Designation: D4762 – 23

Standard Guide for Testing Polymer Matrix Composite Materials[1]

This standard is issued under the fixed designation D4762; 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 guide summarizes the application of ASTM standard test methods (and other supporting standards) to continuous-fiber reinforced polymer matrix composite materials. The most commonly used or most applicable ASTM standards are included, emphasizing use of standards of Committee D30 on Composite Materials.

1.2 This guide does not cover all possible standards that could apply to polymer matrix composites and restricts discussion to the documented scope. Commonly used but non-standard industry extensions of test method scopes, such as application of static test methods to fatigue testing, are not discussed. A more complete summary of general composite testing standards, including non-ASTM test methods, is included in the Composite Materials Handbook (CMH-17).[2] Additional specific recommendations for testing textile (fabric, braided) composites are contained in Guide D6856.

1.3 This guide does not specify a system of measurement; the systems specified within each of the referenced standards shall apply as appropriate. Note that the referenced standards of ASTM Committee D30 are either SI-only or combined-unit standards with SI units listed first.

1.4 *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 limitations prior to use.*

1.5 *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:*[3]

2.1.1 *Standards of Committee D30 on Composite Materials*

C271/C271M Test Method for Density of Sandwich Core Materials

C272/C272M Test Method for Water Absorption of Core Materials for Sandwich Constructions

C273/C273M Test Method for Shear Properties of Sandwich Core Materials

C297/C297M Test Method for Flatwise Tensile Strength of Sandwich Constructions

C363/C363M Test Method for Node Tensile Strength of Honeycomb Core Materials

C364/C364M Test Method for Edgewise Compressive Strength of Sandwich Constructions

C365/C365M Test Method for Flatwise Compressive Properties of Sandwich Cores

C366/C366M Test Methods for Measurement of Thickness of Sandwich Cores

C393/C393M Test Method for Core Shear Properties of Sandwich Constructions by Beam Flexure

C394/C394M Test Method for Shear Fatigue of Sandwich Core Materials

C480/C480M Test Method for Flexure Creep of Sandwich Constructions

C481 Test Method for Laboratory Aging of Sandwich Constructions

C613 Test Method for Constituent Content of Composite Prepreg by Soxhlet Extraction

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

[1] This guide is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.01 on Editorial and Resource Standards.

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[2] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

[3] 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.

of Polymer Matrix Composite Materials

D3518/D3518M Test Method for In-Plane Shear Response of Polymer Matrix Composite Materials by Tensile Test of a ±45° Laminate

D3529 Test Methods for Constituent Content of Composite Prepreg

D3530 Test Method for Volatiles Content of Composite Material Prepreg

D3531/D3531M Test Method for Resin Flow of Carbon Fiber-Epoxy Prepreg

D3532/D3532M Test Method for Gel Time of Carbon Fiber-Epoxy Prepreg

D3800 Test Method for Density of High-Modulus Fibers

D3878 Terminology for Composite Materials

D4018 Test Methods for Properties of Continuous Filament Carbon and Graphite Fiber Tows

D4102 Test Method for Thermal Oxidative Resistance of Carbon Fibers

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

D5448/D5448M Test Method for Inplane Shear Properties of Hoop Wound Polymer Matrix Composite Cylinders

D5449/D5449M Test Method for Transverse Compressive Properties of Hoop Wound Polymer Matrix Composite Cylinders

D5450/D5450M Test Method for Transverse Tensile Properties of Hoop Wound Polymer Matrix Composite Cylinders

D5467/D5467M Test Method for Compressive Properties of Unidirectional Polymer Matrix Composite Materials Using a Sandwich Beam

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

D6264/D6264M Test Method for Measuring the Damage Resistance of a Fiber-Reinforced Polymer-Matrix Composite to a Concentrated Quasi-Static Indentation Force

D6415/D6415M Test Method for Measuring the Curved Beam Strength of a Fiber-Reinforced Polymer-Matrix Composite

D6416/D6416M Test Method for Two-Dimensional Flexural Properties of Simply Supported Sandwich Composite Plates Subjected to a Distributed Load

D6484/D6484M Test Method for Open-Hole Compressive Strength of Polymer Matrix Composite Laminates

D6507 Practice for Fiber Reinforcement Orientation Codes for Composite Materials

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

D6742/D6742M Practice for Filled-Hole Tension and Compression Testing of Polymer Matrix Composite Laminates

D6772/D6772M Test Method for Dimensional Stability of Sandwich Core Materials

D6790/D6790M Test Method for Determining Poisson's Ratio of Honeycomb Cores

D6856 Guide for Testing Fabric-Reinforced "Textile" Composite Materials

D6873/D6873M Practice for Bearing Fatigue Response of Polymer Matrix Composite Laminates

D7028 Test Method for Glass Transition Temperature (DMA Tg) of Polymer Matrix Composites by Dynamic Mechanical Analysis (DMA)

D7078/D7078M Test Method for Shear Properties of Composite Materials by V-Notched Rail Shear Method

D7136/D7136M Test Method for Measuring the Damage Resistance of a Fiber-Reinforced Polymer Matrix Composite to a Drop-Weight Impact Event

D7137/D7137M Test Method for Compressive Residual Strength Properties of Damaged Polymer Matrix Composite Plates

D7205/D7205M Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars

D7248/D7248M Test Method for High Bearing - Low By-pass Interaction Response of Polymer Matrix Composite Laminates Using 2-Fastener Specimens

D7249/D7249M Test Method for Facesheet Properties of Sandwich Constructions by Long Beam Flexure

D7250/D7250M Practice for Determining Sandwich Beam Flexural and Shear Stiffness

D7264/D7264M Test Method for Flexural Properties of Polymer Matrix Composite Materials

D7291/D7291M Test Method for Through-Thickness "Flatwise" Tensile Strength and Elastic Modulus of a Fiber-Reinforced Polymer Matrix Composite Material

D7332/D7332M Test Method for Measuring the Fastener Pull-Through Resistance of a Fiber-Reinforced Polymer Matrix Composite

D7336/D7336M Test Method for Static Energy Absorption Properties of Honeycomb Sandwich Core Materials

D7337/D7337M Test Method for Tensile Creep Rupture of Fiber Reinforced Polymer Matrix Composite Bars

D7522/D7522M Test Method for Pull-Off Strength for FRP Laminate Systems Bonded to Concrete or Masonry Substrates

D7565/D7565M Test Method for Determining Tensile Properties of Fiber Reinforced Polymer Matrix Composites Used for Strengthening of Civil Structures
D7615/D7615M Practice for Open-Hole Fatigue Response of Polymer Matrix Composite Laminates
D7616/D7616M Test Method for Determining Apparent Overlap Splice Shear Strength Properties of Wet Lay-Up Fiber-Reinforced Polymer Matrix Composites Used for Strengthening Civil Structures
D7617/D7617M Test Method for Transverse Shear Strength of Fiber-reinforced Polymer Matrix Composite Bars
D7705/D7705M Test Method for Alkali Resistance of Fiber Reinforced Polymer (FRP) Matrix Composite Bars used in Concrete Construction
D7750 Test Method for Cure Behavior of Thermosetting Resins by Dynamic Mechanical Procedures using an Encapsulated Specimen Rheometer
D7766/D7766M Practice for Damage Resistance Testing of Sandwich Constructions
D7905/D7905M Test Method for Determination of the Mode II Interlaminar Fracture Toughness of Unidirectional Fiber-Reinforced Polymer Matrix Composites
D7913/D7913M Test Method for Bond Strength of Fiber-Reinforced Polymer Matrix Composite Bars to Concrete by Pullout Testing
D7914/D7914M Test Method for Strength of Fiber Reinforced Polymer (FRP) Bent Bars in Bend Locations
D7956/D7956M Practice for Compressive Testing of Thin Damaged Laminates Using a Sandwich Long Beam Flexure Specimen
D7957/D7957M Specification for Solid Round Glass Fiber Reinforced Polymer Bars for Concrete Reinforcement
D7958/D7958M Test Method for Evaluation of Performance for FRP Composite Bonded to Concrete Substrate using Beam Test
D8066/D8066M Practice Unnotched Compression Testing of Polymer Matrix Composite Laminates
D8067/D8067M Test Method for In-Plane Shear Properties of Sandwich Panels Using a Picture Frame Fixture
D8101/D8101M Test Method for Measuring the Penetration Resistance of Composite Materials to Impact by a Blunt Projectile
D8131/D8131M Practice for Tensile Properties of Tapered and Stepped Joints of Polymer Matrix Composite Laminates
D8132/D8132M Test Method for Determination of Prepreg Impregnation by Permeability Measurement
D8285/D8285M Practice for Compressive Properties of Tapered and Stepped Joints of Polymer Matrix Composite Laminates by Sandwich Construction Long Beam Flexure
D8287/D8287M Test Method for Compressive Residual Strength Properties of Damaged Sandwich Composite Panels
D8335 Guide for Identification of Fiber-Reinforced Polymer-Matrix Composite Materials
D8336 Test Method for Characterizing Tack of Prepregs Using a Continuous Application-and-Peel Procedure
D8337/D8337M Test Method for Evaluation of Bond Properties of FRP Composite Applied to Concrete Substrate using Single-Lap Shear Test
D8387/D8387M Test Method for High Bypass – Low Bearing Interaction Response of Polymer Matrix Composite Laminates
D8388/D8388M Practice for Flexural Residual Strength Testing of Damaged Sandwich Constructions
D8453/D8453M Practice for Open-Hole Flexural Strength of Sandwich Constructions
D8454/D8454M Test Method for Open-Hole Compressive Strength of Sandwich Constructions
D8505/D8505M Specification for Basalt and Glass Fiber Reinforced Polymer (FRP) Bars for Concrete Reinforcement
D8509/D8509M Guide for Test Method Selection and Test Specimen Design for Bolted Joint Related Properties
D8510/D8510M Test Method for Local Buckling and Crippling under Axial Compressive Loading
D8511/D8511M Guide for Design and Analysis of Local Buckling and Crippling Test Specimens
E1922 Test Method for Translaminar Fracture Toughness of Laminated and Pultruded Polymer Matrix Composite Materials
F1645/F1645M Test Method for Water Migration in Honeycomb Core Materials

2.1.2 *Standards of Committee D20 on Plastics*

C581 Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service
D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents
D570 Test Method for Water Absorption of Plastics
D618 Practice for Conditioning Plastics for Testing
D638 Test Method for Tensile Properties of Plastics
D648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position
D671 Test Method for Flexural Fatigue of Plastics by Constant-Amplitude-of-Force (Withdrawn 2002)[4]
D695 Test Method for Compressive Properties of Rigid Plastics
D696 Test Method for Coefficient of Linear Thermal Expansion of Plastics Between −30°C and 30°C with a Vitreous Silica Dilatometer
D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D953 Test Method for Pin-Bearing Strength of Plastics
D1505 Test Method for Density of Plastics by the Density-Gradient Technique
D1822 Test Method for Determining the Tensile-Impact

[4] The last approved version of this historical standard is referenced on www.astm.org.

Resistance of Plastics

D2471 Practice for Gel Time and Peak Exothermic Temperature of Reacting Thermosetting Resins (Withdrawn 2008)[4]

D2583 Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor (Withdrawn 2022)[4]

D2584 Test Method for Ignition Loss of Cured Reinforced Resins

D2734 Test Methods for Void Content of Reinforced Plastics

D2990 Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics

D3418 Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry

D3846 Test Method for In-Plane Shear Strength of Reinforced Plastics

D4065 Practice for Plastics: Dynamic Mechanical Properties: Determination and Report of Procedures

D4473 Test Method for Plastics: Dynamic Mechanical Properties: Cure Behavior

D5083 Test Method for Tensile Properties of Reinforced Thermosetting Plastics Using Straight-Sided Specimens

D6272 Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials by Four-Point Bending

2.1.3 *Standards of Other ASTM Committees*

E228 Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer

E289 Test Method for Linear Thermal Expansion of Rigid Solids with Interferometry

E1269 Test Method for Determining Specific Heat Capacity by Differential Scanning Calorimetry

E1461 Test Method for Thermal Diffusivity by the Flash Method

3. Terminology

3.1 Definitions related to composite materials are defined in Terminology D3878.

3.2 Symbology for specifying the orientation and stacking sequence of a composite laminate is defined in Practice D6507.

3.3 For purposes of this document, "low modulus" composites are defined as being reinforced with fibers having a modulus ≤20 GPa (≤3.0 × 10^6 psi), while "high-modulus" composites are reinforced with fiber having a modulus >20 GPa (>3.0 × 10^6 psi).

4. Significance and Use

4.1 This guide is intended to aid in the selection of standards for polymer matrix composite materials. It specifically summarizes the application of standards from ASTM Committee D30 on Composite Materials that apply to continuous-fiber reinforced polymer matrix composite materials. For reference and comparison, many commonly used or applicable ASTM standards from other ASTM Committees are also included.

5. Standard Specimen Preparation

5.1 Preparation of polymer matrix composite test specimens is described in Guide D5687/D5687M.

6. Standard Test Methods

6.1 ASTM test methods for the evaluation of polymer matrix composites are summarized in the tables. Advantages, disadvantages, and other comments for each test method are included where appropriate. Where possible, a single preferred test method is identified.

TEST METHOD CATEGORY	TABLE
Lamina/Laminate Static Properties	Table 1
Lamina/Laminate Dynamic Properties	Table 2
Laminate/Structural Response	Table 3
Sandwich Constructions	Table 4
Constituent/Precursor/Thermophysical Properties	Table 5
Environmental Conditioning/Resistance	Table 6

7. Standard Data Reporting

7.1 *Composite Material Description*—Data reporting of the description of composite materials is documented in Guide D8335. This guide establishes essential and desirable identification elements for fiber-reinforced composite materials and for fibers, fillers, and core materials used in these composite materials.

8. Standard Specifications

8.1 ASTM D30 develops standard specifications for composite materials used in civil structures under Subcommittee D30.10. Other subcommittees under ASTM D30 will not develop standard specifications.

8.2 Specification D7957/D7957M covers glass fiber reinforced polymer (GFRP) bars, provided in cut lengths and bent shapes and having an external surface enhancement for concrete reinforcement.

8.3 Specification D8505/D8505M covers basalt and glass fiber reinforced polymer (FRP) bars for concrete reinforcement.

TABLE 1 Lamina/Laminate Static Test Methods

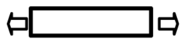
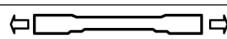
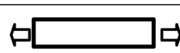
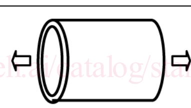
Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments
		In-Plane Tensile Test Methods			
D3039/D3039M		Tensile Strength	Straight sided specimen. Suitable for both random, discontinuous and continuous-fiber composites. Tabbed and untabbed configurations available.	Tabbed configurations require careful adhesive selection and special specimen preparation. Certain laminate layups prone to edge delamination which can affect tensile strength results.	Preferred for most uses. Provides additional configurations, requirements, and guidance that are not found in D5083. Limited to laminates that are balanced and symmetric with respect to the test direction.
		Tensile Modulus, Poisson's Ratio, Stress-Strain Response	Requires use of strain or displacement transducers. Modulus measurements do not require use of tabs.		Modulus measurements typically robust.
D638		Tensile Strength, Tensile Modulus	"Dumbbell" shaped specimen. Ease of test specimen preparation.	Stress concentration at the radii. Unsuitable for highly oriented fiber composites.	Not recommended for high-modulus composites. Technically equivalent to ISO 527-1.
D5083		Tensile Strength, Tensile Modulus	Straight-sided, untabbed specimen only.	Suitable for plastics and low-modulus composites.	A straight-sided alternative to D638. Technically equivalent to ISO 527-4 except as noted below: (*a*) This test method does not include testing of the Type I dog-bone shaped specimen described in ISO 527-4. Testing of this type of specimen, primarily used for reinforced and unreinforced thermoplastic materials, is described in D638. (*b*) The thickness of test specimens in this test method includes the 2 mm to 10 mm thickness range of ISO 527-4, but expands the allowable test thickness to 14 mm.
D5450/D5450M		Transverse (90°) Tensile Strength	Hoop wound cylinder with all 90° (hoop) plies loaded in axial tension. Develops data for specialized process/form.	Limited to hoop-wound cylinders. Limited to transverse tensile properties. Must bond specimen to fixture.	Must ensure adequate bonding to fixture.
		In-Plane Compression Test Methods			
D6641/D6641M		Compressive Strength	Untabbed, or tabbed straight-sided specimen loaded via a combination of shear and end-loading. Smaller lighter, less expensive fixture than that of D3410/D3410M. Better also at non-ambient environments. Suitable for continuous fiber composites.	Tabbed specimens are required for determining compressive strength of laminates containing more than 50% 0° plies.	Preferred method. Thickness must be sufficient to prevent column buckling. Limited to laminates that are balanced and symmetric and contain at least one 0° ply. For strength determination, untabbed specimens are limited to a maximum of 50 % 0° plies, or equivalent.
		Compressive Modulus, Poisson's Ratio, Stress-Strain Response	Requires use of strain or displacement transducers.		Unidirectional tape or tow composites can be tested using untabbed specimens to determine unidirectional modulus and Poisson's ratio.

TABLE 1 *Continued*

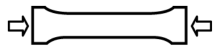
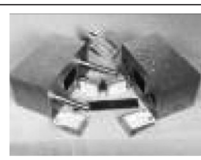
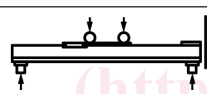
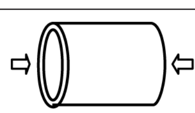
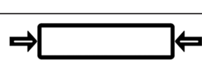
Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments
		In-Plane Compression Test Methods, continued			
D695		Compressive Strength, Compressive Modulus	"Dogbone" shaped specimen with loading applied at the ends via a platen. Tabs are optional.	Failure mode is often end-crushing. Stress concentrations at radii. Specimen must be dog boned and ends must be accurately machined. No assessment of alignment.	Not recommended for highly oriented or continuous fiber composites. Modified version of D695 released as SACMA SRM 1 test method is widely used in aerospace industry, but ASTM D30 and CMH-17 prefer use of D6641/D6641M method.
D3410/D3410M		Compressive Strength	Straight sided specimen with load applied by shear via fixture grips. Suitable for random, discontinuous and continuous fiber composites. Tabbed and untabbed configurations available.	Strain gages required to verify alignment. Poor for non-ambient testing due to massive fixture.	Expensive and heavy/bulky fixturing. Thickness must be sufficient to prevent column buckling.
		Compressive Modulus, Poisson's Ratio, Stress-Strain Response	Requires use of strain or displacement transducers.		
D5467/D5467M		Compressive Strength, Compressive Modulus, Stress-Strain Response	Sandwich beam specimen loaded in 4-point bending. Intended result is a compression failure mode of the facesheet. Data is especially applicable to sandwich structures. Fixturing is simple compared to other compression tests.	An expensive specimen that is not recommended unless the structure warrants its use. Strain gages required to obtain modulus and strain-to-failure data. Narrow (1 in. wide) specimen may not be suitable for materials with coarse features, such as fabrics with large filament count tows (12K or more) or certain braided materials.	Must take care to avoid core failure modes. Limited to high-modulus composites. Due to the nature of the specimen construction and applied flexural loading these results may not be equivalent to a similar laminate tested by other compression methods such as D3410/D3410M or D6641/D6641M.
D5449/D5449M		Transverse (90°) Compressive Strength	Hoop-wound cylinder with all 90° (hoop) plies loaded in compression. Develops data for specialized process/form.	Limited to hoop-wound cylinders. Limited to transverse compressive properties. Must bond specimen to fixture.	Must ensure adequate bonding to fixture.
D8066/D8066M		Compressive Strength, Compressive Modulus, Stress-Strain Response, Poisson's Ratio	Straight-sided, untabbed, unnotched configuration. Procedure and apparatus nearly equivalent to D6484/D6484M.	Limited to multi-directional laminates with balanced and symmetric stacking sequences. Prohibits use of end loading to avoid end brooming/crushing failures.	Provides a longer and wider gage section than D695, D3410/D3410M and D6641/D6641M. Appropriate for testing larger cell-size fabrics.

TABLE 1 *Continued*

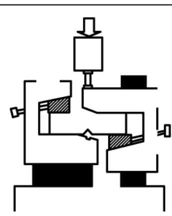
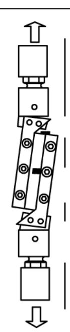
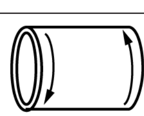
Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments
		In-Plane Shear Test Methods			
D3518/D3518M		Shear Modulus, Stress-Strain Response, Maximum Shear Stress	Tensile test of [+45/-45]ns layup. Simple test specimen and test method.	Poor specimen for measuring ultimate shear strength due to large non-linear response. Limited to material forms/processes that can be made in flat ±45° form. Biaxial transducers required to obtain modulus and strain-to-failure data. Maximum shear stress determination is dependent upon instrumentation-based strain measurements at high shear strain magnitudes.	Widely used due to its low cost and simplicity. Specimen gage section is not under pure shear stress, and stress fields local to free edges are complex.
D5379/D5379M		Shear Strength, Shear Modulus, Stress-Strain Response	V-notched specimen loaded in special bending fixture. Along with D7078/D7078M, provides the best shear response of the standardized methods. Provides shear modulus and strength. Can be used to test most composite types. Produces a relatively pure and uniform shear stress state.	May be necessary to tab the specimen. Specimen can be difficult to machine. Biaxial strain gages required to obtain modulus and strain-to-failure data. Requires good strain-gage installation technique. In-plane tests not suitable for materials with coarse features, such as fabrics with large filament count tows (12K or more) or certain braided materials. Unacceptable failure modes, especially with high-strength laminates, can occur due to localized failure of the specimen at the loading points.	Recommended for quantitative data, or where shear modulus or stress/strain data are required. Enables correlation with out-of-plane properties. Must monitor strain data for specimen buckling. Limited to the following forms: (*a*) unidirectional tape or tow laminates with fibers parallel or perpendicular to loading axis. (*b*) woven fabric laminates with the warp direction parallel or perpendicular to loading axis. (*c*) laminates with equal numbers of 0° and 90° plies with the 0° plies parallel or perpendicular to loading axis. (*d*) short-fiber composites with majority of the fibers randomly distributed. The most accurate modulus measurements obtained from laminates of the [0/90] family.
D4255/D4255M		Shear Strength, Shear Modulus, Stress-Strain Response	Rail shear methods. Suitable for both random and continuous fiber composites.	Difficult test to run. Historically has had poor reproducibility. Stress concentrations at gripping areas. Strain gages required to obtain modulus and strain-to-failure data.	Expensive specimen. Best reserved for testing of laminates.
D5448/D5448M		Shear Strength, Shear Modulus, Stress-Strain Response	Hoop-wound cylinder with all 90° (hoop) plies loaded in torsion. Develops data for specialized process/form.	Limited to hoop-wound cylinders. Limited to in-plane shear properties. Must bond specimen to fixture.	Must ensure adequate bonding to fixture.

TABLE 1 *Continued*

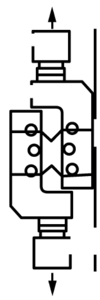
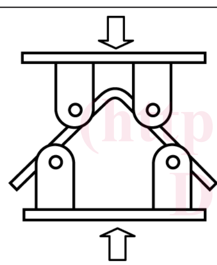
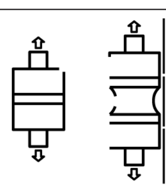
Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments
D7078/D7078M		Shear Strength, Shear Modulus, Stress-Strain Response	V-notched specimen loaded in rail shear fixture. Along with D5379/D5379M, provides the best shear response of the standardized methods. Provides shear modulus and strength. Can be used to test most composite types. Produces a relatively pure and uniform shear stress state. Generally does not require tabs. Permits testing of fabric and textile composites with large unit cells. Less susceptible to loading point failures than D5379/D5379M.	Specimen can be difficult to machine. Biaxial strain gages required to obtain modulus and strain-to-failure data. Requires good strain-gage installation technique.	Recommended for quantitative data, or where shear modulus or stress/strain data are required. Enables correlation with out-of-plane properties. Must monitor strain data for specimen buckling. Material form limitations are equivalent to those for D5379/D5379M. The most accurate modulus measurements obtained from laminates of the [0/90] family.
Out-of-Plane Tensile Test Methods					
D6415/D6415M		Curved Laminate Strength	Right-angle curved laminate specimen loaded in 4-point bending. Suitable for continuous fiber composites.	A complex stress state is generated in the specimen that may cause an unintended complex failure mode. There is typically a large amount of scatter in the curved beam strength data. While the failure mode is largely out-of-plane, the result is generally considered a structural test of a curved beam rather than a material property.	Limited to composites with defined layers (no through-the-thickness reinforcement). For structural comparison, the same manufacturing process should be used for both the test specimen and the structure. Non-standard versions of the curved-beam test yield a different stress state that may affect the strength and failure mode.
		Interlaminar Tensile Strength	See above.	See above.	Tests for interlaminar tensile strength limited to unidirectional materials with fibers oriented continuously along the legs and around the bend.
D7291/D7291M		Flatwise Tensile Strength, Flatwise Modulus	Cylindrical or reduced gage section "spool" specimen loaded in tension. Uses adhesively bonded thick metal end-tabs for load introduction. Suitable for continuous or discontinuous fiber composites. Subjects a relatively large volume of material to an almost uniform stress field.	Results are sensitive to system alignment and load eccentricity. Surface finish and parallelism affect strength results. Results are sensitive to thermal residual stresses, adhesive, and surface preparation at end-tab bondlines.	Requires bonding and machining of laminate and end-tabs. End-tabs may be reused within geometric limits. Low crosshead displacement rate (0.1 mm/mim [0.005 in./min]. Valid tests require failures away from the end-tab bondline.

TABLE 1 *Continued*

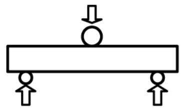
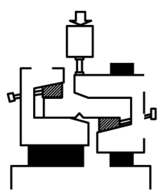
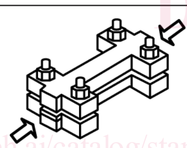
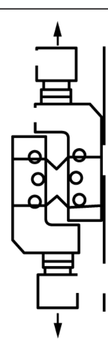
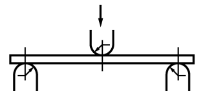
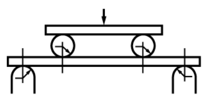
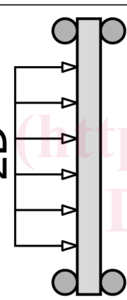
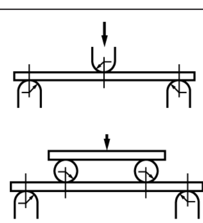
Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments
			Out-of-Plane Shear Test Methods		
D2344/D2344M		Short Beam Strength	Short rectangular beam specimen loaded in 3-point bending. Short Beam Strength is a good indicator of resin-dominated properties. Simple, inexpensive specimen and test configuration.	Short Beam Strength may be related to interlaminar shear strength, but the stress state is quite mixed, and so results are not recommended as an assessment of shear strength due to stress concentrations and high secondary stresses at loading points. Shear modulus cannot be measured.	Intended primarily for quality control, comparative data, and assessment of environmental effects.
D5379/D5379M		Interlaminar Shear Strength, Interlaminar Shear Modulus	V-notched specimen loaded in special bending fixture. Along with D7078/D7078M, provides the best shear response of the standardized methods. Provides shear modulus and strength. Can be used to test most composites. Produces a relatively pure and uniform shear stress state.	May be necessary to tab the specimen. Specimen can be difficult to machine. Strain gages required to obtain modulus and strain-to-failure data. Requires good strain-gage installation technique. Requires a very thick laminate, 20 mm (0.75 in.) for out-of-plane properties.	Recommended for quantitative data, or where shear modulus or stress/strain data are required. Enables correlation with in-plane properties. Must monitor strain data for specimen buckling.
D3846		Shear Strength	Specimen with two machined notches loaded in compression. Suitable for randomly dispersed and continuous fiber reinforced materials. May be preferable to D2344/D2344M for materials with randomly dispersed fiber orientations.	Failures may be sensitive to accuracy of notch machining. Stress concentrations at notches. Failure may be influenced by the applied compression stress. Requires post-failure measurement of shear area. Shear modulus cannot be measured.	Specimen loaded in compression utilizing the D695 loading/stabilizing jig. Shear loading occurs in a plane between two machined notches. Often a problematic test. Note that this is an out-of-plane shear test (using recognized terminology), despite the title that indicates in-plane shear loading.
D7078/D7078M		Interlaminar Shear Strength, Interlaminar Shear Modulus	V-notched specimen loaded in rail shear fixture. Along with D5379/D5379M, provides the best shear response of the standardized methods. Provides shear modulus and strength. Can be used to test most composites. Produces a relatively pure and uniform shear stress state. Less susceptible to loading point failures than D5379/D5379M.	Specimen can be difficult to machine. Strain gages required to obtain modulus and strain-to-failure data. Requires good strain-gage installation technique. Requires an extremely thick laminate, typically consisting of multiple co-bonded sub-laminates, for out-of-plane properties.	Recommended for quantitative data, or where shear modulus or stress/strain data are required. Enables correlation with in-plane properties. Must monitor strain data for specimen buckling.

TABLE 1 *Continued*

Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments
		Laminate Flexural Test Methods			
D790		Flexural Strength, Flexural Modulus, Flexural Stress-Strain Response	Flat rectangular specimen loaded in 3-point bending. Suitable for randomly dispersed and continuous fiber reinforced materials. Ease of test specimen preparation and testing.	Stress concentrations and secondary stresses at loading points. Results sensitive to specimen and loading geometry, strain rate.	Failure mode may be tension, compression, shear, or combination.
D6272		Flexural Strength, Flexural Modulus, Flexural Stress-Strain Response	Flat rectangular specimen loaded in 4-point bending. Suitable for randomly dispersed and continuous fiber reinforced materials. Ease of test specim en preparation and testing. Choice of two procedures enable adjustable tension/ compression/ shear load distribution.	Center-point deflection requires secondary instrumentation. Results sensitive to specimen and loading geometry, strain rate. Span-to-depth ratio must increase for laminates with high tensile strength with respect to in-plane shear strength.	The quarter-span version is recommended for highmodulus composites. Failure mode may be tension, compression, shear, or combination.
D6416/D6416M		Pressure-Deflection Response, Pressure-Strain Response, Plate Bending and Shear Stiffness	Two-dimensional plate flexure induced by a well-defined distributed load. Apparatus, instrumentation ensure applied pressure distribution is known. Failures typically initiate away from edges. Specimens are relatively large, facilitating study of manufacturing defects and process variables.	For studies of failure mechanics and other quantitative sandwich analyses, only small panel deflections are allowed. The test fixture is necessarily more elaborate, and some calibration is required to verify simply-supported boundary conditions. Results highly dependent upon panel edge boundary conditions and pressure distribution. Relatively large specimen and support fixture geometry.	The same caveats applying to D7249/D7249M could apply to D6416/D6416M. However, this method is not limited to sandwich composites; D6416/D6416M can be used to evaluate the 2-dimensional flexural properties of any square plate. Distributed load is provided using a water-filled bladder. Ratio of support span to average specimen thickness should be between 10 to 30.
D7264/D7264M		Flexural Strength, Flexural Modulus, Flexural Stress-Strain Response	Recommended for high-modulus composites. Flat rectangular specimen loaded in 3 or 4-point bending. Suitable for randomly dispersed and continuous fiber reinforced materials. Ease of test specimen preparation and testing. Standardized load and support spans to simplify calculations and to standardize geometry.	Center-point deflection measurement requires secondary instrumentation. Results sensitive to specimen and loading geometry, strain rate. Span-to-depth ratio may need to increase for laminates with high tensile strength with respect to in-plane shear strength.	Standard support span-to-thickness ratio is 32:1. For 4-point load, load points are set at one-half of the support span. Failure mode may be tension, compression, shear, or combination.