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Standard Guide for Testing Polymer Matrix Composite Materials[1]

This standard is issued under the fixed designation D 4762; 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 (MIL-HDBK-17).[2] Additional specific recommendations for testing textile (fabric, braided) composites are contained in Guide D 6856.

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

2. Referenced Documents

2.1 *ASTM Standards: 2.1.1Standards of Committee D30 on Composite Materials ASTM Standards:* [3]

2.1.1 *Standards of Committee D30 on Composite Materials*

C 271/C 271M Test Method for Density of Sandwich Core Materials
C 272 Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions
C 273/C 273M Test Method for Shear Properties of Sandwich Core Materials
C 297/C 297M Test Method for Flatwise Tensile Strength of Sandwich Constructions
C 363 Test Method for Delamination Strength of Honeycomb Core Materials
C 364/C 364M Test Method for Edgewise Compressive Strength of Sandwich Constructions
C 365/C 365M Test Method for Flatwise Compressive Properties of Sandwich Cores
C 366/C 366M Test Methods for Measurement of Thickness of Sandwich Cores
C393Test Method for Flexural Properties of Sandwich Constructions 393/C 393M Test Method for Core Shear Properties of Sandwich Constructions by Beam Flexure
C 394 Test Method for Shear Fatigue of Sandwich Core Materials
C 480 Test Method for Flexure Creep of Sandwich Constructions
C 481 Test Method for Laboratory Aging of Sandwich Constructions
C 613/C 613M Test Method for Constituent Content of Composite Prepreg by Soxhlet Extraction
D 2344/D 2344M Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates
D 3039/D 3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials
D 3171 Test Methods for Constituent Content of Composite Materials
D 3410/D 3410M Test Method for Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading

[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 ASTM, and also from the U.S. DoD Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[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.

D 3479/D 3479M Test Method for Tension-Tension Fatigue of Polymer Matrix Composite Materials
D 3518/D 3518M Test Method for In-Plane Shear Response of Polymer Matrix Composite Materials by Tensile Test of a ~~±45~~45 Laminate
D 3529/D 3529M Test Method for Matrix Solids Content and Matrix Content of Composite Prepreg
D 3530/D 3530M Test Method for Volatiles Content of Composite Material Prepreg
D 3531 Test Method for Resin Flow of Carbon Fiber-Epoxy Prepreg
D 3532 Test Method for Gel Time of Carbon Fiber-Epoxy Prepreg
~~D3544Guide for Reporting Test Methods and Results on High Modulus Fibers~~
D 3800 Test Method for Density of High-Modulus Fibers
D 3878 Terminology ~~of~~for Composite Materials
D 4018 Test Methods for Properties of Continuous Filament Carbon and Graphite Fiber Tows
D 4102 Test Method for Thermal Oxidative Resistance of Carbon Fibers
D 4255/D 4255M Test Method for In-Plane Shear Properties of Polymer Matrix Composite Materials by the Rail Shear Method
D 5229/D 5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
D 5379/D 5379M Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method
D 5448/D 5448M Test Method for ~~In-Plane~~Inplane Shear Properties of Hoop Wound Polymer Matrix Composite Cylinders
D 5449/D 5449M Test Method for Transverse Compressive Properties of Hoop Wound Polymer Matrix Composite Cylinders
D 5450/D 5450M Test Method for Transverse Tensile Properties of Hoop Wound Polymer Matrix Composite Cylinders
D 5467/D 5467M Test Method for Compressive Properties of Unidirectional Polymer Matrix Composite Materials Using a Sandwich Beam
D 5528 Test Method for Mode I Interlaminar Fracture Toughness of Unidirectional Fiber-Reinforced Polymer Matrix Composites
D 5687/D 5687M Guide for Preparation of Flat Composite Panels ~~With~~with Processing Guidelines for Specimen Preparation
D 5766/D 5766M Test Method for Open-Hole Tensile Strength of Polymer Matrix Composite Laminates
D 5961/D 5961M Test Method for Bearing Response of Polymer Matrix Composite Laminates
D 6115 Test Method for Mode I Fatigue Delamination Growth Onset of Unidirectional Fiber-Reinforced Polymer~~-~~ Matrix Composites
D 6264 Test Method for Measuring ~~the~~ Damage Resistance of ~~a~~ Fiber-Reinforced Polymer-Matrix Composite to ~~a~~ Concentrated Quasi-Static Indentation Force
D 6415 Test Method for Measuring the Curved Beam Strength of a Fiber-Reinforced Polymer-Matrix Composite
D 6416/D 6416M Test Method for Two-Dimensional Flexural Properties of Simply Supported Sandwich Composite Plates Subjected to a Distributed Load
D 6484/D 6484M Test Method for Open-Hole Compressive Strength of Polymer Matrix Composite Laminates
D 6507 Practice for Fiber Reinforcement Orientation Codes for Composite Materials
D 6641/D 6641M Test Method for Determining the Compressive Properties of Polymer Matrix Composite ~~Materials~~Laminates Using ~~the~~a Combined Loading Compression (CLC) Test Fixture
D~~6671~~ 6671/D 6671M Test Method for Mixed Mode I-Mode II Interlaminar Fracture Toughness of Unidirectional Fiber Reinforced Polymer Matrix Composites
D 6742/D 6742M ~~Practice for Filled-Hole Tension and Compression Testing of Polymer Matrix Composite Laminates~~ Practice for Filled-Hole Tension and Compression Testing of Polymer Matrix Composite Laminates
D 6772 Test Method for Dimensional Stability of Sandwich Core Materials
D 6790 Test Method for Determining Poisson's Ratio of Honeycomb Cores
D 6856 Guide for Testing Fabric-Reinforced Textile Composite Materials
D 6873~~Practice for Bearing Fatigue Testing of Polymer Matrix Composite Laminates~~ Practice for Bearing Fatigue Response of Polymer Matrix Composite Laminates
D 7078/D 7078M Test Method for Shear Properties of Composite Materials by V-Notched Rail Shear Method
D 7136/D 7136M Test Method for Measuring the Damage Resistance of a Fiber-Reinforced Polymer Matrix Composite to a Drop-Weight Impact Event
D 7137/D 7137M Test Method for Compressive Residual Strength Properties of Damaged Polymer Matrix Composite Plates
D 7205/D 7205M Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars
D 7248/D 7248M Test Method for Bearing/Bypass Interaction Response of Polymer Matrix Composite Laminates Using 2-Fastener Specimens
D 7249/D 7249M Test Method for Facing Properties of Sandwich Constructions by Long Beam Flexure
D 7250/D 7250M Practice for Determining Sandwich Beam Flexural and Shear Stiffness
D 7264/D 7264M Test Method for Flexural Properties of Polymer Matrix Composite Materials
D 7291/D 7291M Test Method for Through-Thickness Flatwise Tensile Strength and Elastic Modulus of a Fiber-Reinforced Polymer Matrix Composite Material

D 7332/D 7332M Test Method for Measuring the Fastener Pull-Through Resistance of a Fiber-Reinforced Polymer Matrix Composite
D 7336/D 7336M Test Method for Static Energy Absorption Properties of Honeycomb Sandwich Core Materials
D 7337/D 7337M Test Method for Tensile Creep Rupture of Fiber Reinforced Polymer Matrix Composite Bars
E 1309 Guide for the Identification of Fiber-Reinforced Polymer-Matrix Composite Materials in Databases
E 1434 Guide for Recording Mechanical Test Data of Fiber-Reinforced Composite Materials in Databases
E 1471 Guide for the Identification of Fibers, Fillers, and Core Materials in Computerized Material Property Databases 2.1.2
Guide for Identification of Fibers, Fillers, and Core Materials in Computerized Material Property Databases
F 1645/F 1645M Test Method for Water Migration in Honeycomb Core Materials

2.1.2 *Standards of Committee D20 on Plastics*

C 581 Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service
D 256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
D 543 ~~Test Method for Evaluating the Resistance of Plastics to Chemical Reagents~~ Practices for Evaluating the Resistance of Plastics to Chemical Reagents
D 570 Test Method for Water Absorption of Plastics
D 618 Practice for Conditioning Plastics for Testing
D 638 Test Method for Tensile Properties of Plastics
D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position
D 671 Test Method for Flexural Fatigue of Plastics by Constant-Amplitude-of-Force
D 695 Test Method for Compressive Properties of Rigid Plastics
D 696 Test Method for Coefficient of Linear Thermal Expansion of Plastics Between ~~-30°C~~30C and ~~30°C With~~30C with a Vitreous Silica Dilatometer
D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D 953 Test Method for Bearing Strength of Plastics
D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
D 1822 Test Method for Tensile-Impact Energy to Break Plastics and Electrical Insulating Materials
D 2471 Test Method for Gel Time and Peak Exothermic Temperature of Reacting Thermosetting Resins
D 2583 Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor
D 2584 Test Method for Ignition Loss of Cured Reinforced Resins
D 2734 Test Methods for Void Content of Reinforced Plastics
D 2990 Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics
D 3418 ~~Test Method for Transition Temperatures of Polymers by Differential Scanning Calorimetry~~ Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry
D 3846 Test Method for In-Plane Shear Strength of Reinforced Plastics
D 4065 Practice for Plastics: ~~Dynamical~~Dynamic Mechanical Properties: Determination and Report of Procedures
D 4473 Test Method for Plastics: Dynamic Mechanical Properties: Cure Behavior
D 5083 Test Method for Tensile Properties of Reinforced Thermosetting Plastics Using Straight-Sided Specimens
D 6272 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*

E 228 Test Method for Linear Thermal Expansion of Solid Materials With a ~~Vitreous Silica~~Push-Rod Dilatometer
E 289 Test Method for Linear Thermal Expansion of Rigid Solids with Interferometry
E 1269 Test Method for Determining Specific Heat Capacity by Differential Scanning Calorimetry
E 1461 Test Method for Thermal Diffusivity ~~of Solids~~ by the Flash Method
E 1922 Test Method for Translaminar Fracture Toughness of Laminated and Pultruded Polymer Matrix Composite Materials

3. Terminology

3.1 Definitions related to composite materials are defined in Terminology D 3878.

3.2 Symbology for specifying the orientation and stacking sequence of a composite laminate is defined in Practice D 6507.

3.3 For purposes of this document, "low modulus" composites are defined as being reinforced with fibers having a modulus $\leq$20 GPa ($\leq 3.0 \times 10^6$ psi), while "high-modulus" composites are reinforced with fiber having a modulus >20 GPa ($>3.0 \times 10^6$ 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 D 5687/D 5687M.

6. Standard Test Methods

6.1 ASTM test methods for the evaluation of polymer matrix composites are summarized in ~~Tables 1-5.~~the tables. Advantages, disadvantages, and other comments for each test method are included where appropriate. Where possible, a single preferred test method is identified.

TABLE 1 Lamina/Laminate Static Test Methods

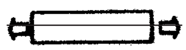
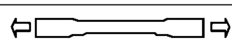
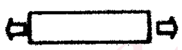
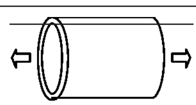
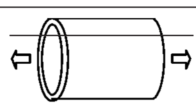
Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments	
In-Plane Tensile Test Methods						
~~D 3039~~		~~Tensile Strength~~	~~Straight sided specimen. Suitable for both random, discontinuous and continuous-fiber composites. Tabbed and untabbed configurations available.~~	~~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 D 5083. Limited to laminates that are balanced and symmetric with respect to the test direction.~~	
	D 3039/D 3039M		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 Provides add are not found Limited to lar to the test di
		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.	
D 638		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.	
D 5083		Tensile Strength, Tensile Modulus	Straight-sided, untabbed specimen only.	Suitable for plastics and low-modulus composites.	A straight-sided alternative to D 638. 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 D 638. (*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.	
~~D 5450~~		~~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.~~	
D 5450/D 5450M		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						

TABLE 1 *Continued*

Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments	
~~D 6641~~		~~Compressive Strength~~	~~Untabbed, straight-sided specimen loaded via a combination of shear and end-loading.~~ ~~Smaller lighter, less expensive fixture than that of D 3410.~~ ~~Better also at non-ambient environments.~~ ~~Suitable for continuous fiber composites.~~	~~May be necessary to tab highly oriented fiber composites or laminates with 0° plies on the surface.~~ ~~Not recommended for determining compressive strength of unidirectional (0° ply orientation) tape or tow laminates.~~	~~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, the laminate is limited to a maximum of 50 % 0° plies, or equivalent.~~	
	D 6641/D 6641M		Compressive Strength	Untabbed, straight-sided specimen loaded via a combination of shear and end-loading. Smaller lighter, less expensive fixture than that of D 3410/D 3410M. Better also at non-ambient environments. Suitable for continuous fiber composites.	May be necessary to tab highly oriented fiber composites or laminates with 0° plies on the surface. Not recommended for determining compressive strength of unidirectional (0° ply orientation) tape or tow laminates.	Preferred metho Thickness must Limited to lamin at least one 0° For strength det 50 % 0° plies, o
		Compressive Modulus, Poisson's Ratio, Stress-Strain Response	Requires use of strain or displacement transducers.		Unidirectional tape or tow composites can be tested to determine unidirectional modulus and Poisson's ratio.	
~~D 695~~		~~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 D 695 released as SACMA SRM 1 test method is widely used in aerospace industry, but ASTM D30 and MIL-HDBK-17 prefer use of D 6641 method.~~	
D 695		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 D 695 released as SACMA SRM 1 test method is widely used in aerospace industry, but ASTM D30 and MIL-HDBK-17 prefer use of D 6641/D 6641M method.	

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

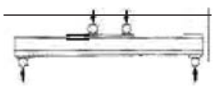
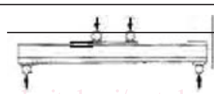
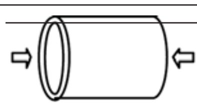
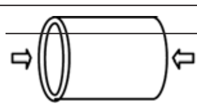
7. Standard Data Reporting

7.1 *Constituent Material Description*— Data reporting of the description of composite material constituents is documented in Guide E 1471.

7.2 *Composite Material Description*— Data reporting of the description of composite materials is documented in Guide E 1309.

7.3 *Composite Material Test Data*—Data reporting of mechanical test data results for composite materials is documented in Guide E 1434~~.~~

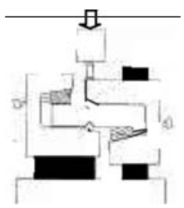
TABLE 1 *Continued*

Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments	
~~D 3410~~	- 	~~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.~~	
	D 3410/D 3410M	- 	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 ar Thickness m
		Compressive Modulus, Poisson's Ratio, Stress-Strain Response	Requires use of strain or displacement transducers.			
~~D 5467~~	- 	~~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 D 3410 or D 6641.~~	
D 5467/D 5467M		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 D 3410/D 3410M or D 6641/D 6641M.	
~~D 5449~~	- 	~~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.~~	
D 5449/D 5449M	- 	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.	
In-Plane Shear Test Methods						

~~**8.Keywords**~~

~~8.1bearing strength; coefficient of thermal expansion; composite materials; composites; compression; compressive strength; constituent content; crack-growth testing; creep; creep strength; CTE; curved-beam strength; damage; data recording; data records;~~

TABLE 1 *Continued*

Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments
~~D 3518~~		~~Shear Strength, Shear Modulus, Stress-Strain Response~~	~~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.~~	~~Widely used due to its low cost and relationship to actual structural laminates.~~
D 3518/D 3518M		Shear Strength, Shear Modulus, Stress-Strain Response	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.	Widely used due to its low cost and relationship to actual structural laminates.
~~D 5379~~		~~Shear Strength, Shear Modulus, Stress-Strain Response~~	~~V-notched specimen loaded in special bending fixture. 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.~~

~~delamination; density; elastic modulus; fatigue; fiber; fiber volume; filament; filled-hole compression strength; filled-hole tensile strength; flatwise tensile strength; flexural modulus; flexure; fracture; fracture toughness; gel time; glass transition temperature; hoop-wound; impact; impact strength; lamina; laminate; matrix content; mixed mode; mode I; mode II; mode III; modulus of elasticity; moisture content; moisture diffusivity; Poisson's ratio; OHC; OHT; open-hole compressive strength; open-hole tensile strength; out-of-plane compressive strength; out-of-plane shear strength; out-of-plane tensile strength; panel; plate; polymer matrix composites; prepreg; reinforcement; reinforcement content; reinforcement volume; resin; resin content; shear; shear modulus; shear strength; short-beam strength; specific heat; strain energy release rate; strength; structure; tensile strength; tension; thermal conductivity; thermal diffusivity; thermal expansion coefficient; tow; V-notched beam strength; void content; winding; yarn~~

TABLE 1 *Continued*

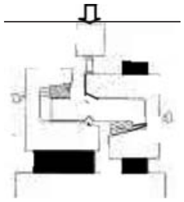
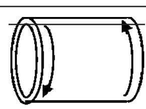
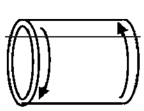
Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments
D 5379/D 5379M		Shear Strength, Shear Modulus, Stress-Strain Response	V-notched specimen loaded in special bending fixture. Along with D 7078/ D 7078M, provides the best shear response of the standardized methods. 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.
~~D 4255~~		~~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.~~
D 4255/D 4255M		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.
~~D 5448~~		~~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.~~
D 5448/D 5448M		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*

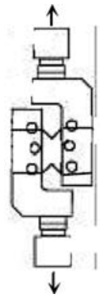
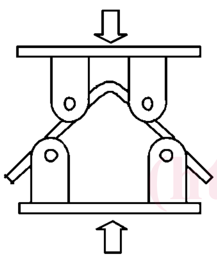
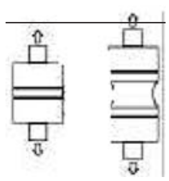
Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments
D 7078/D 7078M		Shear Strength, Shear Modulus, Stress-Strain Response	V-notched specimen loaded in rail shear fixture. Along with D 5379/ 5379M, provides the best shear response of the standardized methods. Provides shear modulus and strength. 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 D 5379/ D 5379M.	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 D 5379/D 5379M. The most accurate modulus measurements obtained from laminates of the [0/90} family.
Out-of-Plane Tensile Test Methods					
D 6415		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.
D 7291/D 7291M		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.
Out-of-Plane Shear Test Methods					

TABLE 1 *Continued*

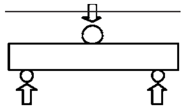
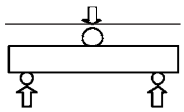
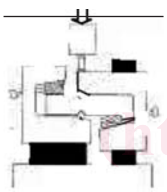
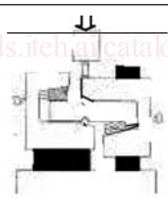
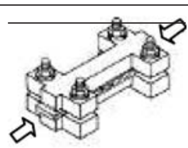
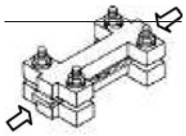
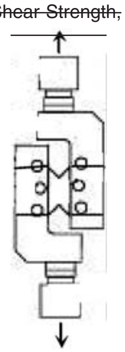
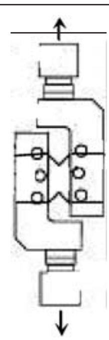
Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments
~~D 2344~~		~~Short Beam Strength~~	~~Short rectangular beam specimen loaded in 3-point bending.~~ ~~Short Beam Strength is a good indicator of resin-dominated properties.~~ ~~Simple, inexpensive specimen and test 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.~~
D 2344/D 2344M		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.
~~D 5379~~		~~Interlaminar Shear Strength, Interlaminar Shear Modulus~~	~~V-notched specimen loaded in special bending fixture.~~ ~~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.~~
D 5379/D 5379M		Interlaminar Shear Strength, Interlaminar Shear Modulus	V-notched specimen loaded in special bending fixture. Along with D 7078/D 7078M, 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.
~~D 3846~~		~~Shear Strength~~	~~Specimen with two machined notches loaded in compression.~~ ~~Suitable for randomly dispersed and continuous fiber reinforced materials.~~ ~~May be preferable to D 2344 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 D 695 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.~~

TABLE 1 *Continued*

Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments
D 3846	 -	Shear Strength	Specimen with two machined notches loaded in compression. Suitable for randomly dispersed and continuous fiber reinforced materials. May be preferable to D 2344/D 2344M 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 D 695 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.
Sandwich Flexural Test Methods					
C 393	Core Shear Strength,  - Core Shear Modulus, Sandwich Flexural Stiffness, Facesheet Compressive Strength, Facesheet Tensile Strength	Sandwich beam specimen for sandwich constructions. Ease of specimen construction and testing. Includes both 3-pointand 4-point techniques, fordifferent test objectives.	Method limited to 1D bending. Failures areoften dominated by stressconcentrations and secondary stresses at loadingpoints,especially with specimens having low-density coresand thin face sheets. Care must be exercised when test ing fo r core shear modulus toinsure that the beam geometry is such that simple sandwich beam theory is valid. Specimen must be care fully designedto obtain the desired failure mode.Since this method was developed for characterizing sand wich composite structures, results apply to a beam that could be made up of both composite and non-composite components. Therefore the failure may initiate in a non-composite element (core, adhesive) of the structure. Span-to-depth ratio >20:1 is recommended when testing for shear modulus. The ratio of face sheet thickness to core thickness (t/c) should be <0.10.		
D 7078/D 7078M	 -	Interlaminar Shear Strength, Interlaminar Shear Modulus	V-notched specimen loaded in rail shear fixture. Along with D 5379/c) should be <0.10.		