Designation: D 4029 – 04

Standard Specification for Finished Woven Glass Fabrics[1]

This standard is issued under the fixed designation D 4029; 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 finished fabrics woven from "E" electrical glass fiber yarns that are intended as a reinforcing material in laminated plastics for structural use. This specification can also be applied to fabrics made of other glass types as agreed upon between the purchaser and the supplier.

1.2 This specification specifies the terminology, definitions, general requirements, and physical requirements for finished woven glass fabrics This specification permits the application of sizing materials to the glass fiber yarn during manufacture that helps facilitate weaving. These organic materials are typically removed from the greige gabric and replaced with a finish that is compatible with the resin matrix specified in the contracting document

NOTE 1—Sizing materials on glass fiber yarns, in most cases, are removed by various cleaning procedures as a first stage in preparing a finished fabric. When these yarn sizing materials are removed during a cleaning procedure they need not be compatible with the subsequent resin matrix.

1.3 This specification shows values in both SI units and in inch-pound units. "SI units" 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 the customary units used in the United States. The values in SI units are provided as information only; the values stated in inch-pound units are to be regarded as standard.

1.4 This specification is one of a series to provide a substitute for Military Specifications: MIL-Y-1140 Yarn, Cord, Sleeving, Cloth, and Tape-Glass; and MIL-C-9084 Cloth, Glass Finished for Resin Laminates.

1.5 Additional ASTM specifications in this series have been drafted and appear in current editions of the Annual Book of ASTM Standards. These include greige glass fabrics, glass tapes, glass sleevings, glass cords, glass sewing threads, and finished laminates made from finished glass fabrics.

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

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 123 Terminology Relating to Textiles
D 578 Specification for Glass Fiber Strands
D 579 Specification for Greige Woven Glass Fabrics
D 1059 Test Method for Yarn Number Based on Short-Length Specimens
D 1423 Test Method for Twist in Yarns by the Direct-Counting Method
D 1776 Practice for Conditioning Textiles for Testing
D 1777 Test Method for Thickness of Textile Materials
D 2150 Specification for Woven Glass Fabric for Polyester Glass Laminates
D 2408 Test Method for Finish Content of Woven Glass Fabric, Cleaned and After-Finished with Amino-Silane Type Finishes, for Plastic Laminates
D 2409 Test Method for Finish Content of Woven Glass Fabric, Cleaned and After-Finished with Vinyl-Silane Type Finishes, for Plastic Laminates
D 2410 Test Method for Finish Content of Woven Glass Fabric, Cleaned and After-Finished with Chrome Complexes, for Plastic Laminates
D 2660 Test Method for Finish Content of Woven Glass Fabric, Cleaned and After-Finished with Acrylic-Silane Type Finishes, for Plastic Laminates
D 3098 Test Method for Finish Content of Woven Glass Fabric, Cleaned and After-Finished with Epoxy—Functional Silane-Type Finishes for Plastic Laminates
D 3773 Test Methods for Length of Woven Fabric
D 3774 Test Methods for Width of Textile Fabric
D 3775 Test Method for Warp End Count and Filling Pick Count of Woven Fabric
D 3776 Test Methods for Mass per Unit Area (Weight) of Fabric
D 4963 Test Method for Ignition Loss of Glass Strands and Fabrics

[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] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D 5035 Test Method for Breaking force and Elongation of Textile Fabrics (Strip Method)

2.2 *ANSI Standard:*

ANSI/ASQC Z1.4 Sampling Procedures for Inspection by Attributes[3]

2.3 *Military Standard and Specifications:*

MIL-Y-1140H Yarn, Cord, Sleeving, Cloth and Tape-Glass[4]

MIL-C-9084C Cloth, Glass Finished for Resin Laminates[4]

2.4 *Textile Institute Documents:*

Textile Terms and Definitions[5]

Woven Cloth Construction[5]

2.5 *Institute for Interconnecting and Packaging Circuits Standard:*

IPC 4412 Specification for Finished Fabric Woven from E Glass for Printed Boards[6]

3. Terminology

3.1 *Definitions:*

3.1.1 *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) .

3.1.1.1 *Discussion*—Glass textiles are used in various products such as reinforced plastics, mat-like materials, 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 Practice D 1776. 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.

3.1.2 *continuous filament yarn*, *n*—a yarn made of filaments that extend substantially throughout the length of the yarn.

3.1.3 *crowfoot weave*, *n*—a broken-twill weave one-up and three-down or three-up and one-down with two ends to the right and two ends to the left, commonly referred to as 4-harness satin or broken crow.

3.1.3.1 *Discussion*—See Figure A1.1 in Annex for the basic weave diagram.

3.1.4 *eight-harness satin*, *n*—a warp-faced or filling-faced weave illustrating the entire face of the fabric surface that is covered with warp or filling yarn, respectively.

3.1.4.1 *Discussion*—There are no distinguishable diagonal lines. In warp-faced fabrics warp yarns show on the face of the fabric seven out of eight adjacent yarns, and in filling-faced fabrics filling yarns show on the face of the fabric seven out of eight adjacent yarns. See Figure A1.5 in Annex for the basic weave diagram.

3.1.5 *finished*, *adj—for glass laminates*, a descriptive term for woven fabrics that have passed through a treating procedure which is compatible with a resin matrix or facilitates manufacturing, or both.

3.1.6 *leno weave*, *n*—a weave in which two adjacent warp yarns cross each other between the picks.

3.1.6.1 *Discussion*—See Figure A1.3 in Annex for the basic weave diagram.

3.1.7 *mock leno weave*, *n*—a weave in which the warp yarns remain parallel but form open warp stripes by programmed interlacing of warp and filling yarns simulating a leno appearance.

3.1.7.1 *Discussion*—See Figure A1.4 in Annex for the basic weave diagram.

3.1.8 *twelve-harness satin*, *n*—a weave similar to eight-harness satin except in warp-faced fabrics warp yarns show on the face of the fabric eleven out of twelve adjacent yarns and in filling-faced fabrics filling yarns show on the face of the fabric eleven out of twelve adjacent yarns.

3.1.8.1 *Discussion*—See Figure A1.6 in Annex for the basic weave diagram.

3.2 For definitions of other textile terms used in this specification, refer to Terminology D 123.

NOTE 2—The terminology section will be reballoted to reflect the adopted ASTM format for compiling D13.18 terminology in one document upon the approval to the Standard Terminology Relating to Glass Fibers and Its Products (Terminology D 7018).

CLASSIFICATION

4. Classification

4.1 The designation of a fabric shall be by style numbers that are standard throughout the industry. Generally used style numbers are listed in numerical order in Table 1.

REQUIREMENTS

5. Material

5.1 The yarn shall be continuous filament, unless otherwise specified, free of any free alkali metal salts, such as soda or potash, and foreign particles, dirt, and other impurities.

6. Fabric Count

6.1 For fabrics listed in Table 1, the nominal fabric count shall conform to the requirements of Table 1. For fabrics not listed in Table 1, the nominal fabric count shall be agreed upon between the purchaser and the supplier. The average count of warp ends shall be within two ends of the nominal count and the average count of the filling picks shall be within two picks of the nominal count.

7. Yarn Designations

7.1 For fabrics listed in Table 1, the yarn designations shall conform to the requirements of Table 1. For fabrics not listed in Table 1, the yarn designations may be agreed upon between the purchaser and the supplier. The requirements of the individual elements of the designation are specified in Sections 8-12.

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

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

[5] Available from the Textile Institute, 10 Blackfriars St., Manchester, M3 5DR England.

[6] Available from the Institute for Interconnecting and Packaging Electronic Circuits, 7380 N. Lincoln Ave., Lincolnwood, IL 60646.

7.1.1 In some cases ECE 225 yarn is specified in Table 1. ECD 225 may be substituted with no significant decrease in property performance.

8. Yarn Number

8.1 For fabrics listed in Table 1, the nominal size-free yarn numbers of the yarns designated shall conform to Specification D 578. For fabrics not listed in Table 1, the nominal size-free yarn number may be agreed upon between the purchaser and the supplier.

9. Filament Diameter

9.1 The nominal filament diameter for the yarns in the fabric shall conform to the nominal range for filament diameter average values specified in Table 1 of Specification D 578.

10. Strand Construction

10.1 The basis for specifying strand construction is given in Specification D 578. For fabrics listed in Table 1 of this specification, the construction of the component strands shall conform to the requirements of Table1 in Specification D 578. For fabrics not listed in Table 1, the construction of the component strands may be agreed upon between the purchaser and the supplier.

11. Direction of Twist

11.1 The primary twist in the singles strands shall be "Z" twist and the final twist in the plied yarns shall be "S" twist unless otherwise agreed upon between the purchaser and the supplier.

12. Twist Level

12.1 The nominal twist in the component strands and the finished yarns shall conform to the requirements of Table 1 in Specification D 578 unless otherwise agreed upon between the purchaser and the supplier. The tolerances for the primary twist and the final twist shall conform to Table 2 of this specification.

13. Fabric Weave Type

13.1 For fabrics listed in Table 1, the fabric weave type shall conform to the requirements of Table 1. For fabrics not listed in Table 1, the fabric weave type shall be agreed upon between the purchaser and the supplier.

14. Mass Per Unit Area

14.1 For fabrics listed in Table 1, the nominal mass per unit area shall conform to the requirement of Table 1. For fabrics not listed in Table 1, the nominal mass per unit area shall be agreed upon between the purchaser and the supplier. The average mass per unit area for the lot shall conform to the requirements of Table 3.

15. Thickness

15.1 For fabrics listed in Table 1, the nominal thickness shall conform to the requirements of Table 1. For fabrics not listed in Table 1, the nominal thickness shall be agreed upon between the purchaser and the supplier. The average thickness of the fabric in the lot shall conform to the requirements of Table 4, unless otherwise specified.

16. Breaking Strength

16.1 For fabrics listed in Table 1, the minimum breaking strength shall conform to the requirements of Table 1. For fabrics and/or minimum breaking strengths not listed in Table 1, the minimum breaking strength shall be agreed upon between the purchaser and the supplier. The average breaking strength for the lot shall exceed the specified breaking strength, and no individual break shall be less than 80 % of the specified minimum breaking strength.

17. Width

17.1 Fabric width shall be agreed upon between the purchaser and the supplier. The fabric width, including both selvages but excluding any feathered edges, shall be no narrower than the specified width and no more than 13 mm (0.5 in) wider than the specified width.

NOTE 3—During the processing of glass fabrics the selvages may be slit to minimize tension influences. This slit distance is generally excluded when measuring the fabric width.

18. Length

18.1 The fabric roll length, length between splices, and number of splices per roll shall be agreed upon between purchaser and supplier. All splices must be thermoset unless otherwise agreed upon between the purchaser and the supplier.

19. Ignition Loss

19.1 The ignition loss of finished fabric shall be no less than 0.05 % and no more than 0.30 % unless otherwise agreed upon between the purchaser and the supplier.

NOTE 4—In certain cases the limits of the ignition loss may exceed that described in 19.1. When this limit is known, it must be specified in the contractual document.

19.2 The type of, nominal level of, and tolerances for fabric finish shall be agreed upon between the purchaser and the supplier. The fabric finish should be compatible with, and produce the required performance characteristics for the resin system specified in the applicable laminate specification or other procurement document. If the purchaser and the supplier agree that laminate testing (wet and dry) is to be used to determine acceptability of the finish content, this fact and the test method to be used shall be specified in the contracting document.

20. Fabric Appearance

20.1 The woven finished fabric shall be generally uniform in quality and condition, clean, smooth, and free of foreign particles and defects detrimental to fabrication, appearance, or performance. Current industry practice for fabrics utilized in electronic applications is described in Specification IPC-4412 in Section 4.4.1 Fabric Appearance.

20.2 The fabric in the laboratory sample for the fabric appearance shall be examined for the defects listed in Table 5 and the acceptable quality levels (AQLs) shall be 2.5 major and 6.5 total (major and minor combined) defects per hundred units of fabric unless otherwise agreed upon between the purchaser and the supplier.

20.3 When specified, the warp direction of the fabric may be marked by blue direction-indicator yarns running warpwise in the cloth and spaced approximately 150 mm (6 in.) apart.

20.4 Preservation and packaging for fabrics utilized in electronics application are described in Specification IPC-4412 in Section 5.1.

21. Put-Up

21.1 Fabric shall be furnished in rolls and shall be wound on spiral tubes. The tube dimensions shall be as agreed upon between purchaser and supplier. The maximum number of pieces contained in any roll may be as specified in 18.1.

22. Packaging

22.1 Each roll of fabric, put up as specified, shall be packaged to afford adequate protection against physical damage during shipment from the supply source to the receiving activity. The supplier may use his standard practice when it meets this requirement.

22.2 Unless otherwise agreed upon, as when specified in an applicable contract or purchase order, each roll shall be wrapped in polyethylene not less than 0.05 mm (0.002 in.) thick in such a manner as to ensure that the fabric, during shipment and storage, will be protected against damage from exposure to moisture, weather, or any other normal hazard.

23. Marking

23.1 Each package shall be marked to show the information listed below unless specified otherwise by the purchaser and the supplier. Characters shall be of such size as to be clearly legible and shall not be obliterated by normal handling to:

100 % Fiber Glass Cloth
Style
Length
Width
Purchase Order Number
Manufacturer's Identification
Finish Designation

23.1.1 All fabrics will be considered Type "E" electrical, unless specified otherwise. If glass type is other than electrical "E", each package shall be marked accordingly.

SAMPLING AND CONDITIONING

24. Sampling

24.1 *Lot Size*—A lot shall consist of each 9000 m (10 000 yd) of a single fabric style unless otherwise agreed upon between the purchaser and the supplier.

24.1.1 When small multiple shipments are made from an inspected lot, the shipments may be made without additional inspection as agreed upon between the purchaser and the supplier.

24.2 *Lot Sample*—Take at random as a lot sample the number of rolls of fabric specified in ANSI/ASQC Z1.4 and a single sampling plan unless otherwise agreed upon between the purchaser and the supplier.

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

24.3.1 For fabric appearance, fabric width, mass per unit area, and fabric length, the rolls in the lot sample serve as the laboratory sample.

24.3.2 For other properties, take at random from the rolls in the lot sample the number of rolls specified in Table 6. From each roll in the laboratory sample, take a 1-m (1-yd) full-width swatch from the end of the roll after first discarding a minimum of 1 m or 1 yd of fabric from the very outside of the roll. Remove only the outer layer of fabric if the circumference of the roll is less than 1 m (1 yd).

24.4 *Test Specimens*—For fabric appearance, fabric width 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 specification.

25. Conditioning

25.1 Condition the laboratory samples without preconditioning for a period of at least 5 h in the atmosphere for testing glass textiles as directed in Practice D 1776, unless otherwise specified.

TEST METHODS

26. Material

26.1 Accept the supplier's certification that the material is of the correct grade as specified in Specification D 578. Unless otherwise specified, during testing fro strand construction as directed in Section 30, verify that the yarn is continuous filament. Determine the freedom from objectionable impurities during the inspection for fabric appearances as directed in Section 40.

27. Fabric Count

27.1 Determine the fabric count as directed in Test Method D 3775, making one count in each direction on each of the swatches in the laboratory sample.

28. Yarn Number

28.1 Determine the yarn number in tex (yds/lb.) for both the warp and filling yarns as directed in Test Method D 1059.

29. Filament Diameter

29.1 Determine the filament diameter for both the warp and filling yarns as directed in Specification D 578 by using 50 individual filaments from one yarn test specimen from both the warp and filling yarns in each of the swatches in the laboratory sample.

30. Strand Construction

30.1 Verify the number of singles strands and the number of plied or cabled strands on one test specimen of warp yarn and one specimen of filling yarn while determining the twist direction or twist level. See Section 26.

31. Direction of Twist

31.1 Verify the direction of twist as directed in Test Method D 1423 in each of five test specimens of warp and filling yarns taken from each of the swatches in the laboratory.

32. Twist Level

32.1 Determine the twist level in each of the component strands as directed in Test Method D 1423 upon five test

specimens of warp yarn and five test specimens of filling yarn from each of the swatches in the laboratory sample.

33. Fabric Weave Type

33.1 *Scope*—This method covers the recognition of the six fabric weave types referred in Table 1. The weaves included are: crowfoot, leno, mock leno, plain, eight-harness satin, and twelve-harness satin. A similar technique is also cited in Specification IPC-4412.

33.2 *Significance and Use*:

33.2.1 The fabric weave type is important. It can affect the performance of the final product depending on its end use in terms of strength, durability and aesthetics. This method specifies a procedure for recognizing specified weaves.

33.2.2 This procedure for recognizing fabric weave type is considered satisfactory for acceptance testing of commercial shipments.

33.3 *Apparatus*:

33.3.1 *Rectangular Coordinate Graph Paper*.

33.3.2 *Linen or Magnifying Glass*.

33.3.3 *Marking Pen or Pencil*.

33.4 *Procedure*:

33.4.1 Place a swatch of the sample on a flat surface, face side up (see Section 3 – Terminology; definitions for eeight and twelve harness satins). Position the swatch with the warp direction extending forward and away from the observer.

33.4.2 Select a starting point on the surface of the fabric where a warp end is raised over a filling pick (raiser yarn).

33.4.3 Denote a filling end raised over a warp end (sinker yarn) on the face of the fabric by an unmarked block.

33.4.4 Plot the weave construction by first marking a block on the graph paper designating the starting raiser yarn.

33.4.5 Continue plotting from left to right, from the first raiser yarn, showing raiser yarns as marked blocks and sinker yarns as unmarked blocks until a minimum two repeats of the pattern are observed. In a like manner, plot up from the first raiser yarn until a minimum of two repeats of the pattern are observed corresponding to each designated block in the left-to-right pattern.

33.4.6 Compare the design plot to Figs. A1.1-.

33.4.6.1 Leno and mock leno have a distinct visual appearance and may be identified without plotting.

33.5 *Report*:

33.5.1 State that the fabric weave type of the rolls of fabric was determined as directed in Specification D 4029. Describe the material or product sampled and the method of sampling used.

33.5.2 Report the fabric weave type for each roll including the raiser/sinker pattern in terms of the warp ends up and down.

33.6 *Precision and Bias*—No justifiable statement can be made either on the precision or on the bias of this procedure, since the procedure merely determines whether the weave in the test specimen conforms to that specified.

34. Mass Per Unit Area

34.1 Determine the mass per unit area of the fabric as directed in Test Method D 3776, Option A, using each of the rolls in the laboratory sample.

35. Thickness

35.1 Determine the thickness of the fabric as directed in Test Method D 1777, using ten test specimens from each swatch in the laboratory sample.

35.2 For glass fabrics and tapes made with continuous filament yarns, use Table 1, Option 3 of Test Method D 1777. For fabrics made with textured or open-end yarns, use Table 1, Option 1 of Test Method D 1777.

36. Breaking Strength

36.1 Determine the breaking strength in newtons per 25 mm (or pounds-force per inch) of fabric in both the warp and filling directions as directed in Test Method D 5035, unless otherwise specified between purchaser and supplier:

There may be no overall correlation between the results obtained with the CRE machine and the CRT machine. Consequently, these two testers cannot be used interchangeably. In case of controversy the CRE tensile tester shall prevail.

36.1.1 The use of hydraulic pneumatic clamping systems with 50 by 75-mm (2 by 3-in.) serrated jaw faces is recommended for testing samples prepared as directed in 36.4 and 36.5. The 50-mm (2-in.) dimension of the jaw face shall be in the direction of test. Manual clamping is permitted.

NOTE 5—When using jaw faces other than serrated, minimize crushing and cutting of the glass yarns in the test specimens by lining the inside surface of the jaws with cardboard 0.25 to 0.40 mm (0.010 to 0.015 in.) in thickness or moleskin. Secure the end of the jaws with pressure sensitive tape.

36.2 Prepare specimens as directed in 36.3, 36.4, or 36.5, as applicable.

36.3 *Procedure 1*—Procedure 1 is for fabrics having breaking strengths of 445 N/25 mm (100 lbf/in) or less.

NOTE 6—Fabrics having breaking strength less than 445 N/25 mm (100 lbf/in.) can be prepared as outlined in 36.4 with no effect on the obtained value. Preparation Procedure 1 is provided to allow for a lower test specimen preparation cost when extensive preparation is not required.

36.3.1 *Reagents and Materials*:

36.3.1.1 *Butyl Methacrylate Solution* is prepared by mixing 45 parts by mass of butyl methacrylate with 55 parts by weight of toluene or xylene and adding a small amount of oil-soluble dye. The viscosity of this solution should be about 3000 mPa·g (cP) approximately that of honey at room temperature. It may be necessary to change the consistency for some types of fabrics to permit complete penetration of all interstices and to prevent capillary migration of the solution along the yarns into the test area.

NOTE 7—Substitute solutions can be used providing specimen damage does not occur or that specimens break or slip at the jaw faces.

36.3.1.2 **Precaution**—Butyl Methacrylate solution ingredients are flammable. Keep away from heat, sparks and open flame. Keep containers closed. Use only with adequate ventilation. Avoid prolonged breathing of vapor or spray mist. Avoid prolonged or repeated contact with skin. Spillage and fire instructions will depend on nature of solution.

36.3.1.3 *Multipurpose Paper*, 20 lb. bond or greater (as needed to prevent slippage in the grips)..

36.3.1.4 *Paint Brush*, to 16 to 25 mm (.625 to 1.0 in.), bristles 25 mm (1 in.) long.

36.3.2 Cut two swatches of fabric from the laboratory sample each 200 by 250 mm (8 by 10 in.), one with the warp yarns and the other with filling yarns parallel to the 200-mm (8-in.) direction.

36.3.3 Lay each sample cut as directed in 36.3.2 on a piece of wrapping paper of similar size. Lay out five test specimens 38 by 150 mm (1.5 by 6 in.) on the fabric by drawing light lines with a soft wax pencil so that the yarns to be tested, warp or filling, are parallel to the longer direction. Draw lines across the specimens 40 mm (1⅝ in.) from each end, using very light pressure on the wax pencil to avoid possible damage to the surface filaments. Thoroughly impregnate the 40 mm (.625 in.) specimen end strips with butyl methacrylate solution (or substitute) which must soak through the fabric in order to secure firm adhesion to the paper. Spread the solution in an even film to secure a uniform pressure from the testing machine jaws against the test specimen. Dry the impregnated sample slowly, 24 h without forcing, until the solvent is completely removed. Be sure to have the impregnant cover the cross lines to reinforce those sections where some of the surface fibers may have been fractured when those lines were drawn. On thick fabrics, paint both sides of the specimens by applying a coat of the impregnant to the back of the fabric or to the top surface of the backing paper.

36.3.4 Cut the 150 by 38-mm (6 by 1.5-in.) test specimen strips from the prepared sample without removing the paper backing. Ravel the central unimpregnated portion of the specimen to 25 mm (1 in.) in width as directed in Test Method D 5035. After raveling, load samples in the test clamps, cut the 38-mm (1.5-in.) wide paper backing across midway between the ends, taking care not to damage the fabric specimen.

NOTE 8—Raveling of the specimen can be facilitated by slitting each test specimen at its center, perpendicular to the yarn components severing all yarns except those in the central 25 mm (1 in).

36.4 *Procedure 2*—Procedure 2 is for fabrics having breaking strengths greater than 445 N/25 mm (100 lbf/in.)or tending to consistently break in, or slip from, the jaws when using Procedure 1 stated in 36.3.

36.4.1 Prepare test specimens as directed in 36.3 except as described in 36.4.2-36.4.10.

36.4.2 Substitute Sub 65 grade white cardboard in place of the wrapping paper.

36.4.3 Draw two legible lines 75 ± 1 mm (3.0 ± 0.05 in.) from each other and parallel across the center section of the cardboard.

36.4.4 Uniformly apply a resin solution on the cardboard along the drawn lines and outwards for a distance of 50 ± 1 mm (2.0 ± 0.05 in.). Do not include the center 75 ± 1 mm (3.0 ± 0.05 in.) between the drawn lines.

NOTE 9—A mixture by weight of 60 parts CIBA Giegy 6004 Epoxy resin and 40 parts General Mills Versimid 125 polyamide resin has been found suitable for this purpose.

36.4.5 Lay the cut swatches of fabrics each 200 by 250 mm (8 by 10 in.), one with the warp yarns and the other with the filling yarns parallel to the 200-mm (8-in.) direction, centrally and equally spaced on the resin prepared cardboard. The shorter direction of the sample is perpendicular to the drawn lines.

36.4.6 Uniformly reapply the resin mixture on the specimen directly above the first application.

36.4.7 Place a 50 ± 1-mm (2.0 ± 0.05-in.) by 250-mm (10-in.) strip of cardboard over the resin impregnated area of the specimen. Allow to dry a minimum of 16 h.

NOTE 10—When substitute solutions are used, drying time may vary.

36.4.8 Cut five specimens, 150 by 38 mm (8.0 by 1.5 in) in each of the warp and filling directions, and label accordingly having the longer direction in the direction of test.

36.4.9 Ravel a sufficient number of yarns from each side of the specimen so that the central portion is a 25-mm (1.0-in.) width plus two yarns.

36.4.10 After the specimen is loaded in the test clamps, cut and ravel one yarn from each side of the test specimen and cut the cardboard backing across, midway between the ends, taking care not to damage the fabric specimen.

36.4.11 In the case of hydraulic pneumatic clamps, apply a pressure of 6750 to 7650 N (1500 to 1700 lbf) to the clamp faces. In the case of manual clamping, tighten sufficiently to prevent slippage of the test specimen.

36.5 *Procedure 3*—Procedure 3 is for fabrics having breaking strengths greater than 2224 N/25 mm (500 lbf/in.) or show that cascading breaks across the specimen when using Procedure 2 stated in 36.4, or both.

NOTE 11—Glass yarns have a tendency to move within some fabrics when cut and handled in the greige state. This procedure is designed to ensure straightness of individual yarn components throughout the test.

36.5.1 Cut five specimens, 300 by 50 mm (12 by 2 in.) from the laboratory sample in each of the warp and filling directions, and label accordingly having the longer direction in the direction of test.

36.5.2 Draw two legible lines 75 ± 1 mm (3.0 ± 0.05 in.) from each other and parallel to the long directions and across the center section of a 200 by 280-mm (8 by 11-in.) piece of Sub 65 white cardboard. Prepare one for each the warp and filling directions.

36.5.3 Place the cardboard sections at the outer edge of a workbench that is covered with a 0.75-in. (19-mm) thick piece of plywood. The 11-in. (280-mm) length is parallel to the bench edge.

36.5.4 Lay the cut specimens on the lined cardboard so that one end is 25 mm (1 in) above the cardboard and the other end is hanging over the bench edge. Secure the top edge of the specimen to the plywood base by nailing through a 25 by 50-mm (1 by 2-in.) 19-mm (0.75-in.) plywood block placed above the specimen to the base. The 2-in. (50-mm) dimension is placed parallel to the specimen width. Four or five 32-mm (1.25-in.) nails equally spaced have been found acceptable for this purpose.

NOTE 12—A permanent fixture can be designed to replace the wooden blocks to facilitate testing.

36.5.5 Place two similar wooden blocks, one on each side of the other end of the specimen so that the fabric is sandwiched between the blocks. Nail the blocks and fabric together.