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Standard Guide for Testing Fabric-Reinforced “Textile” Composite Materials¹

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INTRODUCTION

A variety of fabric-reinforced composite materials have been developed for use in aerospace, automotive, civil, construction, 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 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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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 either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be

used independently of the other, and values from the two systems shall not be combined.

1.4.1 Within the text the inch-pound units are shown in brackets.

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, health, and environmental practices and determine the applicability of regulatory requirements prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

- D792** Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
- D883** Terminology Relating to Plastics
- D2344/D2344M** Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates
- D3039/D3039M** Test Method for Tensile Properties of Polymer Matrix Composite Materials
- D3171** Test Methods for Constituent Content of Composite Materials
- D3410/D3410M** Test Method for Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading
- D3479/D3479M** Test Method for Tension-Tension Fatigue of Polymer Matrix Composite Materials
- D3518/D3518M** Test Method for In-Plane Shear Response of Polymer Matrix Composite Materials by Tensile Test of a $\pm 45^\circ$ Laminate
- D3846** Test Method for In-Plane Shear Strength of Reinforced Plastics
- D3878** Terminology for Composite Materials
- D4255/D4255M** Test Method for In-Plane Shear Properties of Polymer Matrix Composite Materials by the Rail Shear Method
- D5229/D5229M** Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
- D5379/D5379M** Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method
- D5528** Test Method for Mode I Interlaminar Fracture Toughness of Unidirectional Fiber-Reinforced Polymer Matrix Composites
- D5687/D5687M** Guide for Preparation of Flat Composite Panels with Processing Guidelines for Specimen Preparation
- D5766/D5766M** Test Method for Open-Hole Tensile

- Strength of Polymer Matrix Composite Laminates
 - D5961/D5961M** Test Method for Bearing Response of Polymer Matrix Composite Laminates
 - D6115** Test Method for Mode I Fatigue Delamination Growth Onset of Unidirectional Fiber-Reinforced Polymer Matrix Composites
 - D6415/D6415M** Test Method for Measuring the Curved Beam Strength of a Fiber-Reinforced Polymer-Matrix Composite
 - D6484/D6484M** Test Method for Open-Hole Compressive Strength of Polymer Matrix Composite Laminates
 - D6641/D6641M** Test Method for Compressive Properties of Polymer Matrix Composite Materials Using a Combined Loading Compression (CLC) Test Fixture
 - D6671/D6671M** Test Method for Mixed Mode I-Mode II Interlaminar Fracture Toughness of Unidirectional Fiber Reinforced Polymer Matrix Composites
 - D7078/D7078M** Test Method for Shear Properties of Composite Materials by V-Notched Rail Shear Method
 - D7264/D7264M** Test Method for Flexural Properties of Polymer Matrix Composite Materials
 - D7291/D7291M** Test Method for Through-Thickness “Flat-wise” Tensile Strength and Elastic Modulus of a Fiber-Reinforced Polymer Matrix Composite Material
 - D7774** Test Method for Flexural Fatigue Properties of Plastics
 - E6** Terminology Relating to Methods of Mechanical Testing
 - E83** Practice for Verification and Classification of Extensometer Systems
 - E122** Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process
 - E251** Test Methods for Performance Characteristics of Metallic Bonded Resistance Strain Gages
 - E456** Terminology Relating to Quality and Statistics
 - E1237** Guide for Installing Bonded Resistance Strain Gages
- 2.2 *Other Standards:*
- ISO 19927** Fibre-reinforced plastic composites – Determination of interlaminar strength and modulus by double beam shear test

3. Terminology

3.1 *Definitions*—Definitions used in this guide are defined by various ASTM methods. Terminology **D3878** defines terms relating to high-modulus fibers and their composites. Terminology **D883** defines terms relating to plastics. Terminology **E6** defines terms relating to mechanical testing. Terminology **E456** defines terms relating to statistics. In the event of a conflict between definitions of terms, Terminology **D3878** shall have precedence over the other standards. Terms relating specifically to textile composites are defined by Ref (1).³

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 material’s “unit cell.” It is defined as the smallest section of

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.

³ The boldface numbers in parentheses refer to the list of references at the end of this standard.