



Designation: D7745 – 19

Standard Practice for Testing Pultruded Composites¹

This standard is issued under the fixed designation D7745; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope*

1.1 This protocol summarizes the applicable ASTM and other standard test methods commonly used for pultruded composites. The individual performance requirements to these test methods are defined by specific customer specifications.

1.2 This protocol also defines appropriate specimen locations for sampling from the pultruded composites.

1.3 This protocol does not discuss all possible standard test methods that may be utilized for pultruded composites.

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.*

NOTE 1—There is no known ISO equivalent to this guide.

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:²

- D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
- D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
- D495 Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation
- D570 Test Method for Water Absorption of Plastics

- D635 Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
- D638 Test Method for Tensile Properties of Plastics
- 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
- D732 Test Method for Shear Strength of Plastics by Punch Tool
- 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
- D883 Terminology Relating to Plastics
- D953 Test Method for Pin-Bearing Strength of Plastics
- D2291 Practice for Fabrication of Ring Test Specimens for Glass-Resin Composites
- D2343 Test Method for Tensile Properties of Glass Fiber Strands, Yarns, and Rovings Used in Reinforced Plastics
- D2344/D2344M Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates
- D2583 Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor
- D2584 Test Method for Ignition Loss of Cured Reinforced Resins
- D2734 Test Methods for Void Content of Reinforced Plastics
- D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials
- D3647 Practice for Classifying Reinforced Plastic Pultruded Shapes According to Composition
- D3846 Test Method for In-Plane Shear Strength of Reinforced Plastics
- D3914 Test Method for In-Plane Shear Strength of Pultruded Glass-Reinforced Plastic Rod
- D3916 Test Method for Tensile Properties of Pultruded Glass-Fiber-Reinforced Plastic Rod
- D3917 Specification for Dimensional Tolerance of Thermosetting Glass-Reinforced Plastic Pultruded Shapes
- D4065 Practice for Plastics: Dynamic Mechanical Properties: Determination and Report of Procedures
- D4385 Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products

¹ This practice is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.18 on Reinforced Thermosetting Plastics.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

D4475 Test Method for Apparent Horizontal Shear Strength of Pultruded Reinforced Plastic Rods By the Short-Beam Method

D4476 Test Method for Flexural Properties of Fiber Reinforced Pultruded Plastic Rods

D5028 Test Method for Curing Properties of Pultrusion Resins by Thermal Analysis

D5117 Test Method for Dye Penetration of Solid Fiberglass Reinforced Pultruded Stock

D5379/D5379M Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method

D5420 Test Method for Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Striker Impacted by a Falling Weight (Gardner Impact)

D6641/D6641M Test Method for Compressive Properties of Polymer Matrix Composite Materials Using a Combined Loading Compression (CLC) Test Fixture

D7029 Test Method for Determination of Reactivity of Unsaturated Polyesters and Vinyl Esters at 180.0°F (82.2°C)

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

D7290 Practice for Evaluating Material Property Characteristic Values for Polymeric Composites for Civil Engineering Structural Applications

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

D7792 Practice for Freeze/Thaw Conditioning of Pultruded Fiber Reinforced Polymer (FRP) Composites Used in Structural Designs

D7992 Practice for Elevated Temperature and Moisture Conditioning of Pultruded Fiber Reinforced Polymer (FRP) Composites Used in Structural Designs

D8019 Test Methods for Determining the Full Section Flexural Modulus and Bending Strength of Fiber Reinforced Polymer Crossarms Assembled with Center Mount Brackets

D8069 Test Method for Determining Flexural Modulus of Full Section Pultruded Fiber Reinforced Polymer (FRP) Composite Members with Doubly Symmetric Cross Sections under Bending

E84 Test Method for Surface Burning Characteristics of Building Materials

E662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials

E1922 Test Method for Translaminar Fracture Toughness of Laminated and Pultruded Polymer Matrix Composite Materials

F1092 Specification for Fiberglass (GRP) Pultruded Open-Weather Storm and Guard, Square Railing Systems

G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

2.2 *UL Standards:*

UL94 Tests for Flammability of Plastic Materials for Parts in Devices and Appliances³

3. Terminology

3.1 Terminology relating to pultruded composites is found in Terminology **D3917**.

4. Significance and Use

4.1 This practice is intended to aid in the selection of test protocols for reinforced pultruded composites.

4.2 This practice is intended to define the locations from which test specimens shall be taken from the reinforced pultruded composite.

5. General Requirements

5.1 All test specimens shall conform to the geometry and specimen quantity specified by the test methods of Section 2.

5.1.1 See Section 6.

5.2 All test specimens shall have a constant cross-section prior to machining the specimens.

5.3 The test specimens shall be machined from a flat constant thickness wall. The edges of the gage area of the test specimen shall be no closer than 3.18 mm (1/8 in.) from any deviation of the flat surface.

5.3.1 At least one specimen shall be taken from each side or flange of the pultruded shape.

5.4 Multiple sets of test specimens are required when:

5.4.1 The pultruded composite has two or more different thicknesses. A different set of specimens is required for each thickness of the pultruded shape.

5.4.2 The pultruded composite inherently has different reinforcement arrangements in different areas of the part such as the flange and web of W/I-Beams.

5.4.3 There are material overlaps required within the laminate for the pultruded composites such as tubes. The overlap area reinforcement is different from the remainder of the part.

5.4.4 Different reinforcement types or ratios are used for different sizes within the same general part geometry (for example, large and small tubes).

5.5 The flammability shall be tested on the thinnest wall of the thinnest pultruded composite of the same material configuration.

6. Simulated Plate Test

6.1 A simulated flat test plate shall be used when the required specimen geometry cannot be acquired from the pultruded composite. Round tubes are an example.

³ Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, <http://www.ul.com>.

6.2 The simulated test plate shall be used for all variations as identified in 5.4.

6.3 The simulated flat test plate shall have the same thickness and composite as the original pultruded shape.

7. Data Reporting

7.1 The data shall be reported as required by the specific test methods.

7.2 The report shall include the source of the specimens (for example, an actual pultruded composite or a flat plate simulation).

7.2.1 The report shall state if the off-axis reinforcement overlap has been considered if a flat plate simulation has been used.

TABLE 1 List of Practices and Specifications

Designation	Title	Scope
D883	Terminology Relating to Plastics	This terminology covers definitions of technical terms used in the plastics industry. Terms that are generally understood or adequately defined in other readily available sources are not included.
D2291	Practice for Fabrication of Ring Test Specimens for Glass-Resin Composites	This practice is intended for use in the fabrication of ring type test specimens to be used in the evaluation of the mechanical properties of reinforcement and resins in a composite structure. The practice outlines the steps in the preparation of the test specimens, including the final specimen machining where applicable. Four final ring configurations are included.
D3647	Practice for Classifying Reinforced Plastic Pultruded Shapes According to Composition	This practice outlines a method for classifying reinforced plastic pultruded shapes according to their composition.
D3917	Specification for Dimensional Tolerance of Thermosetting Glass-Reinforced Plastic Pultruded Shapes	This specification defines production tolerances applicable to standard rods, bars, shapes, and flat sheet pultruded from thermosetting glass-reinforced plastics.
D4065	Practice for Plastics: Dynamic Mechanical Properties: Determination and Report of Procedures	This practice is for general use in gathering and reporting dynamic mechanical data. It incorporates laboratory practice for determining dynamic mechanical properties of plastic specimens subjected to various oscillatory deformations on a variety of instruments of the type commonly called dynamic mechanical analyzers or dynamic thermo-mechanical analyzers.
D4385	Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products	This practice covers acceptance criteria for visual acceptance of thermosetting reinforced plastic pultruded rods, bars, shapes, and sheets.
D7290	Practice for Evaluating Material Property Characteristic Values for Polymeric Composites for Civil Engineering Structural Applications	This practice covers the procedures for computing characteristic values of material properties of polymeric composite materials intended for use in civil engineering structural applications. The characteristic value is a statistically-based material property representing the 80 % lower confidence bound on the 5th-percentile value of a specified population. Characteristic values determined using this standard practice can be used to calculate structural member resistance values in design codes for composite civil engineering structures and for establishing limits upon which qualification and acceptance criteria can be based.
D7745	Practice for Testing Pultruded Composites	This protocol summarizes the applicable ASTM and other standard test methods commonly used for pultruded composites. The individual performance requirements to these test methods are defined by specific customer specifications.
D7792	Practice for Freeze/Thaw Conditioning of Pultruded Fiber Reinforced Polymer (FRP) Composites Used in Structural Designs	In general, it is feasible that the mechanical properties of FRP composites will be affected by environmental conditions such as freeze/thaw cycling. In order to make reliable comparisons between different materials under freeze/thaw environmental conditions, it is necessary to standardize the freeze/thaw conditions to which specimens of these materials are subjected prior to and during testing. This practice defines procedures for freeze/thaw conditioning of pultruded FRP composites intended for use in structural design applications.

TABLE 1 *Continued*

Designation	Title	Scope
D7992	Practice for Elevated Temperature and Moisture Conditioning of Pultruded Fiber Reinforced Polymer (FRP) Composites Used in Structural Designs	In general, it is feasible that the mechanical properties of FRP composites will be affected by environmental conditions such as exposure to moisture at elevated temperatures. In order to make reliable comparisons between different materials under elevated temperature and moisture environmental conditions, it is necessary to standardize the elevated temperature and moisture conditions to which specimens of these materials are subjected prior to and during testing. This practice defines procedures for elevated temperature and moisture conditioning of pultruded FRP composites intended for use in structural design applications. The conditioning medium representing elevated temperature and moisture exposure described in this standard practice is distilled water maintained at $37.8 \pm 1.5^{\circ}\text{C}$ ($100 \pm 3^{\circ}\text{F}$) for 1000 hours.
F1092	Specification for Fiberglass (GRP) Pultruded Open-Weather Storm and Guard, Square Railing Systems	This specification provides the material requirements, construction, installation, and testing requirements for openweather deck, storm-and-guard, fiberglass square railing systems. Components are to be manufactured by the pultrusion process.
G154	Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials	This practice is limited to the basic principles for operating a fluorescent UV lamp and water apparatus; on its own, it does not deliver a specific result.

8. Standard Test Methods, Practices, and Specifications

8.1 Standard practices and specifications are summarized in **Table 1** and standard test methods for pultruded composites are summarized in **Table 2**. In **Table 1**, the standard number, title,


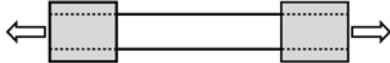
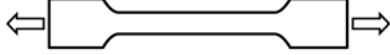

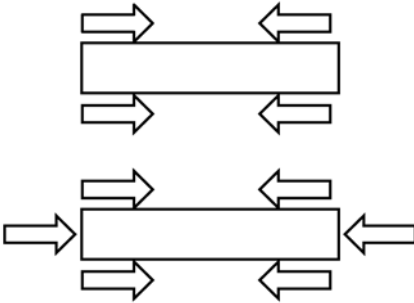
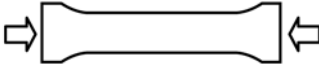
and an excerpt of the scope for each specification and practice are listed. In **Table 2**, examples of test fixtures or specimens, properties reported, and excerpts from the scope of each standard are included.

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TABLE 2 List of Test Methods

Method	Specimen/Test Configuration	Measured Properties	Scope
D3039/D3039M		Tensile Strength Modulus Poissons Ratio Stress-Strain Response	This test method determines the in-plane tensile properties of polymer matrix composite materials reinforced by high-modulus fibers. The composite material forms are limited to continuous fiber or discontinuous fiber-reinforced composites in which the laminate is balanced and symmetric with respect to the test direction.
D3916		Tensile Strength Tensile Modulus Stress-strain response	This test method describes a procedure for determining the tensile properties of pultruded, glass-fiber-reinforced thermosetting plastic rod of diameters ranging from 3.2 mm (1/8 in.) to 25.4 mm (1 in.).
D638		Tensile Strength Modulus Poissons Ratio Stress-Strain Response	This test method covers the determination of the tensile properties of unreinforced and reinforced plastics in the form of standard dumbbell-shaped test specimens when tested under defined conditions of pretreatment, temperature, humidity, and testing machine speed.
D2343		Tensile Strength Tensile Modulus Density of Glass Resin Content	This test method covers the determination of the comparative tensile properties of glass fiber strands, yarns, and rovings in the form of impregnated rod test specimens when tested under defined conditions of pretreatment, temperature, humidity, and tension testing machine speed.
D6641/D6641M		Compressive Strength Modulus Poisson's Ratio Stress-Strain Response	This test method determines the compressive strength and stiffness properties of polymer matrix composite materials using a combined loading compression (CLC) (1)2 test fixture.
D695		Compressive Strength Modulus Stress-Strain Response	This test method covers the determination of the mechanical properties of unreinforced and reinforced rigid plastics, including high modulus composites, when loaded in compression at relatively low uniform rates of straining or loading.

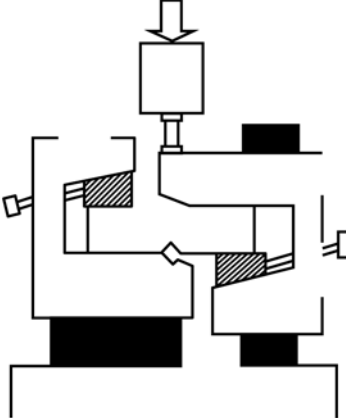


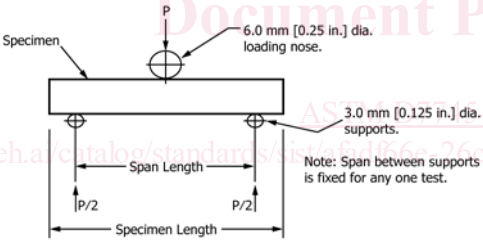
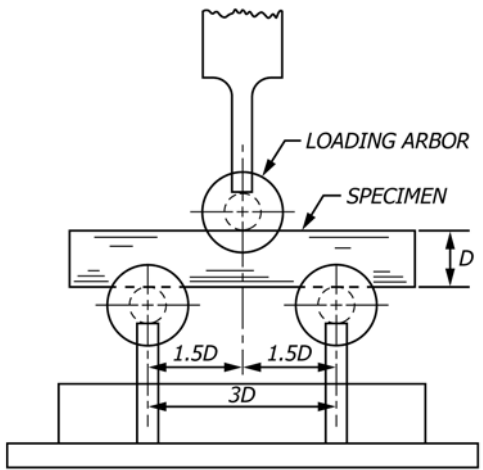
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TABLE 2 Continued

Method	Specimen/Test Configuration	Measured Properties	Scope
D5379/D5379M		Shear Strength Shear Modulus Stress-Strain Response	This test method covers the shear properties of composite materials reinforced by high-modulus fibers. The composite materials are limited to continuous-fiber or discontinuous-fiber-reinforced composites.
D3846		In-Plane Shear Strength	This test method covers the determination of the in-plane shear strength of reinforced thermosetting plastics in flat sheet form in thicknesses ranging from 2.54 to 6.60 mm (0.100 to 0.260 in.).
D3914		In-Plane Shear Strength	This test method covers the determination of the in-plane shear strength of pultruded, glass-fiber reinforced, thermosetting plastic rod of diameters ranging from 19 to 32 mm (¾ to 1¼ in.).
D2344/D2344M	 <p>Specimen</p> <p>6.0 mm [0.25 in.] dia. loading nose.</p> <p>3.0 mm [0.125 in.] dia. supports.</p> <p>Span Length</p> <p>Specimen Length</p> <p>$P/2$</p> <p>$P/2$</p> <p>Note: Span between supports is fixed for any one test.</p>	Short Beam Strength Failure Mode	This test method determines the short-beam strength of high-modulus fiber-reinforced composite materials.
D4475	 <p>LOADING ARBOR</p> <p>SPECIMEN</p> <p>$1.5D$</p> <p>$1.5D$</p> <p>$3D$</p> <p>D</p>	Apparent Shear Strength Type/Location of Failure	This test method covers the determination of the apparent horizontal shear strength of fiber reinforced plastic rods. The specimen is a short beam in the form of lengths of pultruded rods.