total radiant exposure in kJ/m^2 for each time increment when available.

20.7 Determine the breaking strength and trapezoid tear strengths for each machine direction and cross-machine direction exposed samples, as directed in this standard.

20.8 Report the test option used and the breaking strength and trapezoid tear strength values obtained.

21. Solar Optical Properties

21.1 Determine the solar optical properties of fabrics by one or more of the following two test method options as directed by an applicable material specification or contract. Both methods for determining solar properties are used for acceptance testing of fabrics for architectural use since they have been used extensively in the trade for acceptance testing. The decision on which test method option to use is determined by agreement between the purchaser and supplier. It is generally based on particular job type, location, and various state building codes as defined by the contractual parties. There is a distinct difference between each of the test method options. Option 1 is useful

when translucency of the full light spectrum is essential to make evaluations of solar heat gain. Option 2 is useful when light transmission in the visible range is essential. Each has its own application depending on the degree of solar optical needs. Consequently, these two method options cannot be used interchangeably.

21.1.1 Prior to testing, treat specimens by artificially bleaching as agreed upon between the purchaser and the supplier. In the absence of such an agreement, the supplier may use their normal practice.

NOTE 12—PTFE coated fabrics bleach to a white state when exposed to ultraviolet light. A significant change in optical properties occurs from the "as produced" state to a fully bleached fabric that has been exposed to the outdoor environment. Prior to testing, the material must be artificially bleached to induce this exposed condition. There are a number of procedures that have been used to accelerate the bleaching process. An agreement between the purchaser and the supplier must be made as to which method to use based upon mathematical correlation. Likewise, for fabrics other than PTFE coated, agreement between the purchaser and the supplier must be made whether this bleaching, or other treatment, is needed prior to testing for optical properties.

21.2 *Option 1*—Determine the average light transmittance and reflectance data relative to pressed barium sulfate (BaSO₄)¹⁶ using selected ordinates as directed in Test Method E 424, Method A, on one specimen from each of the rolls in the laboratory sample.

21.3 *Option 2*—Determine the average light transmittance as directed in Test Method D 1003, Procedure B, on one specimen from each of the rolls in the laboratory sample.

21.4 Report the test method option used, the pretreatment and the solar optical values obtained.

22. Flame Resistance

22.1 Determine the flame resistance of fabrics by one or more of the following five methods as required by an applicable material specification or contract. All five methods for determining flame resistance are used for acceptance testing of fabrics for architectural use since they have been used extensively in the trade for acceptance testing. The decision on which test procedure to use is determined by agreement between the purchaser and supplier. It is generally based on particular job type, location, and various state building codes as defined by the contractual parties. There is a distinct difference between each of the test procedures. Each has its own application depending on the degree of flame resistance needs. Consequently, these five methods cannot be used interchangeably.

22.2 *Test Specimens*—Prepare test specimens as covered in the specific test methods.

22.2.1 *Option 1*—Use NFPA 701, reporting small scale and large scale test ratings for each of the machine and cross-machine directions.

22.2.2 *Option 2*—Use Test Method E 84, reporting the flame spread and smoke developed rating for the machine direction only.

22.2.3 *Option 3*—Use Federal Test Method Standard 191b, Method 5903, reporting the time of afterglow, after flame, and char length for each of the machine and cross-machine directions.

22.2.4 *Option 4*—Use Method E 108, reporting observations and classifications for: A) Intermittent Flame Exposure Test; B) Spread of Flame Test; and C) Burning Brand Test, using two test decks for each test condition.

22.2.5 *Option 5*—Use Test Method E 136, reporting the pass or fail criteria.

23. Noise Reduction Coefficient

23.1 Determine the noise reduction coefficient of fabrics as directed in Test Method C 423 using a Number 7 mounting positioned with the face of the specimen 0.4 m (16 in.) above the reverberation room floor. Calculate the noise reduction coefficient (NRC) as the average of the sound absorption coefficient in metric sabins/m² (sabins/ft²) obtained at 1/3 octave band center frequencies of 250, 500, 1000, and 2000 Hz.

¹⁶ Eastman White Reflectance Standard Catalog Number 6091, Eastman White Reflectance Coating Catalog Number 6080, and Eastman White Reflectance Holders, including Glass Cover Plate, Catalog Number 6093 are acceptable for standardizing with barium sulfate (BaSO₄), available from Eastman Kodak Co., 343 State Street, Rochester, NY, 14650, have been found satisfactory for this purpose.

NOTE 13—Sabin is the unit of measure of sound absorption in the inch-pound system. Metric sabin is the unit of measure of sound absorption in the metre-kilogram-second system. One sabin multiplied by 0.0929 is equal to one metric sabin.

24. Precision and Bias

24.1 The precision and bias for measuring, fabric count, mass per unit area, thickness, fabric width, fabric bow, breaking strength, elongation at break, trapezoid tear strength, resistance to accelerated weathering, solar optical properties flame resistance, and noise reduction coefficient are as specified in the respective test method designations listed in Section 2. The precision and bias for measuring, adhesion of coating to fabric, uniaxial elongation under load, and breaking strength after crease fold are as given in 24.2.

24.2 *Interlaboratory Test Data*,¹⁷ for Adhesion of Coating to Fabric, Uniaxial Elongation under Static Force, and Breaking Force after Crease Fold—An interlaboratory test was run in 1988 in which randomly-drawn samples of six materials were tested by the test procedures and number of laboratories shown in Table 1. Two operators in each laboratory each tested ten specimens of each material. Five of the ten specimens were tested on one day and five specimens were tested on a second day. Analysis of the data was conducted using Practices D 2904 and D 2906 and the adjunct Tex-Pac. The components of variance for air permeability expressed as standard deviations were calculated to be the values listed in Table 2.

24.2.1 *Summary*—In comparing two averages, the differences should not exceed the single-operator precision values shown in Table 2 for the respective number of tests and for materials having averages similar to those shown in Table 2 in 95 out of 100 cases when all the observations are taken by the same well-trained operator using the same piece of equipment and specimens randomly drawn from the sample of material. Larger differences likely are to occur under all other circumstances.

24.2.2 *Precision*—For the components of variance reported in Table 2, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences listed in Tables 3-5. There were sufficient differences related to the

¹⁷ Available in rolls from American Durafilm Co., Inc., 2300 Washington St., Newton Lower Falls, MA, 02162, has been found satisfactory for this purpose.

TABLE 1 Fabric, Types, Test Procedures, and Number of Participating

Fabric Types	
1.0 Kg (35 oz) FEP ^A coated glass fiber fabric	
0.8 Kg (28 oz) Vinyl coated polyester fabric	
0.4 Kg (14 oz) FEP ^A coated glass fiber fabric	
0.9 Kg (32 oz) Vinyl coated polyester fabric	
0.3 Kg (10 oz) Vinyl laminated polyester fabric	
0.5 Kg (18 oz) Vinyl laminated polyester fabric	
Test Procedures	No. of Participating Laboratories
Adhesion of coating to fabric	3
Uniaxial elongation under static force	2
Breaking force after crease fold	3

^A FEP is Fluorinated Ethylene Propylene Copolymer.

TABLE 2 Grand Average and Components of Variation, Coated and Laminated Fabrics for Architectural Use

Property, Units of Measure and Material ^A	Grand Average		Components of Variance Expressed as Standard Deviations ^B					
			Single-Operator Component		Between-Laboratory Component		Within-Laboratory Component	
	Warp	Fill	Warp	Fill	Warp	Fill	Warp	Fill
Adhesion of coating to fabric—lb/in.								
35 oz FEP coated glass	18.0	17.9	1.62	1.12	0.00	0.00	1.28	1.37
28 oz Vinyl coated polyester	22.0	17.8	3.12	2.14	0.63	1.13	7.14	3.46
14 oz FEP coated glass	6.10	6.80	0.52	0.84	0.31	0.27	0.48	1.17
32 oz Vinyl coated polyester	24.0	27.6	3.25	1.73	1.83	0.68	6.74	5.39
10 oz Vinyl laminated polyester	22.2	29.2	6.16	4.90	0.00	4.52	10.3	13.0
18 oz Vinyl laminated polyester	22.0	30.5	4.79	9.12	0.17	2.56	14.7	10.3
Uniaxial elongation under static force—%								
35 oz FEP coated glass	1.23	4.54	0.07	0.20	0.10	0.28	0.12	0.28
28 oz Vinyl coated polyester	0.72	1.30	0.07	0.14	0.07	0.00	0.00	0.09
14 oz FEP coated glass	1.65	1.48	0.23	0.12	0.00	0.09	0.00	0.09
32 oz Vinyl coated polyester	0.56	4.32	0.11	0.19	0.02	0.08	0.04	0.28
10 oz Vinyl laminated polyester	2.60	12.4	0.19	0.40	0.36	1.04	0.67	2.52
18 oz Vinyl laminated polyester	1.66	3.80	0.14	0.25	0.07	0.29	0.22	0.82
Breaking force after crease fold—lb/in.								
35 oz FEP coated glass	640	463	100	67.9	57.0	41.7	0.00	0.00
28 oz Vinyl coated polyester	489	476	18.5	30.7	9.81	0.00	14.3	28.8
14 oz FEP coated glass	368	289	4.67	24.4	0.00	17.9	53.7	24.4
32 oz Vinyl coated polyester	447	731	24.6	57.3	0.00	5.96	17.3	57.3
10 oz Vinyl laminated polyester	81.1	69.5	7.49	3.86	0.00	0.66	3.96	3.86
18 oz Vinyl laminated polyester	172	157	9.11	10.0	5.52	1.74	11.5	0.00

^A The square roots of the components of variance are being reported to express the variability in the appropriate units of measure rather than as the squares of those units of measure.

^B FEP is Fluorinated Ethylene Propylene Copolymer.

TABLE 3 Critical Differences for Adhesion of Coating to Fabric—lb/in., Coated and Laminated Fabrics for Architectural Use

Material ^A	Number of Observations in Each Average	Critical Differences for the Conditions Noted ^B					
		Single-Operator Precision		Between-Laboratory Precision		Within-Laboratory Precision	
		Warp	Fill	Warp	Fill	Warp	Fill
35 oz FEP coated glass	1	4.5	3.1	4.5	3.1	5.7	4.9
	2	3.2	2.2	3.2	2.2	4.8	4.4
	5	2.0	1.4	2.0	1.4	4.1	4.0
	10	1.4	1.0	1.4	1.0	3.8	3.9
28 oz Vinyl coated polyester	1	8.6	5.9	8.8	6.7	21.7	11.7
	2	6.1	4.2	6.4	5.2	20.8	10.9
	5	3.9	2.6	4.2	4.1	20.2	10.4
	10	2.7	1.9	3.2	3.6	20.1	10.3
14 oz FEP coated glass	1	1.4	2.3	1.7	2.4	2.1	4.1
	2	1.0	1.6	1.3	1.8	1.9	3.7
	5	0.6	1.0	1.1	1.3	1.7	3.5
	10	0.5	0.7	1.0	1.0	1.6	3.4
32 oz Vinyl coated polyester	1	9.0	4.8	10.3	5.2	21.4	15.8
	2	6.4	3.4	8.1	3.9	20.4	15.4
	5	4.0	2.1	6.5	2.8	19.8	15.2
	10	2.8	1.05	5.8	2.4	19.6	15.1
10 oz Vinyl laminated polyester	1	17.1	13.6	33.3	18.5	33.3	40.4
	2	12.1	9.6	31.0	15.8	31.0	39.3
	5	7.6	6.1	29.6	13.9	29.6	38.6
	10	5.4	4.3	29.1	13.2	29.1	38.3
18 oz Vinyl laminated polyester	1	13.3	25.3	13.3	26.3	42.5	38.8
	2	9.4	17.9	9.4	19.2	41.9	34.4
	5	5.9	11.3	6.0	13.4	41.2	31.5
	10	4.2	8.0	4.2	10.7	41.0	30.5

^A FEP is Fluorinated Ethylene Propylene Copolymer.

^B The critical differences were calculated using $t = 1.960$, which is based on infinite df.

material type and structure to warrant listing the components of variance and the critical differences separately. Consequently, no multimaterial comparisons were made.

NOTE 14—Since the interlaboratory test included less than five laboratories, estimates of between-laboratory precision may be either understated or overestimated to a considerable extent and should be used with special caution.

NOTE 15—The tabulated values of the critical differences should be considered to be a general statement, particularly with respect to between-laboratory precision. Before a meaningful statement can be made about two specific laboratories, the amount of statistical bias, if any, between them must be established, with each comparison being based on recent data obtained on specimens taken from a lot of material to the type being evaluated, so as to be as nearly homogeneous as possible, and then randomly assigned in equal numbers to each of the laboratories.

TABLE 4 Critical Differences for Uniaxial Elongation Under Static Force—%, Coated and Laminated Fabrics for Architectural Use

Material ^A	Number of Observations in Each Average	Critical Differences for the Conditions Noted ^B					
		Single-Operator Precision		Between-Laboratory Precision		Within-Laboratory Precision	
		Warp	Fill	Warp	Fill	Warp	Fill
35 oz FEP coated glass	1	0.21	0.56	0.36	0.96	0.48	1.23
	2	0.15	0.40	0.33	0.87	0.46	1.16
	5	0.09	0.25	0.31	0.81	0.44	1.12
	10	0.07	0.18	0.30	0.79	0.44	1.10
28 oz Vinyl coated polyester	1	0.19	0.39	0.27	0.39	0.27	0.46
	2	0.14	0.27	0.23	0.27	0.23	0.37
	5	0.09	0.17	0.20	0.17	0.20	0.31
	10	0.06	0.12	0.19	0.12	0.19	0.28
14 oz FEP coated glass	1	0.63	0.33	0.63	0.41	0.63	0.48
	2	0.45	0.23	0.45	0.34	0.45	0.43
	5	0.28	0.15	0.28	0.29	0.28	0.38
	10	0.20	0.10	0.20	0.27	0.20	0.37
32 oz Vinyl coated polyester	1	0.30	0.54	0.30	0.59	0.32	0.98
	2	0.21	0.38	0.22	0.45	0.25	0.90
	5	0.13	0.24	0.14	0.34	0.18	0.85
	10	0.09	0.17	0.11	0.29	0.16	0.83
10 oz Vinyl laminated polyester	1	0.52	1.12	1.13	3.09	2.18	7.65
	2	0.37	0.79	1.07	2.98	2.15	7.61
	5	0.23	0.50	1.03	2.92	2.13	7.58
	10	0.16	0.35	1.01	2.90	2.13	7.58
18 oz Vinyl laminated polyester	1	0.40	0.68	0.44	1.05	0.76	2.52
	2	0.28	0.48	0.34	0.94	0.70	2.47
	5	0.18	0.30	0.26	0.86	0.66	2.44
	10	0.13	0.22	0.23	0.83	0.65	2.43

^A FEP is Fluorinated Ethylene Propylene Copolymer.

^B The critical differences were calculated using $t = 1.960$, which is based on infinite df.

TABLE 5 Critical Differences for Breaking Force After Crease Fold—lb/in., Coated and Laminated Fabrics for Architectural Use

Material ^A	Number of Observations in Each Average	Critical Differences for the Conditions Noted ^B					
		Single-Operator Precision		Between-Laboratory Precision		Within-Laboratory Precision	
		Warp	Fill	Warp	Fill	Warp	Fill
35 oz FEP coated glass	1	278	188	320	221	320	221
	2	196	133	252	176	252	176
	5	124	84	201	143	201	143
	10	88	59	181	130	181	130
28 oz Vinyl coated polyester	1	51	85	58	85	70	117
	2	36	60	45	60	60	100
	5	23	38	36	38	53	88
	10	16	27	29	27	49	84
14 oz FEP coated glass	1	75	68	76	84	167	170
	2	53	48	54	69	159	163
	5	33	30	36	58	153	159
	10	24	21	27	54	151	157
32 oz Vinyl coated polyester	1	68	159	68	160	83	532
	2	48	112	48	113	68	520
	5	30	71	30	73	57	513
	10	22	50	22	53	53	510
10 oz Vinyl laminated polyester	1	21	11	21	11	24	19
	2	15	7.6	15	7.8	18	17
	5	9.3	4.8	9.3	5.1	14	16
	10	6.6	3.4	6.6	3.8	13	16
18 oz Vinyl laminated polyester	1	25.3	29	30	30	44	30
	2	17.9	21	24	21	40	21
	5	11.3	13	19	14	37	14
	10	7.99	9.2	17	10	36	10

^A FEP is Fluorinated Ethylene Propylene Copolymer.

^B The critical differences were calculated using $t = 1.960$, which is based on infinite df.

24.3 *Bias*—Interlaboratory testing indicated that a bias between laboratories could occur for the adhesion of coating fabric procedure due to consistency in making adhesion test specimens and for breaking strength after crease fold due to the manner in which the crease fold is made. Before a meaningful statement can be made about two specific laboratories performing these two tests, the amount of statistical bias, if any,

between them must be established with each comparison being based on recent data obtained on specimens taken from a lot of material of the type being evaluated, so as to be homogeneous as possible, and then randomly assigned in equal numbers in each laboratory. Refer to 5.1.1.

24.3.1 The values for the other test methods cited in this test method only can be defined in terms of a test method. Within

this limitation, the procedures in this test method have no known bias.

ANNEXES

(Mandatory Information)

A1. SEALING TECHNIQUES SUITABLE FOR COATING ADHESION OF POLYTETRAFLUOROETHYLENE AND FLUORINATED ETHYLENE PROPYLENE COPOLYMER COATINGS AND GLASS FIBER FABRIC

A1.1 *Summary of Sealing Technique*—A piece of FEP (Fluorinated Ethylene Propylene) film is sandwiched between two pieces of fabric. This sandwiched structure is heated under pressure to melt the film and coating and bond the two fabric pieces together.

A1.2 Apparatus and Materials:

A1.2.1 *Steel Rule*, 25 by 300 mm (1 by 12 in.) with 1 mm or $\frac{1}{16}$ in. divisions.

A1.2.2 *Knife*, razor type.

A1.2.3 *Film*, fluorinated ethylene propylene (FEP) 0.125 mm (0.005 in.) thick.¹⁷

A1.2.4 *Hydraulic Press or Equivalent Heated Die Apparatus*¹⁸, with indicating pyrometer and two heated 175 by 250 mm (7 by 10 in.) surfaces capable of maintaining $343 \pm 10^\circ\text{C}$ ($650 \pm 20^\circ\text{F}$) while exerting a pressure of 35 ± 14 kPa (5 ± 2 psi).

A1.2.5 *Timer*, capable of measuring an elapsed time of 5 min ± 10 s.¹⁹

A1.2.6 *Utility Basin or Pan*, approximately 200 mm (8 in.) long and a minimum of 100 mm (4 in.) deep; polyethylene, glass or stainless.²⁰

A1.2.7 *Insulated Gloves*.²¹

A1.2.8 *Hood*, or well-ventilated area for hydraulic press.

A1.2.9 *Distilled or Deionized Water*.

A1.2.10 *Ruler*, transparent plastic about 300 mm (12 in.) in length, 2 mm (0.1 in.) increments.²²

A1.3 Specimen Preparation:

A1.3.1 Place the laboratory sample on a smooth surface. Cut two rectangular strips 175 by 200 mm ± 3 mm (7 by 8 in. $\pm \frac{1}{8}$ in.) each with the 200-mm (8-in.) dimension parallel to the direction of test. Bond the strips together back to front, unless otherwise specified. Identify the front of each piece with a small pencil or pen mark near its end. Cut a piece of 0.125-mm (0.005-in.) thick FEP film 210 by 185 mm ± 3 mm ($8\frac{1}{4}$ by $7\frac{1}{4}$ in. $\pm \frac{1}{8}$ in.). With a clean, dry towel, wipe any dust or dirt from the surfaces of the film and strips.

A1.3.2 Place one piece of the strip, with the front surface up, on a smooth, clean work surface. Position the piece of FEP film squarely on top of the strip with its long dimension aligned to the long dimension of the strip. Place the second strip on top of the FEP-specimen stack. The side marked “front” must be up and the long dimension of the top strip parallel to the long dimension of the FEP-strip stack. Align the edges of all three strips. Any excess in the dimensions should be divided between the edges.

A1.3.3 Check the temperatures of both press platens or other heated surfaces. The temperature must be $343 \pm 10^\circ\text{C}$ ($650 \pm 20^\circ\text{F}$) and stabilized at that temperature for 2 h prior to use.

NOTE A1.1—**Precaution:** In addition to other precautions, the press *must* be located in a well ventilated area or in a fume hood to remove any decomposition products. Fluoropolymers begin to decompose above a temperature of 315°C (600°F). Thermal decomposition products of such materials will cause polymer fume fever, if inhaled, which is characterized by flu-like symptoms (chills and fever). Use insulated gloves when inserting or removing specimens from the press.

A1.3.4 Place the layered stack squarely between the two heated platens or other heated surfaces. Allow 25 to 40 mm (1 to $1\frac{1}{2}$ in.) of the 200 mm (8 in.) length to hang over the front edge of the lower heated surface or platen. Close the platen or other heated surfaces and slowly apply a pressure of 35 ± 14 kPa (5 ± 2 psi) to the pressed area of the sample. Start the timer after reaching the stated pressure. Periodically throughout the pressing step, check the pressure and restore to 35 kPa (5 psi) if the pressure drops below 21 kPa (3 psi). After 3 min ± 10 s, lower the platen and remove the hot, bonded strips.

A1.3.5 Place the bonded strip on a smooth, flat surface and allow to cool to room temperature. Wipe any adhering residue from the platens after removing the bonded strips. Trim the bonded specimen to approximately 170 by 200 mm (6.75 by 8 in.) by removing equal amounts of material from each side. Do not trim any material from the unbonded end. Carefully cut two 25 by 200 mm (1 by 8 in.) strips from the bonded strips for the test specimen.

A1.3.6 Prepare like specimens for both the machine and cross-machine directions as directed in A1.3.1-A1.3.5.

A1.3.7 For the wet condition specimens, prepare additional specimens as directed in A1.3.1-A1.3.5. Immerse the strips under 75 ± 6 mm (3 ± 0.25 in.) of 15 to 27°C (60 to 80°F) distilled water for 24 h. Remove the specimens from the water and wipe the strips dry with a cloth or paper towel not more than 10 min prior to testing.

¹⁸ Wabash Model 3-10×7-2T, Wabash Metal Products, 1569 Mom's Street, Wabash, IN, or equivalent, has been found satisfactory for this purpose.

¹⁹ Fisher Scientific Co., No. 6-656, or equivalent, has been found satisfactory for this purpose.

²⁰ Cole Palmer No. 6013-10, or equivalent, has been found satisfactory for this purpose.

²¹ Fisher Scientific Co., No. 11-393, or equivalent, has been found satisfactory for this purpose.

²² C-Thru W25, C-Thru Ruler Co., Hartford, CT, or equivalent, has been found satisfactory for this purpose.

A2. SEALING TECHNIQUES SUITABLE FOR COATING ADHESION OF VINYL COATED FABRIC

A2.1 *Summary of Sealing Technique*—Two pieces of fabric are placed on top of one another, face to back. A high radio frequency sealer is used to bond the two fabric pieces together. This sealing technique is applicable to vinyl coated fabric that is reinforced with nylon, polyester, or glass fiber fabric.

A2.2 *Apparatus and Materials:*

A2.2.1 *High Radio Frequency Sealer*,²³ equipped with a 50 by 150 mm (2 by 6 in.) die mounted on an air cylinder that can apply 550 kPa (80 psi) pressure to press the die firmly on the lower grid. The sealer should also be designed for a 1 s preseal, 5 s sealing, and a 10 s cooling period. The power output on the sealer should be 3.0 kW.

A2.2.2 *Hood*, or well ventilated area.

A2.2.3 *Steel Rule*, 25 by 300 mm (1 by 12 in.) with 1 mm or $\frac{1}{16}$ in. divisions.

A2.2.4 *Knife*, razor type.

A2.2.5 *Timer*, capable of measuring an elapsed time from 0 to 10 s.

A2.3 *Specimen Preparation:*

A2.3.1 Place the laboratory sample on a smooth surface. Cut two rectangular strips 75 by 200 ± 3 mm (3 by $8 \pm \frac{1}{8}$ in.) each with the 200-mm (8-in.) dimension parallel to the direction of test. Identify the front of each piece with a small pencil or pen mark near the end of the strip. With a clean, dry towel, wipe any dust or dirt from the surfaces of the film and strips.

A2.3.2 Place one strip, with the front surface up, on a smooth, clean work surface. Place the second strip on top of the first strip. Bond the strips together back to front, unless otherwise specified. The side marked “front” must be up and

the long dimension of both specimen strips parallel. Align the edges of the two strips.

A2.3.3 Place the 75 by 200 mm (3 by 8 in.) two layer arrangement under the 50 by 150 mm (2 by 6 in.) die of the high radio frequency sealer. This should be placed under the die in such a way that approximately 25 mm (1 in.) of fabric protrudes from either end of the die and approximately 13 mm (0.5 in.) of fabric protrudes from either side of the die.

NOTE A2.1—**Precaution:** In addition to other precautions, the high frequency sealer should be located in a well ventilated area or in a fume hood to remove any by-products from sealing. Appropriate safety precautions are described in FCC regulation Part 18, OSHA Radiation standards, and four-hand safety procedures approved by OSHA.

A2.3.4 Initiate the welding process which will lower the die onto the two layers of fabric, preseal for 1 s, seal for 5 s via high frequency current, cool for 10 s, then lift the die off the welded fabric and remove the bonded specimen.

NOTE A2.2—The preseal, sealing, and cooling time and the power settings will vary slightly depending on the thickness of the coated fabric and the type of thermoplastic coating compound. In any event, when the bonded strips are pulled apart, they should separate between the base fabric and the coating compound. If the sample separates between the face coat and the back then the bonded strips should be rejected. Also, if the base fabric has been distorted during the welding process the bonded strips should be rejected. A starting frequency of 27 ± 1 % mHz is suggested.

A2.3.5 Place the bonded strip on a smooth, flat surface and allow to cool to room temperature. Carefully cut two 25.4 by 200 mm (1.0 by 8 in.) strips from the bonded strip. Do not trim any material from the unbonded end.

A2.3.6 Prepare like specimens for both the machine and cross-machine directions as directed in A2.3.1-A2.3.5.

A2.3.7 For the wet condition specimens, prepare additional specimens as directed in Annex A2. Immerse the strips under 75 ± 6 mm (3 ± 0.25 in.) of 15 to 27°C (60 to 80°F) distilled water for 24 h. Remove the specimens from the water and wipe the strips dry with a cloth or paper towel not more than 10 min prior to testing.

²³ Devices available from Kabar Mfg. Co., 140 Schmitt Blvd., Farmingdale, NY 11735; J. A. Callan Co., 1844 Brummel Drive, Grove Village, IL 60007 and Thermex/Thermatron, 60 Spence Street, Bay Shore, NY 11706, have been found satisfactory for this purpose.

A3. SEALING TECHNIQUES SUITABLE FOR COATING ADHESION OF SILICONE COATED FABRIC

A3.1 *Summary of Sealing Technique*—A coating of silicone adhesive is sandwiched between two pieces of fabric. This sandwiched structure is heated to bond the two fabric specimens together.

NOTE A3.1—The sealing technique that follows, describes adhesion procedures that have been used satisfactorily in the industry and apply to heat curable systems, such as peroxide-initiated or platinum-catalyzed. Room temperature cure silicone adhesives, however, generally supply acceptable adhesion of previously vulcanized silicone rubbers and can be used when they provide sufficient bond to meet the requirements of this test method and are acceptable to the contractual parties involved.

A3.2 *Apparatus and Materials:*

A3.2.1 *Silicone Adhesive*, as agreed upon by the purchaser and supplier.

A3.2.2 *Oven*, ventilated and thermostatically controlled in the temperature range of $175 \pm 2^\circ\text{C}$ ($350 \pm 5^\circ\text{F}$). The oven may be the air circulating or convection type.

A3.2.3 *Hood*, or well ventilated area.

A3.2.4 *Coating Thickness Metering Device*.²⁴

A3.2.5 *Circular Neoprene Rubber Roller*, 1.8 ± 0.05 kg (4.0 ± 0.1 lb).

A3.2.6 *Timer*, capable of measuring an elapsed time of 10 ± 1 min.²⁵

²⁴ Gardner coater type available from Pacific Scientific, or equivalent, has been found satisfactory for this purpose.

²⁵ Fisher Scientific Co., No. 06-662-10, or equivalent, has been found satisfactory for this purpose.

A3.2.7 *Utility Basin or Pan*, approximately 200 mm (8 in.) long and a minimum of 100 mm (4 in.) deep, made of polyethylene, glass, or stainless.²⁰

A3.2.8 *Insulated Gloves*.

A3.2.9 *Masking Tape*, 25 mm (1 in.) in width.

A3.2.10 *Steel Rule*, 25 by 300 mm (1 by 12 in.) with 1 mm or 1/16 in. divisions.

A3.2.11 *Knife*, razor type.

A3.3 *Specimen Preparation:*

A3.3.1 Place the laboratory sample on a smooth surface. Cut two rectangular strips 75 by 200 mm \pm 3 mm (3 by 8 in. \pm 1/8 in.) each with the 200-mm (8-in.) dimension parallel to the direction of test. Identify the front of each piece with a small pencil or pen mark near the end of the strip. With a clean, dry towel, wipe any dust or dirt from the surfaces of the strips.

A3.3.2 On a clean, smooth work surface, place, side by side one strip with the front surface up, the other with the front surface down. Apply a piece of 25 mm (1 in.) masking tape across the top of the two strips securing them to the work surface to keep them from sliding on the surface. Apply a coating of the agreed upon silicone adhesive 0.25 ± 0.02 mm (0.010 ± 0.001 in.) thick to each of the strip surfaces, 25 mm (1 in.) from the top edge. Use the coater thickness metering device to meter the coating along the length of the strips. Remove the masking tape from the top of the strips. Press the silicone adhesive coated surfaces against each other and place

the specimen sandwich on the flat work surface. Roll the 1.8 kg (4 lb) neoprene rubber roller along the length of the specimen sandwich, first, in one direction, then reversing in the other direction to ensure intimate contact. Bond the strips together back to front, unless otherwise specified. The side marked “front” must be up and the long dimension of both strips parallel. Align the edges of the two strips.

A3.3.3 Place the 75 by 200 mm (3 by 8 in.) specimen sandwich in an oven set to $175 \pm 2^\circ\text{C}$ ($350 \pm 5^\circ\text{F}$) for 10 ± 1 min.

NOTE A3.2—**Precaution:** In addition to other precautions, the oven should be located in a well-ventilated area or in a fume hood to remove any by-products from sealing. Use insulated gloves to insert and remove specimens from the oven.

A3.3.4 Remove the bonded strips from the oven. Place the bonded strips on a smooth, flat surface and allow to cool to room temperature. Carefully cut two 25.4 by 200 mm (1.0 by 8 in.) strips from the bonded strips. Do not trim any material from the unbonded end.

A3.3.5 Prepare like specimens for both the machine and cross-machine directions as directed in A3.3.1-A3.3.4.

A3.3.6 For the wet condition specimens, prepare additional specimens as directed in Annex A3. Immerse the specimen strips under 75 ± 6 mm (3 ± 0.25 in.) of 15 to 27°C (60 to 80°F) distilled water for 24 h. Remove the specimens from the water and wipe the strips dry with a cloth or paper towel not more than 10 min prior to testing.

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