



Designation: D 4762 – 04

Standard Guide for Testing Polymer Matrix Composite Materials¹

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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:³

2.1.1 Standards of Committee D30 on Composite Materials C 393 Test Method for Flexural Properties of Sandwich Constructions

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.

- C 480 Test Method for Flexure Creep 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 Composite Materials and Their Laminates
- D 3039/D 3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials
- D 3171 Test Method 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
- 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 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
- D 3544 Guide for Reporting Test Methods and Results on High Modulus Fibers⁴
- D 3800 Test Method for Density of High-Modulus Fibers
- D 3878 Terminology of 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

⁴ Withdrawn.

- D 5448/D 5448M Test Method for In-Plane 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 Composites 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 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 Using the Combined Loading Compression (CLC) Test Fixture
- D 6671 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
- D 6856 Guide for Testing Fabric Reinforced Textile Composite Materials
- D 6873 Practice for Bearing Fatigue Testing of Polymer Matrix Composite Laminates
- 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 *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 Method for Determining the Izod Pendulum Impact Resistance of Plastics
- D 543 Test Method for Evaluating the Resistance of Plastics to Chemical Reagents
- 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- Force⁴
- 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 and 30°C 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 Method 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
- D 3846 Test Method for In-Plane Shear Strength of Reinforced Plastics
- D 4065 Practice for Plastics: Dynamical 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 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 Polymer Matrix Composite Materials

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	Table 4
Environmental Conditioning/Resistance	Table 5

3. Terminology

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

3.2 Symbolology 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 ≤ 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.

6. Standard Test Methods

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

7. Standard Data Reporting

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

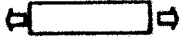

7.2 *Composite Material Description*—Data reporting of the description of composite materials is documented in Guide E 1309.

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

8. Keywords

8.1 bearing 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; 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 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.
		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.
In-Plane Compression Test Methods					
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.
		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.

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TABLE 1 *Continued*


Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments
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 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.
		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 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.
In-Plane Shear Test Methods					
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.

TABLE 1 *Continued*

Test Method	Specimen	Measured Property	Description and Advantages	Disadvantages	Comments
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.
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 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.
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.