Designation: D5449/D5449M – 93 (Reapproved 2006)

Standard Test Method for Transverse Compressive Properties of Hoop Wound Polymer Matrix Composite Cylinders[1]

This standard is issued under the fixed designation D5449/D5449M; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method determines the transverse compressive properties of wound polymer matrix composites reinforced by high-modulus continuous fibers. It describes testing of hoop wound (90°) cylinders in axial compression for determination of transverse compressive properties.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text the inch-pound units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.3 *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]

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D883 Terminology Relating to Plastics
D2584 Test Method for Ignition Loss of Cured Reinforced Resins
D2734 Test Methods for Void Content of Reinforced Plastics
D3171 Test Methods for Constituent Content of Composite Materials
D3878 Terminology for Composite Materials
D5229/D5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
D5448/D5448M Test Method for Inplane Shear Properties of Hoop Wound Polymer Matrix Composite Cylinders
D5450/D5450M Test Method for Transverse Tensile Properties of Hoop Wound Polymer Matrix Composite Cylinders
E4 Practices for Force Verification of Testing Machines
E6 Terminology Relating to Methods of Mechanical Testing
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process
E132 Test Method for Poisson's Ratio at Room Temperature
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E251 Test Methods for Performance Characteristics of Metallic Bonded Resistance Strain Gauges
E456 Terminology Relating to Quality and Statistics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E1237 Guide for Installing Bonded Resistance Strain Gages

3. Terminology

3.1 *Definitions*—Terminology D3878 defines terms relating to high-modulus fibers and their composites. Terminology D883 defines terms relating to plastics. Terminology E6 defines terms relating to mechanical testing. Terminology E456 and Practice E177 defines terms relating to statistics. In the event of a conflict between terms, Terminology D3878 shall have precedence over other standards.

[1] This test method is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.04 on Lamina and Laminate Test Methods.

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

3.2 *Definitions of Terms Specific to This Standard:* [3]

3.2.1 *winding*—an entire part completed by one winding operation and then cured.

3.2.2 *hoop wound*, *n*—a winding of a cylindrical component in which the filaments are circumferentially oriented.

3.2.3 *specimen*—a single part cut from a winding. Each winding may yield several specimens.

3.2.4 *transverse compressive modulus,* E_{22}[$MT^{-2}L^{-1}$], *n*—the compressive elastic modulus of a unidirectional material in the direction perpendicular to the reinforcing fibers.

3.2.5 *transverse compressive strength,* $\sigma_{22}{}^{uc}$, [$MT^{-2}L^{-1}$], *n*—the strength of a unidirectional material when a compressive load is applied in the direction perpendicular to the reinforcing fibers.

3.2.6 *transverse compressive strain at failure,* $\varepsilon_{22}{}^{uc}$[*nd*], *n*—the value of strain, perpendicular to the reinforcing fibers in a unidirectional material, at failure when a compressive load is applied in the direction perpendicular to the reinforcing fibers.

4. Summary of Test Method

4.1 A thin-walled hoop wound cylinder nominally 100 mm [4 in.] in diameter and 140 mm [5½ in.] in length is bonded into two end fixtures. The specimen fixture assembly is mounted in the testing machine and monotonically loaded in compression while recording load. The transverse compressive strength can be determined from the maximum load carried before failure. If the coupon strain is monitored with strain gages then the stress-strain response, the compressive strain at failure, transverse compression modulus of elasticity, and Poisson's ratio can be derived.

5. Significance and Use

5.1 This test method is designed to produce transverse compressive property data for material specifications, research and development, quality assurance, and structural design and analysis. Factors that influence the transverse compressive response and should therefore be reported are: material, method of material preparation, specimen preparation, specimen conditioning, environment of testing, specimen alignment and gripping, speed of testing, void content, and fiber volume fraction. Properties in the test direction that may be obtained from this test method are:

5.1.1 Transverse compressive strength, $\sigma_{22}{}^{uc}$,

5.1.2 Transverse compressive strain at failure, $\varepsilon_{22}{}^{uc}$,

5.1.3 Transverse compressive modulus of elasticity, E_{22}, and

5.1.4 Poisson's ratio, γ_{21}.

6. Interference

6.1 *Material and Specimen Preparation*—Poor material fabrication practices, lack of control of fiber alignment, and damage induced by improper coupon machining are known causes of high material data scatter in composites.

6.2 *Bonding Specimens to Test Fixtures*—A high percentage of failures in or near the bond between the test specimen and the test fixture, especially when combined with high material data scatter, is an indicator of specimen bonding problems. Specimen to fixture bonding is discussed in 11.5.

6.3 *System Alignment*—Excessive bending may cause premature failure, as well as highly inaccurate modulus of elasticity determination. Every effort should be made to eliminate excess bending from the test system. Bending may occur as a result of misaligned grips, misaligned specimens in the test fixtures, or from departures of the specimens from tolerance requirements. The alignment should always be checked as discussed in 12.2.

7. Apparatus

7.1 *Micrometers*, suitable ball type for reading to within 0.025 ± 0.010 mm [0.001 ± 0.0004 in.] of the specimen inner and outer diameters. Flat anvil-type micrometer or calipers of similar resolution may be used for the overall specimen length and the gage length (the free length between the fixtures).

7.2 *Compression Fixture*—The compression fixture consists of a steel outer shell and insert. An assembly drawing for these components and the test fixture is shown in Fig. 1.

7.2.1 *Outer Shell*—The outer shell (SI units Fig. 2, English units Fig. 3) is circular with a concentric circular hollow in one face, a groove along the diameter of the other face, and a center hole through the thickness. Along the diameter perpendicular to the groove, three pairs of small eccentric holes are placed at three radial distances. The two outer pairs of holes are threaded. Four additional threaded holes are placed at the same radial distance as the innermost pair of holes at 90° intervals starting 45° from the diameter that passes through the center groove.

7.2.2 *Insert*—The fixture insert is circular with a center hole through the thickness (SI units Fig. 4, English units Fig. 5). Two sets of holes are placed along a concentric centerline. These holes align with the innermost set of holes in the outer

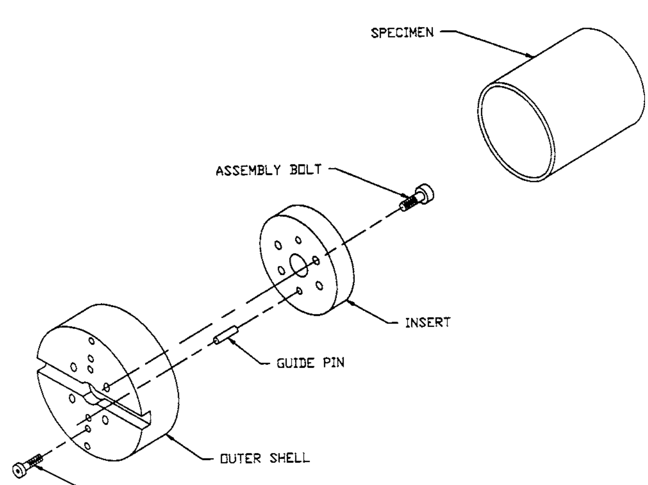

FIG. 1 Assembly Drawing for the Compression Fixture and Specimen

[3] If the term represents a physical quantity, its analytical dimensions are stated immediately following the term (or letter symbol) in fundamental dimension form, using the following ASTM standard symbology for fundamental dimensions, shown within square brackets: [*M*] for mass, [*L*] for length, [*T*] for time, [θ] for thermodynamic temperature, and [*nd*] for nondimensional quantities. Use of these symbols is restricted to analytical dimensions when used with square brackets, as the symbols may have other definitions when used without the brackets.