Designation: D 6856 – 03

Standard Guide for Testing Fabric-Reinforced "Textile" Composite Materials[1]

This standard is issued under the fixed designation D 6856; 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.

INTRODUCTION

A variety of fabric-reinforced composite materials have been developed for use in aerospace, automotive, and other applications. These composite materials are reinforced with continuous fiber yarns that are formed into two-dimensional or three-dimensional fabrics. Various fabric constructions, such as woven, braided, stitched, and so forth, can be used to form the fabric reinforcement. Due to the nature of the reinforcement, these materials are often referred to as "textile" composites.

Textile composites can be fabricated from 2-dimensional (2-D) or 3-dimensional (3-D) fabrics. Stitched preforms and 3-D fabrics contain through-thickness yarns, which can lead to greater delamination resistance. Textile composites are also amenable to automated fabrication. However, the microstructure (or fiber architecture) of a textile composite, which consists of interlacing yarns, can lead to increased inhomogeneity of the local displacement fields in the laminate. Depending upon the size of the yarns and the pattern of the weave or braid, the inhomogeneity within a textile composite can be large compared to traditional tape laminates.

Thus, special care should be exercised in the use of the current ASTM standards developed for high performance composites. In many cases, the current ASTM standards are quite adequate if proper attention is given to the special testing considerations for textile composites covered in this guide. However, in some cases, current standards do not meet the needs for testing of the required properties. This guide is intended to increase the user's awareness of the special considerations necessary for the testing of these materials. It also provides the user with recommended ASTM standards that are applicable for evaluating textile composites. The specific properties for which current ASTM standards might not apply are also highlighted in this guide.

1. Scope

1.1 This guide is applicable to the testing of textile composites fabricated using fabric preforms, such as weaves, braids, stitched preforms, and so forth, as the reinforcement. The purpose of this guide is to:

1.1.1 Ensure that proper consideration is given to the unique characteristics of these materials in testing.

1.1.2 Assist the user in selecting the best currently available ASTM test method for the measurement of commonly evaluated material properties for this class of materials.

1.2 Areas where current ASTM test methods do not meet the needs for testing of textile composites are indicated.

1.3 It is not the intent of this guide to cover all test methods which could possibly be used for textile composites. Only the most commonly used and most applicable standards are included.

1.4 The values stated in SI units are to be regarded as the standard. The values in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[2]

D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement[2]

D 883 Terminology Relating to Plastics[2]

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[1] This guide is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.04 on Lamina and Laminate Test Methods.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

D 2344/D 2344M Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates[3]
D 3039/D 3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials[3]
D 3171 Test Method for Constituent Content of Composite Materials[3]
D 3410/D 3410M Test Method for Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading[3]
D 3479/D 3479M Test Method for Tension-Tension Fatigue of Polymer Matrix Composite Materials[3]
D 3518/D 3518M Test Method for In-Plane Shear Response of Polymer Matrix Composite Materials by Tensile Test of a ±45° Laminate[3]
D 3846 Test Method for In-Plane Shear Strength of Reinforced Plastics[4]
D 3878 Terminology for Composite Materials[3]
D 4255/D 4255M Test Method for In-Plane Shear Properties of Polymer Matrix Composite Materials by the Rail Shear Method[3]
D 5229/D 5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials[3]
D 5379/D 5379M Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method[3]
D 5528 Test Method for Mode I Interlaminar Fracture Toughness of Unidirectional Fiber-Reinforced Polymer Matrix Composites[3]
D 5766/D 5766M Test Method for Open Hole Tensile Strength of Polymer Matrix Composite Laminates[3]
D 5961/D 5961M Test Method for Bearing Response of Polymer Matrix Composite Laminates[3]
D 6115 Test Method for Mode I Fatigue Delamination Growth Onset of Unidirectional Fiber-Reinforced Polymer Matrix Composites[3]
D 6415 Test Method for Measuring the Curved Beam Strength of a Fiber-Reinforced Polymer-Matrix Composite[3]
D 6272 Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials by Four-Point Bending[5]
D 6484/D 6484M Test Method for Open-Hole Compressive Strength of Polymer Matrix Composite Laminates[3]
D 6641/D 6641M Test Method for Determining the Compressive Properties of Polymer Matrix Composite Laminates Using a Combined Loading Compression (CLC) Test Fixture[3]
D 6671 Test Method for Mixed Mode I-Mode II Interlaminar Fracture Toughness of Unidirectional Fiber Reinforced Polymer Matrix Composites[3]
E 6 Terminology Relating to Methods of Mechanical Testing[6]
E 122 Practice for Calculating Sample Size to Estimate, With a Specified Tolerable Error, the Average for Characteristic of a Lot or Process[7]
E 251 Test Methods for Performance Characteristics of Metallic Bonded Resistance Strain Gages[6]
E 456 Terminology Relating to Quality and Statistics[7]
E 1237 Guide for Installing Bonded Resistance Strain Gages[6]

3. Terminology

3.1 *Definitions*—Definitions used in this guide are defined by various ASTM methods. Terminology D 3878 defines terms relating to high-modulus fibers and their composites. Terminology D 883 defines terms relating to plastics. Terminology E 6 defines terms relating to mechanical testing. Terminology E 456 defines terms relating to statistics. In the event of a conflict between definitions of terms, Terminology D 3878 shall have precedence over the other standards. Terms relating specifically to textile composites are defined by Ref **(1)**.[8]

3.2 *textile unit cell*—In theory, textile composites have a repeating geometrical pattern based on manufacturing parameters. This repeating pattern is often referred to as the materials "unit cell." It is defined as the smallest section of architecture required to repeat the textile pattern (see Figs. 1-4). Handling and processing can distort the "theoretical" unit cell. Parameters such as yarn size, yarn spacing, fabric construction, and fiber angle may be used to calculate theoretical unit cell dimensions. However, several different "unit cells" may be defined for a given textile architecture. For example, Fig. 2 shows two different unit cells for the braided architectures. Thus, unit cell definition can be somewhat subjective based on varying interpretations of the textile architecture. The user is referred to Refs **(1, 2)** for further guidance. In this guide, to be consistent, the term "unit cell" is used to refer to the smallest unit cell for a given textile architecture. This smallest unit cell is defined as the smallest section of the textile architecture required to replicate the textile pattern by using only in-plane translations (and no rotations) of the unit cell. Examples of the smallest unit cells for some of the commonly used textile composites are shown in Figs. 1-4. For the 3-D weaves in Figs. 3 and 4, the smallest unit cell length (as indicated) is defined by the undulating pattern of the warp yarns. The smallest unit cell width is the distance between two adjacent warp stuffer yarn columns (in the fill yarn direction) and the smallest unit cell height is the consolidated woven composite thickness.

4. Significance and Use

4.1 This guide is intended to serve as a reference for the testing of textile composite materials.

4.2 The use of this guide ensures that proper consideration is given to the unique characteristics of these materials in testing. In addition, this guide also assists the user in selecting the best currently available ASTM test method for measurement of commonly evaluated material properties.

[3] *Annual Book of ASTM Standards*, Vol 15.03.
[4] *Annual Book of ASTM Standards*, Vol 08.02.
[5] *Annual Book of ASTM Standards*, Vol 08.03.
[6] *Annual Book of ASTM Standards*, Vol 03.01.
[7] *Annual Book of ASTM Standards*, Vol 14.02.
[8] The boldface numbers in parentheses refer to the list of references at the end of this standard.

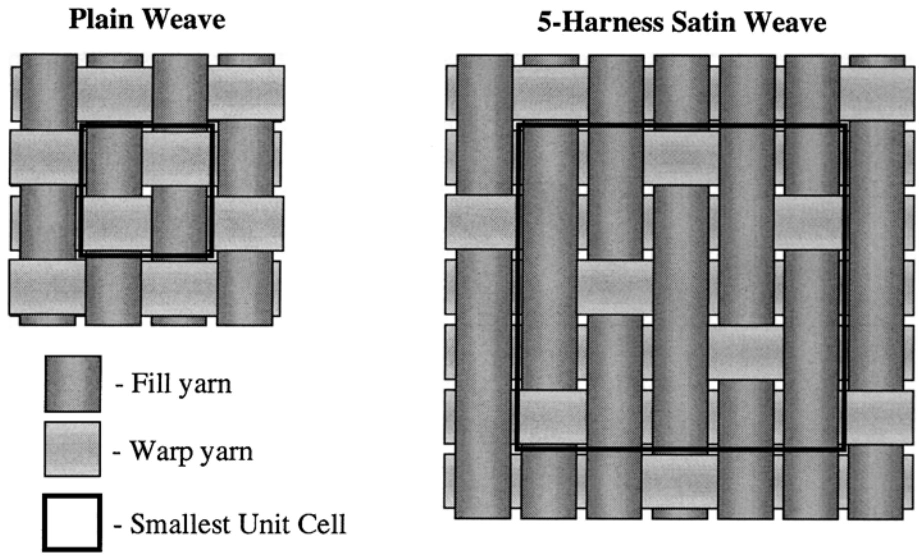

FIG. 1 Smallest Unit Cells for Plain Weave and 5-Harness Satin Weave Architectures

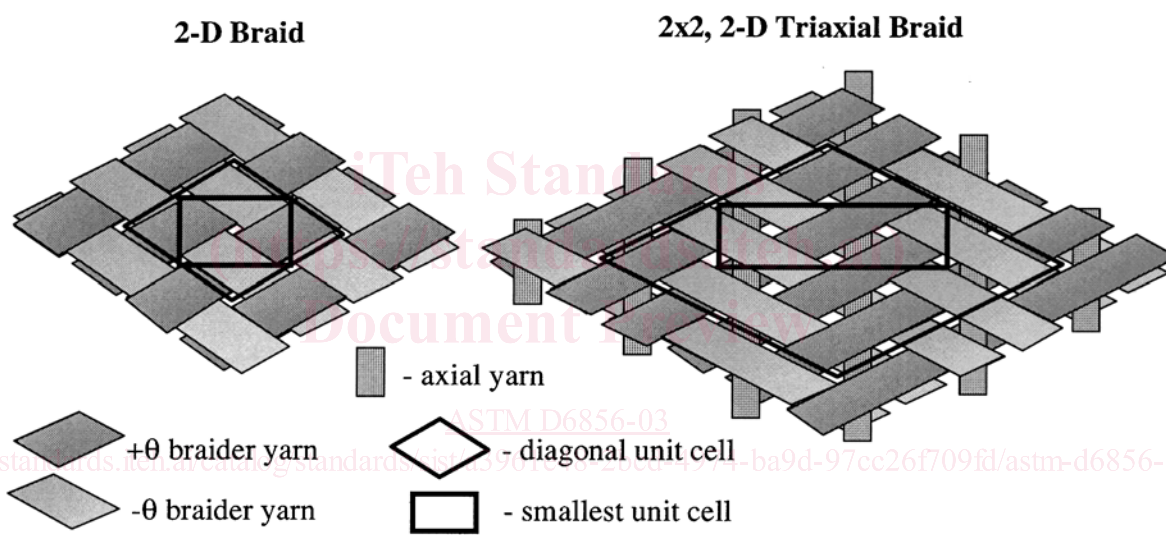

FIG. 2 Smallest Unit Cells for a 2-D Braid and a 2×2, 2-D Triaxial Braid

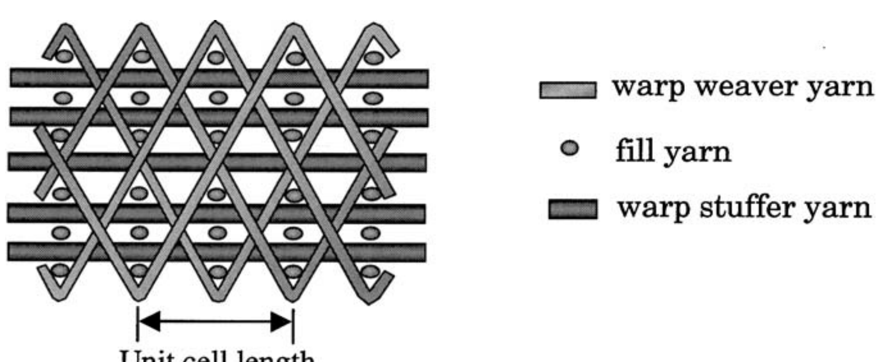

FIG. 3 Smallest Unit Cell Length for Through-Thickness Angle-Interlock Weave

5. Summary of Guide

5.1 Special testing considerations unique to textile composites are identified and discussed. Recommendations for handling these considerations are provided. Special considerations covered are included in Section 7 on Material Definition; Section 8 on Gage Selection; Section 9 on Sampling and Test