Designation: D 4028 – 96 (Reapproved 2002)

Standard Specification for Solar Screening Woven from Vinyl-Coated Fiber Glass Yarn[1]

This standard is issued under the fixed designation D 4028; 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 This specification covers the requirements for vinyl-coated fiber glass solar screening, and should help users recognize the characteristics of acceptable vinyl-coated fiber glass solar screening. This specification is limited in application to vinyl-coated fiber glass solar screening that is produced with a ribbed pattern woven in the warp direction. The applicability of this specification to vinyl-coated fiber glass type solar screening of a non-rib, a double rib (ribs in both warp and filling direction), or a filling rib construction is not known.

1.2 This specification shows the definitions, general requirements, and physical requirements for commercial standard vinyl-coated fiber glass solar screening designed and woven for installation in any dwelling, building, or structure for the purpose of providing a significant reduction in solar heat gain, while providing outward view and interior light. Solar screening provides a structure that has insect-restraining capabilities equivalent to standard insect screening.

NOTE 1—For information on standard insect screening, see Specification D 3656.

1.3 This specification shows the values in both SI units and inch-pound units. "SI" is the technically correct name for the system of metric units known as the International System of Units. "Inch-pound units" is the technically correct name for customary units used in the United States. The values stated in either SI units or in other units shall be regarded separately as standard. The values expressed in each system may not be exact equivalents; therefore, each system must be used independently of the other without combining in any way.

1.4 The following precautionary caveat pertains only to the test method portion, Sections 8-21 of this specification: *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.*

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 578 Specification for Glass Fiber Strands[2]
D 883 Terminology Relating to Plastics[3]
D 1776 Practice for Conditioning Textiles for Testing[2]
D 3374 Specification for Vinyl-Coated Glass Yarns[4]
D 3656 Specification for Insect Screening and Louver Cloth Woven from Vinyl-Coated Glass Fiber Yarn[4]
D 3773 Test Methods for Length of Woven Fabric[4]
D 3774 Test Method for Width of Woven Fabric[4]
D 3775 Test Method for Fabric Count of Woven Fabric[4]
D 3776 Test Methods for Mass per Unit Area (Weight) of Fabric[4]
D 4909 Test Method for Color Stability of Vinyl-Coated Glass Textiles to Accelerated Weathering[4]
D 4912 Test Method for Fabric Stability of Vinyl-Coated Glass Yarn Insect Screening and Louver Cloth[4]
D 4963 Test Method for Ignition Loss of Glass Strands and Fabrics[4]
D 5035 Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)[4]
E 171 Specification for Standard Atmospheres for Conditioning and Testing Flexible Barrier Materials[5]

2.2 *AATCC Standard:*[6]

Evaluating Procedure 1, Grey Scale for Color Change.

2.3 *ANSI ASHRAE Standard:*[7]

Standard 74-1988, Method of Measuring Solar-Optical Properties of Materials

2.4 *Federal Test Method Standards:*[8]

No. 191, Method 5872, Effect of High Temperature on Cloth Blocking, Textile Test Methods
No. 191, Method 5903, Flame Resistance of Cloth, Vertical,

[1] This specification is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.18 on Glass Fiber and Its Products.

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[2] *Annual Book of ASTM Standards*, Vol 07.01.
[3] *Annual Book of ASTM Standards*, Vol 08.01.
[4] *Annual Book of ASTM Standards*, Vol 07.02.
[5] *Annual Book of ASTM Standards*, Vol 15.09.
[6] Available from American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.
[7] Available from American Society of Heating, Refrigeration, and Air-Conditioning Engineers, 1791 Tullie Circle N.E., Atlanta, GA 30329.
[8] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

Textile Test Methods
CCC D-950 Specification, Dyeing and After Treating Processes for Cotton Cloths
2.5 *Military Standard:*[6]
MIL-STD-105D Sampling Procedures and Tables for Inspection by Attributes

3. Terminology

3.1 *Definitions:*

3.1.1 *acceptable quality level (AQL or P1)*—in acceptance sampling the maximum fraction of nonconforming items at which the process average can be considered satisfactory; the process average at which the risk of rejection is called the producer's risk.

3.1.2 *atmosphere for testing textiles, n—for glass*, air maintained at a relative humidity of at least 48 % and no greater than 67 %, and at a temperature of at least 20°C (68°F) and no greater than 25°C (77°F).

3.1.2.1 *Discussion*—Glass textiles are used in various products such as reinforced plastics, mat-like material, tire cords, electrical insulation, etc. Each of these materials require different testing atmospheres. It is the intent of this wide spread in testing atmosphere to allow testing of glass textiles in respective laboratories where end product test atmosphere requirements differ. The test atmospheres for respective products should be controlled as specified in Specification E 171. It is the opinion of Subcommittee D13.18 that the physical properties cited in respective specifications would not be affected by the range selected. In any event, the test atmosphere should be stated in the report.

3.1.3 *fabric stability, n—in vinyl coated glass screening and louver cloth*, the property denoting the ability to resist movement of yarn segments in one direction over yarn segments in the opposite direction.

3.1.3.1 *Discussion*—The movement of the yarns may be a result of weak bonds between crossing yarns as the coating is fused during manufacture.

3.1.4 *mesh, n—in coated glass yarn fabrics*, the number of warp yarns or ends per linear 25.4 mm (1 in.) followed by the number of filling yarns or picks per linear 25.4 mm (1 in.).

3.1.5 *shading coefficient, n*—the ratio of the solar heat gain through a glazing system under a specific set of conditions to the solar gain through a single light of double-strength sheet glass under the same conditions.

3.1.5.1 *Discussion*—This definition is from the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE) Handbook of Fundamentals.

3.1.6 *solar screening, n—of coated fiber glass yarn solar screening*, a woven fabric that imparts a shielding or protection from light, heat, wind, and insects without excessive alteration or impairment of visual viewing, and that has a mesh in excess of 12 by 12 with a rib pattern in the warp direction formed by the weaving of two or more contiguous yarns with a minimum of space between such yarns followed by space equivalent to the width of one or more of the yarns in the rib.

3.1.7 For definitions of other textile terms used in this method refer to Terminology D 123.

3.1.8 For definitions of plastic terms used in this method refer to Terminology D 883.

4. General Requirements

4.1 *Material*:

4.1.1 *Workmanship*—All commercial standard vinyl-coated glass yarn solar screening shall be made of high grade material with good workmanship and meet the yarn requirements specified in Specification D 3374. Products shall be free of any defects that might affect serviceability or appearance, except those permitted in footnote C of Table 1. The quality acceptance levels will be determined by agreement between the purchaser and the supplier.

4.1.2 *Plasticizers*—The material used to coat or impregnate the fibrous glass yarn shall be a compound of polymerized or copolymerized vinyl chloride resin, plasticized with phosphate or phthalate ester plasticizers exclusively, pigmented and stabilized to meet the requirements herein.

4.1.2.1 *Optional Plasticizer*—At the supplier's option, plasticizers other than phosphates and phthalates may be used provided the color is not affected and the coating compound is treated with solubilized copper 8 quinolinolate which is listed as inhibitor (e) in Federal Standard CCC-D-950. The amount of fungicide shall be based on the nonvolatile content of the coating. The coating compound shall be chemically analyzed for copper 8 quinolinolate content in accordance with Federal Standard CCC-D-950.

4.1.3 *Color*—For colors listed in Table 2, the maximum and minimum shade limits shall be defined by color designations listed in Federal Standard 595A as agreed upon between the purchaser and the supplier.

TABLE 1 Defects[A]

Bias or bowed filling – distortion at any point 13 mm (½ in.) or more from horizontal	Scalloped selvage
Broken or missing end or pick	Slack, or tight selvage
Curled (doubled, rolled, or folded) selvage	Smash
Cut, hole, or tear	Splice – more than one in 929 cm^2(1 ft^2)
Damaged selvage extending into body of screening	Splice – more than 25 mm (1 in.) in length
Double picks	Splice – not well made or showing loose ends exceeding 25 mm (1 in.) in length
Floats	Spot, stain, streak, or mottled[B]
Hitch-back, open place, or slippage	Tight end or pick – causing waviness or ridge
Jerked-in filling, slough-off, or kinky filling	Uncoated yarns[C]
Knots	Warp streaks or filling bar
Offshade[B]	Wrong draw

[A] For definitions of terms used in this table, refer to Terminology D 123.
[B] At normal inspection distance, approximately 1 m (1 yd).
[C] Single ends or picks unevenly coated and giving the appearance of a streak, or light-colored, but coated yarn, shall not be scored as a defect when examined at normal inspection distance of approximately 1 m (1 yd).

TABLE 2 Generally Available Mesh, Widths, and Colors

Product	Nominal Yarn Diameter		Standard Constructions (Mesh)		Standard Minimum Widths		Colors
	µm	in.	Warp	Fill	cm	in.	
Fiber glass solar screening	292	0.0115	53	16	46, 51, 56, 61, 66, 71,	18, 20, 22, 24, 26, 28,	bronze
	330	0.0130	54	16	76, 81, 86, 91, 96, 102,	30, 32, 34, 36, 38, 40,	charcoal
			54	18	107, 112, 117, 122,	42, 44, 46, 48, 54, 60,	gray
					137, 152, 168, 183,	66, 72, 78, 84	
					198, 213		

4.1.4 *Selvage*—Vinyl-coated glass screening may be supplied with or without selvages as agreed between the purchaser and supplier.

4.1.5 *Yarn Splices*—Vinyl-coated glass yarn splices shall be permitted provided they show no tails and do not exceed 25 mm (1 in.) in length. Yarn splices in the solar screening shall not exceed 15 per standard 30 m (100 ft) roll, and no more than one splice shall occur in any 9.30 cm^2 (1 ft^2) of product.

4.2 *Put-Up*—Vinyl-coated glass yarn solar screening shall be put-up on rolls and in containers whose dimensions shall be agreed upon between the purchaser and the supplier.

5. Physical Requirements

5.1 *Appearance*—Unless otherwise agreed upon between the purchaser and the supplier, a roll shall be defective if it contains one or more defects from the list in Table 1, and the lot shall be unacceptable if the number of defective sample rolls exceeds the acceptance number in Table 6. Table 6 is based on an acceptable quality level (AQL) of 4 % defective rolls.

5.2 *Mesh*—The standard average mesh shall be approximately even-spaced as specified in Table 2, ±0.5 mesh per 25.4 mm (1 in.) in the non-rib direction and ±2 mesh in the rib direction. There are no tolerance requirements within 13 mm (0.5 in.) of the selvage.

5.3 *Roll Length*—Each roll of solar screening complying with Specification D 4028 shall contain not less than 30 linear m (100 linear ft), and shall contain not more than two pieces per roll with no piece less than 3 linear m (10 linear ft).

5.3.1 The lot shall be unacceptable if the total of the actual gross lengths of rolls in the sample is less than the total of the gross lengths marked on the roll tickets.

5.4 *Width*—The standard average roll width shall be as specified in Table 2 +7 or −0 mm (+0.25 or −0 in.).

5.5 *Mass per Unit Area*—The minimum average mass per unit area for each class shall be as specified in Table 3.

5.6 *Ignition Loss*—The average ignition loss shall equal or exceed the value specified in Table 3.

5.7 *Breaking Strength*—The average breaking strength shall equal or exceed the value specified in Table 3.

5.8 *Fabric Stability*—The yarns shall be bonded at the contact or cross-over points to give sufficient fabric stability to the finished product to equal or exceed the applicable average force values specified in Table 3.

5.9 *Shading Coefficient*—The average shading coefficient shall equal or be less than the value specified in Table 3.

5.10 *Flame Resistance*—There shall be no propagation of flame along any specimen for longer than 10 s after removal of flame source, and no single specimen may propagate flame along its entire length in any time increment.

TABLE 3 Properties—Sample Average

Properties	Mesh 53 by 16	Mesh 54 by 16	Mesh 54 by 18
Mass per unit area, min:			
g/m^2	246	246	246
oz/yd^2	7.25	7.25	7.25
Ignition loss, min, %	50	50	50
Breaking strength, min:			
Warp N	400	400	400
lbf	90	90	90
Fill N	155	155	155
lbf	35	35	35
Fabric stability, min:			
Warp N	67	67	89
lbf	15	15	20
Fill N	67	67	89
lbf	15	15	20
Shading coefficient,max	0.36	0.36	0.36

5.11 *Blocking Resistance*—The surfaces of the solar screening shall not adhere or exhibit blocking in excess of Scale No. 1.

5.12 *Color Stability to Accelerated Weathering*—The change from the original color after 480 h of accelerated weathering exposure shall be no greater than Step 3 of the AATCC Gray Scale for evaluating change in color.

5.12.1 The change from the original color after 960 h of accelerated weathering exposure shall be no greater than Step 2 of the AATCC Gray Scale.

5.12.2 Exposure periods and acceptable changes for colors other than the colors as listed in Table 2 shall be as agreed upon between the purchaser and the supplier.

6. Sampling Inspection and Number of Specimens

6.1 *Lot Size*—A lot shall consist of each shipment of a single solar screening having the same color and mesh, unless otherwise agreed upon between the purchaser and the supplier. The lot size shall be designated in linear units of metres (feet).

6.2 *Lot Sample*—As a lot sample for acceptance testing, take the number of rolls of solar screening directed in an applicable material specification or other agreement between the purchaser and the supplier. Consider rolls of solar screening to be the primary sampling unit. In the absence of such an agreement, take the number of rolls specified in Table 4.

NOTE 2—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between rolls of solar screening and between test specimens from a swatch or roll of solar screening to produce a sampling plan with meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

TABLE 4 Sample Size and Acceptance Number[A]

Lot Size		Rolls	
Length, m	Length, ft	Sample Size	Acceptance Number
Up to 365 inclusive[B]	Up to 1 200 inclusive[B]	3	0
366 up to and including 975	1 201 up to and including 3 200	5	0
976 up to and including 3 048	3 201 up to and including 10 000	8	0
3 049 up to and including 10 668	10 001 up to and including 35 000	13	0
10 669 up to and including 45 720	35 001 up to and including 150 000	20	1
45 721 and over	150 001 and over	32	2

[A] Based on MIL-STD-105D, Inspection Level II, and an AQL of 4.0 defects per 30.5-m (100-ft) length.
[B] If lot contains fewer than 3 rolls, each roll in the lot shall be examined.

6.3 *Laboratory Sample*—As a laboratory sample for acceptance testing, proceed as directed in an applicable material specification or other agreement between the purchaser and the supplier. In the absence of such an agreement, proceed as follows:

6.3.1 For solar screening appearance, width, mass per unit area, and length, the rolls in the lot sample serve as the laboratory sample.

6.3.2 For other properties, take at random from the rolls in the lot sample the number of rolls specified in Table 5. From each roll in the laboratory sample, take a 2-m (2-yd) full-width swatch from the end of the roll, but taken no closer than 1 m (1 yd) from the outside end of the roll.

6.4 *Test Specimens*—For solar screening appearance, width, and 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 specification. Take test specimens from each swatch in the laboratory sample in such a way that no specimen is closer than one tenth the width of the swatch from the selvage with no two specimens cut parallel to the warp containing the same set of warp ends or if cut parallel to the filling, containing the same set of filling picks, and the specimens from different swatches for a specific property are each taken from a different part of the width of the swatches.

7. Conditioning

7.1 Condition the laboratory samples without preconditioning for a period of at least 5 h in the atmosphere for testing glass textiles, unless otherwise specified.

NOTE 3—In any event, 24 h is considered ample exposure time to bring the samples to moisture equilibrium.

TEST METHODS

8. Material

8.1 Upon prior agreement, the purchaser may accept the supplier's certification that the materials comply with the requirements of Section 4. In the absence of such an agreement, compliance will be tested using Specification D 3374 and Federal Standard CCC-D-950.

TABLE 5 Sample Size for Lot Quantities

Lot Quantity		Sample Size, Number of Rolls
Length, m	Length, ft	
243 or less	800 or less	2
244 to 6705	801 up to and including 22 000	3
6706 and over	22 001 and over	5

9. Put-Up

9.1 Verify that the rolls and shipping containers conform to the inspection agreement in the purchaser's plant.

10. Solar Screening Appearance

10.1 *Scope*:

10.1.1 This test method covers the visual examination of screening material appearance using a major and minor evaluation system. A list of defects is provided designating the degree of the defect and whether minor or major. This test method is applicable to screening fabrics woven from vinyl-coated glass fiber yarns.

10.2 *Summary*:

10.2.1 The entire roll of screening material is examined on a lighted flat surface as it is rewound under controlled conditions. Minor and major defects are assigned when observed and the number of occurrences are reported.

10.3 *Significance and Use*:

10.3.1 The visual inspection of screening for defects is performed using an acceptable industry cloth room procedure and equipment before doing any other testing, and is considered satisfactory for acceptance testing of commercial shipments.

10.3.2 In using this test method for acceptance testing, in case of disagreement in values reported by the purchaser and the supplier, inspect the same rolls of screening at each station to determine the statistical bias, if any, between the examination station of the purchaser and the examination station of the supplier.

10.4 *Apparatus*:

10.4.1 *Fabric-Inspection Machine* that provides a flat viewing area and a controlled fabric-rewinding mechanism.

10.4.2 *Lighting Source* mounted parallel to the viewing surface of the fabric inspection machine so as to illuminate the surface with direct perpendicular impinging light rays that produce an illumination level of approximately 1075 lx (100 fc).

10.5 *Test Specimen*—Use the entire roll as the test specimen to inspect for appearance. (See 6.2-6.4.)

10.6 *Conditioning*—There are no specific requirements for conditioning.

10.7 *Procedure*:

10.7.1 Visually examine (inspect) each test specimen in the linear direction, full width, of the finished solar screening. Examine the entire length of each roll.

10.7.2 Traverse the screening longitudinally through the inspection machine at a compatible visual inspection speed.

10.7.3 View and inspect the moving screening from a distance of approximately 1 m (1 yd). Stop the traverse to affirm marginal or suspected defects.

10.7.3.1 Count all defects found regardless of their proximity to one another, except where two or more defects represent a single local condition of the solar screening. In this case, count only the more serious defect as one defect for each warp

direction 0.3 m (1 ft) or fraction thereof in which it occurs. Classify the defects as listed in Table 1.

10.7.3.2 Unless agreed otherwise between the purchaser and the supplier, do not count defects on the back of the screening unless the defects are visible on the face of the screening.

10.8 *Report*:

10.8.1 State that the rolls of screening were visually inspected for defects as directed in Section 10 of Specification D 4028.

10.8.2 Report the following information:

10.8.2.1 Description of material sampled,

10.8.2.2 Roll length sampled,

10.8.2.3 For each roll, the number and type of defects per roll length, and

10.8.2.4 For the lot, the average number and type of defects per roll length.

10.9 *Precision and Bias*—No justifiable statement can be made on the precision and bias of Specification D 4028 for measuring appearance since the result is based upon a visual examination and of subjective evaluation of what is observed and merely states whether there is conformance to criteria for success specified in the procedure.

11. Roll Length

11.1 Unless agreed otherwise between the purchaser and the supplier, determine the length of a roll by the clock method as directed in Test Methods D 3773, Option C.

12. Color

12.1 The color shall be as agreed upon between the purchaser and the supplier.

12.2 The color of each sample lot shall be determined by evaluation and comparison to the standard color swatches using the evaluation procedure and light source as described in AATCC Evaluation Procedure 1.

13. Mesh

13.1 Determine the mesh as directed in Test Method D 3775. Count the number of warp yarns in 25 mm (1 in.) of fabric width in five randomly designated places across the width of each swatch in the laboratory sample. Count the number of filling picks in 25 mm (1 in.) of fabric length in five randomly designated places across the length of each swatch in the laboratory sample.

14. Width

14.1 Determine the fabric width as directed in Test Method D 3774, Option A. Measure the width of the screening at five evenly spaced points along the length of the roll. Make no measurements within 1 m (1 yd) of the ends of the roll.

15. Mass Per Unit Area

15.1 Determine the solar screening mass per unit area as directed in Test Methods D 3776, Option C for small swatches.

16. Ignition Loss

16.1 Determine the ignition loss of each swatch in the laboratory sample as directed in Test Method D 4963 using a specimen weighing at least 5 g (0.2 oz).

17. Breaking Strength

17.1 *Significance and Use*:

17.1.1 This breaking strength method is applicable whenever it is needed to determine the breaking force required to rupture a specific width of screening and can serve as a basis for determining differences between fabrics that may be due to the effect of variables in processing, yarns in the fabric, finishes applied to the yarns or fabric, and the geometric factors of the fabric construction.

17.1.2 Special measures are provided for in the test specimen preparation to prevent the screening from slipping in the clamps or from being damaged as a result of being gripped in the clamps. The testing for breaking strength without the use of the special specimen preparations usually gives breaking force forces that are significantly lower than when testing the specially prepared specimens.

17.2 *Apparatus*:

17.2.1 *Tensile Testing Machine*, constant-rate-of-extension (CRE) type, or constant-rate-of-traverse (CRT) type, as described in Specification D 76.

17.2.1.1 In cases of dispute, the CRE-type tensile tester shall be preferred, unless agreed otherwise between the purchaser and the supplier.

NOTE 4—Normally it is expected that the use of the CRE-type or the CRT-type tensile testers would give different test results. However, interlaboratory test results on nine commercial vinyl-coated fiber glass solar screening fabrics indicated no significant differences in breaking strengths when the fabrics were tested as directed in Section 16, while using both types of machines.

17.3 *Reagents and Materials*:

17.3.1 *Methacrylate Polymer Solution*, such as *Butyl Methacrylate or Poly (Methyl Methacrylate*). Some solutions are usable in the commercially available premixed form. A butyl methacrylate solution may be prepared by mixing 45 parts by mass of butyl methacrylate with 55 parts by mass of toluene or xylene and adding a small amount of oil-soluble dye. The viscosity of this solution should be about 3000 mPa·s (cP), approximately that of honey at room temperature. It may be necessary to change the consistency for some fabrics for proper protection.

17.3.1.1 **Hazards**—Solution is flammable, keep away from heat, sparks and open flame. Keep containers closed. Use only with adequate ventilation. Avoid prolonged or repeated contact with skin. Spillage and fire instructions will depend on nature of solution.

17.3.2 *Wrapping Paper*, kraft or bleached, minimum 81.35-g/m^2 (50-lb) basis.

NOTE 5—It has been found that other commercially available paper will suffice for the mounting of the specimens.

17.3.3 *Paint Brush*, 25 mm (1 in.) wide.

17.4 *Sampling*:

17.4.1 Sample the finished screening to be tested as directed in 6.4.

17.4.2 Unless otherwise agreed upon, prepare five warp and five filling specimens for testing from each swatch.

17.5 *Test Specimen Preparation for CRE-Type Tensile Tester*:

17.5.1 Cut each test specimen 38 by 250 mm (1.5 by 10 in.)

with the long dimension parallel to the direction being tested. The final width of the specimen shall be the number of ribs or yarns per 38 mm (1.5 in.).

17.5.2 Draw four horizontal parallel lines on the mounting paper to designate the specimen length and the areas to be covered with the methacrylate solution. The four lines shall be long enough to accommodate the widths of the number of specimens to be tested with approximately 10-mm (0.5-in.) spaces between the specimens. The second line shall be approximately 50 mm (2 in.) below the first line. The third line shall be approximately 200 mm (8 in.) below the first line, and the fourth line shall be approximately 250 mm (10 in.) below the first line.

17.5.3 Draw a sufficient number of vertical lines approximately 50 mm (2 in.) apart, perpendicular to the four horizontal lines, to accommodate the number of specimens to be tested. The perpendicular lines are used for guide lines for laying the specimens flat and straight on the mounting paper.

17.5.4 With the brush, apply a smooth uniform layer of a sufficient amount of methacrylate solution to the area within the first and second lines and to the area within the third and fourth lines to provide a coating to the specimens.

NOTE 6—Some fabrics have a tendency to break at the edge of the methacrylate coating, and if the coating is at the edge of the jaw face during testing, it can be difficult to distinguish these from jaw breaks. Therefore, it is advisable, on these fabrics, to extend the methacrylate coating approximately 10 mm (0.375 in.) below line number two and above line number three into the testing zone of the specimens.

17.5.5 Use the horizontal and vertical lines as guide lines and quickly lay the individual specimens flat and straight on the mounting paper, so that a vertical line is coincident to one edge of a specimen and the first and fourth horizontal lines are coincident to an end of the specimen.

17.5.6 Immediately apply an additional amount of methacrylate solution over the ends of the specimens, covering the full width areas within the first and second horizontal lines, and within the third and fourth horizontal lines (see Note 6).

17.5.7 Secure the edges of the mounting paper in some manner to prevent curling of the specimens and the paper during drying. Dry the mounted specimens slowly, 16 to 24 h without forcing, until the solvent is completely removed from the solution.

NOTE 7—Some solutions dry to a harder state than others. The coating is usually more effective in protecting and securing the weave, when in a pliable state. Do not allow the coating to become extremely hard, before testing, by overdrying.

17.5.8 Cut the specimens apart and trim the mounting paper to the edges and ends of the specimens. Do not remove the mounting paper from the specimens.

17.5.9 Cut each specimen across the width with a single cut from each side. Center the cut on each side from the ends of the specimen; it shall be of such length (approximately 5 mm (0.25 in.)) that the resulting specimen has an effective width equivalent to the number of yarns per 25-mm (1-in.) width. Do not cut the mounting paper.

17.6 *Test Specimen Preparation for CRT-Type Tensile Tester*:

17.6.1 Cut each test specimen 38 by 150 mm (1.5 by 6 in.) with the long dimension parallel to the direction being tested. The final width of the specimen shall be the number of ribs or yarns per 38 mm (1.5 in.).

17.6.2 Proceed as in 17.5.2 except that: the second, third, and fourth horizontal lines shall be approximately 38, 115, and 150 mm (1.5, 4.5, and 6 in.) below the first line.

17.6.3 Proceed as in 17.5.3-17.5.9.

17.7 *Procedure*:

17.7.1 Use clamps provided with jaws having smooth, flat, rubber faces. Select the load range of the testing machine such that the break occurs between 10 and 90 % of full-scale force.

17.7.2 Secure the specimen centrally in the clamps of the testing machine, taking care that the long dimension is as nearly as possible parallel to the direction of application of the force. Be sure that the tension in the specimen is uniform across the clamped width. After securing the specimen, cut across the full width of the mounting paper between the upper and lower clamps.

17.7.3 Operate the CRE-type tensile tester with a crosshead speed of 125 ± 5 mm/min (5 ± 0.2 in./min) and the clamps at 350 ± 15 kPa (50 ± 2 psi) of air pressure, and with a jaw distance of 150 ± 1 mm (6 ± 0.05 in.).

17.7.4 Operate the CRT-type tensile tester with a speed of 300 ± 10 mm/min (12 ± 0.5 in./min) with a jaw distance of 75 ± 1 mm (3 ± 0.05 in.).

17.7.5 Activate the testing machine and record the maximum force required to break the specimen. If a specimen slips in the jaws, breaks at the edge of, or in, the jaws, or if for any reason attributed to faulty operation the result falls markedly below the average for the set of specimens, discard the result and take another specimen. Continue this procedure until the required number of acceptable breaks have been obtained. See Test Method D 5035 for information on discarding breaks.

17.8 *Calculation*—Calculate the average of the breaking force to the nearest 0.5 N (0.1 lbf) observed for all acceptable specimens for each swatch of screening fabric, that is, the maximum load to cause a specimen to rupture as read directly from the testing instrument. Average by warp and filling for each swatch and average by warp and filling for the lot.

17.9 *Report*:

17.9.1 State that the specimens were tested as directed in Section 17 of Specification D 4028.

17.9.2 Report the following information:

17.9.2.1 Description of material sampled,

17.9.2.2 For each swatch of solar screening tested, the average breaking force in the warp direction and in the filling direction,

17.9.2.3 For the lot of solar screening tested, the average breaking force in the warp direction and in the filling direction, and

17.9.2.4 The type of tensile testing machine used.

17.10 *Precision and Bias*:

17.10.1 *Summary*—In comparing two single warp direction observations, the difference should not exceed 24.1 % of the average of the two observations in 95 out of 100 cases when both observations are taken using the same piece of test equipment and specimens randomly drawn from the same swatch of material; the difference in two single filling direction

observations should not exceed 30.1 % of the average of the two observations. Larger differences are likely to occur under all other circumstances.

17.10.2 *Interlaboratory Test Data*—Three to five laboratories participated in two interlaboratory tests conducted in 1978–1979 with a total of 16 vinyl-covered fiber glass solar screening styles. Decisions on limiting the scope of this specification and the availability of some styles reduced the number of styles (samples) to nine. This analysis is based on data from nine styles tested by three laboratories using a CRE-type or a CRT-type tensile testing machine, or both. A particular laboratory did, or did not, use both types of testing machines. All samples were tested in the warp and filling direction. The components of variance of fabric stability results expressed as coefficients of variation were calculated to be:

	Warp Direction	Filling Direction
Within-laboratory component	8.74 % of the average	10.9 % of the average
Between-laboratory component	12.8 % of the average	16.4 % of the average

17.10.3 *Critical Differences*—For the components of variance reported in 17.10.2 two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the following critical differences:

Number of Observations in Each Average	Critical Difference, Percent of Grand Average, for the Conditions Noted			
	Within-Laboratory Precision		Between-Laboratory Precision	
	Warp	Fill	Warp	Fill
1	24.1	30.1	43.0	54.5
5	10.8	13.5	37.2	47.4
10	7.66	9.52	36.4	46.4

NOTE 8—Since the interlaboratory test included only three laboratories, estimates of between-laboratory precision should be used with special caution.

NOTE 9—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 bias, if any, between them must be established, with each comparison being based on recent data obtained on specimens randomly drawn from one swatch of the material to be evaluated.

17.10.4 *Bias*—The value of breaking strength can be defined only in terms of a specific test method. Within this limitation, the procedure has no known bias.

18. Fabric Stability

18.1 Determine the fabric stability of each swatch in the laboratory sample as directed in Test Method D 4912 except:

18.1.1 Unless otherwise agreed upon, prepare three warp and three filling specimens for testing from each swatch in the laboratory sample.

18.1.2 Set the jaw distance to 150 ± 1 mm (6 ± 0.05 in.).

18.1.2.1 Cut each test specimen 50 by 250 mm (2 by 10 in.), with the long dimension parallel to the direction being tested and with different warp ends in each of the warp specimens and different filling picks in each of the filling specimens. The final width of the specimen shall be the number of ribs or yarns per 50 mm (2 in.).

18.1.2.2 Cut alternate ribs or yarns along two horizontal lines across the 50-mm (2-in.) width of the specimen, equidistant from the center of the specimen. (See Fig. 1).

18.1.2.3 Rib or Yarn No. 1 shall be cut on Line No. 1; Rib or Yarn No. 2 shall be cut on Line No. 2; Rib or Yarn No. 3 shall be cut on Line No. 1; and Rib or Yarn No. 4 shall be cut on Line No. 2; etc.

18.1.2.4 The cuts No. 1 and No. 2 shall be 10 mm (0.4 in.) apart to the nearest whole rib or yarn.

18.1.3 *Precision and Bias*:

18.1.3.1 *Summary*—In comparing two single warp direction observations, the difference should not exceed 53.6 % of the average of the two observations in 95 out of 100 cases when both observations are taken using the same piece of test equipment and specimens randomly drawn from the same swatch of material; the difference in two single filling direction observations should not exceed 60.9 % of the average of the two observations. Larger differences are likely to occur under all circumstances.

18.1.3.2 *Interlaboratory Test Data*—Three to five laboratories participated in two interlaboratory tests conducted in 1978–1979 with a total of 16 vinyl-covered fiber glass solar screening styles. Decisions on limiting the scope of this specification and the availability of some styles, reduced the number of styles (samples) to nine. This analysis is based on data from nine styles tested by three laboratories using a CRE-type or a CRT-type tensile testing machine, or both. A particular laboratory did, or did not, use both types of testing machines. All samples were tested in the warp and filling direction. The components of variance of fabric stability results expressed as coefficients of variation were calculated to be:

	Warp Direction	Filling Direction
Within-laboratory component	19.3 % of the average	22.0 % of the average
Between-laboratory component	23.3 % of the average	20.0 % of the average

18.1.3.3 *Critical Differences*—For the components of variance reported in 17.8.2, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the following critical differences:

Number of Observations in Each Average	Critical Difference, Percent of Grand Average, for the Conditions Noted			
	Within-Laboratory Precision		Between-Laboratory Precision	
	Warp	Fill	Warp	Fill
1	53.6	60.9	84.0	82.4
3	31.0	35.1	71.6	65.7
5	24.0	27.2	68.9	61.8

18.1.3.4 The true value of fabric stability can only be defined in terms of a specific test method. Within this limitation, the procedure has no known bias.

NOTE 10—Since the interlaboratory test included only three laboratories, estimates of between-laboratory precision should be used with special caution.

NOTE 11—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 bias, if any, between them must be established, with each comparison being based on recent data obtained on specimens randomly drawn from one swatch of the material to be evaluated.

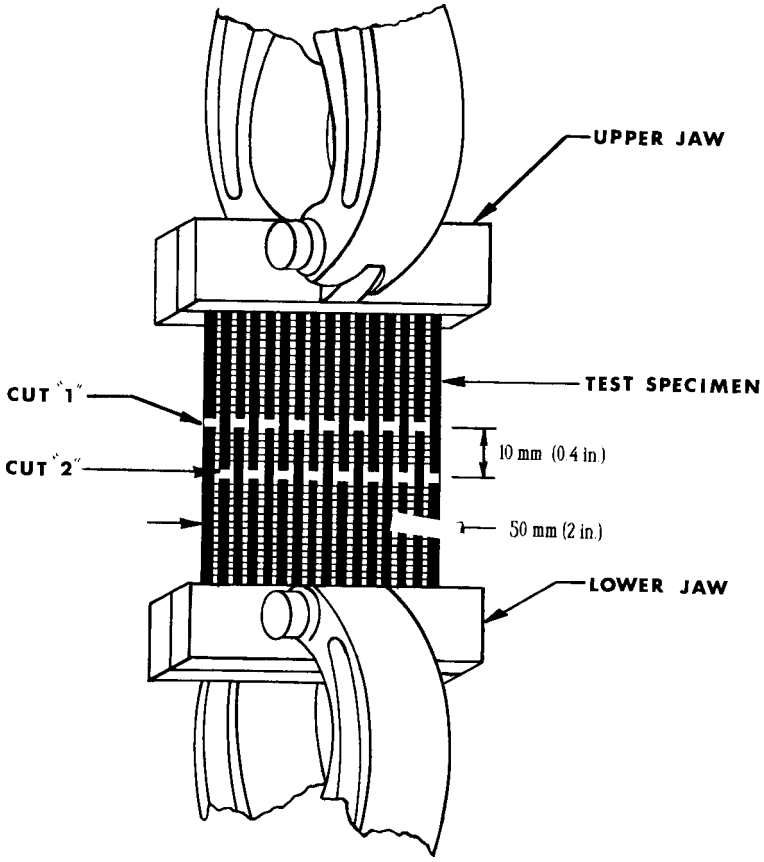

FIG. 1 Solar Screening, Nonmetallic, Cut Pattern of Specimen

19. Shading Coefficient

19.1 *Scope*:

19.1.1 Procedure C of ANSI/ASHRAE Standard 74-1988 covers the measurement of solar transmittance (terrestrial) of materials using a pyranometer, and enclosure, and the sun and sky as the source of radiation. It is applicable to transparent, translucent, textured, or patterned sheet materials and includes materials that are inhomogeneous, fiber reinforced, or corrugated.

19.2 *Summary*—A light sensor is used with a cubical box. The box is solidly enclosed on five of six sides, and each of the five sides is interlined on its inside face with a black colored, nonreflective surface. An open frame is used to mount the solar screening and form the sixth side of the box. The properties of solar transmittance and solar reflectance are measured and the solar absorptance is calculated.

19.3 *Significance and Use*:

19.3.1 This test method is considered satisfactory for acceptance testing of commercial shipments since current estimates of between-laboratory precision are acceptable and the test method is used extensively in the trade for acceptance testing.

19.3.1.1 In case of a dispute arising from differences in reported test results when using this test method 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 that are as homogeneous as possible and that are from a lot of material of the type in question. 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 the appropriate statistical analysis and an acceptable probability level chosen by the two parties before 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.

19.3.2 The properties of transmittance, reflectance, andabsorptance of fiber glass solar screening can be used to determine the reduction in solar heat gain through sun exposed windows, doors, and other structures, while providing outward view and interior light.

19.3.3 An acceptable, universal equation, for applicability of the properties of transmittance, reflectance, and absorptance in determining a shading coefficient, is not known. Eq 2 in 19.7.2 is one method of application.

19.3.3.1 The applicability of Eq 2 in determining shading coefficients for solar screens spaced at varying distances from outside glass surfaces is not known.

19.3.4 It is not practical in a method of this type to try to establish details of construction and procedures to cover all contingencies. This method is not intended to restrict, in any way, the future development by research work of new or improved methods or procedures.

19.3.4.1 Other methods may be used as agreed upon between the purchaser and the supplier.

19.4 *Test Specimens*:

19.4.1 Sample the finished screening to be tested as directed in 6.4.

19.4.2 Unless otherwise agreed upon, prepare one specimen for testing from each swatch of screening.

19.5 *Specimen Preparation*—Cut each test specimen with a minimum workable field 600 by 600 mm (24 by 24 in.). The exact specimen dimensions shall be determined by the dimensions of the testing box and the dimensions required for secure mounting of the specimen to the testing frame.

19.6 *Procedure*:

19.6.1 Mount the solar screening in the test frame with the screening ribs parallel to the sides, and perpendicular to the top and bottom, of the frame. The screening should be in a smooth flat plane with no noticeable distortion of the weave.

19.6.2 Install the mounted frame on the testing box with the screening ribs running in a vertical direction perpendicular to the bottom front edge of the test box.

19.6.3 Determine the solar transmittance, solar reflectance, and the solar absorptance as directed in ASHRAE Standard 74-1988.

19.6.3.1 Perform the testing with the plane of the screening perpendicular to the rays of the sun, that is, the angle of incidence shall be 0 rad (0°).

19.6.3.2 Test for the properties of solar transmittance and solar reflectance, by obtaining ten individual determinations for each property. Obtain both properties under similar as possible test conditions. A cloudless sunshine day normally provides test results that have fewer oscillations in the data.

19.7 *Calculation:*

19.7.1 Calculate the solar absorptance of the screening to the nearest 0.01 unit using Eq 1.

$$\text{Solar absorptance, } A_s = 1 - (T_s + R_s) \quad (1)$$

where:

T_s = solar transmittance of the screening, and
R_s = solar reflectance of the screening.

NOTE 12—The solar transmittance, the solar reflectance, and the solar absorptance can be expressed as a percent value by multiplying the decimal equivalents by 100.

19.7.2 Calculate the shading coefficient using Eq 2:[9]

$$\text{Shading coefficient} = 1.15[(T_s \times T_g) + (0.10 \times A_s) + 0.75(T_s \times A_g)] \quad (2)$$

where:

T_s = solar transmittance of the solar screening,
T_g = transmittance of the window glass,
A_s = solar absorptance of the solar screening,
A_g = absorptance of the window glass, and
1.15, 0.10, and 0.75 = empirical constants.[9]

19.7.2.1 The reference glazing material for the ASHRAE procedure for determination of shading coefficient is double-strength sheet glass with 0.86 transmittance and 0.06 absorptance at normal incidence.[10] It is recommended that these glass transmittance and absorptance factors be used in Eq 2.

19.7.2.2 Optional glazing material transmittance and absorptance factors as determined, or listed in manufacturer's literature, may be used by agreement between the purchaser and the supplier.

19.7.3 Calculate the average shading coefficient for the lot.

19.8 *Report*:

19.8.1 State that the samples were tested as directed in Section 19 of Specification D 4028.

19.8.2 Report the following information for each swatch of solar screening tested.

19.8.2.1 Description of material sampled and method of sampling,

19.8.2.2 Solar transmittance, solar reflectance, solar absorptance, and shading coefficient,

19.8.2.3 Transmittance and absorptance of the glazing material used in the calculations, and

19.8.2.4 Type of instrumentation used, and other specified variables as listed in ANSI/ASHRAE Standard 73-1988.

19.8.3 Report the average shading coefficient for the lot.

19.9 *Precision and Bias*:

19.9.1 *Precision*—The precision and bias of the procedure in Specification D 4028 are as specified in ANSI/ASHRAE Standard 74-1988.

20. Flame Resistance

20.1 Determine the flame resistance as directed in Method 5903 of Federal Test Method Standard 191A.

21. Blocking Resistance

21.1 Determine the resistance to blocking as directed in Method 5872 of Federal Test Method Standard 191A. Test one 200 by 200-m (8 by 8-in.) specimen from each laboratory sampling unit.

22. Color Stability to Accelerated Weathering

22.1 Determine the color stability to accelerated weathering as directed in Test Method D 4909 using one appropriate size specimen for a total exposure of 480 h and one appropriate size specimen for a total exposure of 960 h for each laboratory sampling unit.

22.1.1 Rate the specimens for color change after exposure in accordance with AATCC Evaluation Procedure 1.

CONFORMANCE AND INDEXING

23. Conformance

23.1 The purchaser and the supplier may agree on a procedure to establish conformance, including control charts furnished by the supplier, a sequential sampling plan, or the

[9] This equation was developed by John Yellott of John Yellot Engineering Associates, Inc. A copy of this information is on file at The Screen Manufacturers Association. This equation is used in SMA 4001-1978 Proposed American National Standard Specifications for Solar Screening for Windows: Vinyl-Coated Fiber Glass for Energy Conservation.

[10] This information is referenced in ASHRAE Handbook of Fundamentals which is available from ASHRAE (see footnote 7).

double-sampling plan outlined in 23.2.

23.2 In the absence of a control chart or sequential sampling plan, proceed as directed in 23.2.1-23.2.3.

23.2.1 If the test results for the lot conform to the requirements for all characteristics listed in Sections 5 and 6 and Tables 1 through 6, the lot shall be considered acceptable.

23.2.2 If the test results for one or more characteristics do not conform to the requirements, take a new laboratory sample from either the original lot sample or a new lot sample. Test the new sample for the characteristic(s) that did not conform to the requirements in the first test and average the results of the first and second samples as if they were one test of double the original number of specimens. If the average(s) conform(s) to the specified requirements, the lot shall be acceptable.

23.2.3 If the test results obtained as directed in 23.2.2 do not conform to the specified requirements, the lot shall be considered unacceptable.

24. Keywords

24.1 appearance; blocking resistance; breaking strength; colorfastness; fabric stability; flammability; ignition loss; length; mass per unit area; shading coefficient; width