Designation: D8066/D8066M – 23

Standard Practice Unnotched Compression Testing of Polymer Matrix Composite Laminates[1]

This standard is issued under the fixed designation D8066/D8066M; 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 practice provides instructions for using the Test Method D6484/D6484M open hole compression test fixture to determine unnotched compressive strength of multi-directional laminates. The composite material forms are limited to continuous-fiber reinforced polymer matrix composites in which the laminate is both symmetric and balanced with respect to the test direction. The range of acceptable test laminates and thicknesses are described in 8.2.1.

1.2 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.2.1 Within the text the inch-pound units are shown in brackets.

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

1.4 *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:*

D695 Test Method for Compressive Properties of Rigid Plastics

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D883 Terminology Relating to Plastics

D3410/D3410M Test Method for Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading

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

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

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

D6507 Practice for Fiber Reinforcement Orientation Codes for Composite Materials

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

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

E6 Terminology Relating to Methods of Mechanical Testing

E132 Test Method for Poisson's Ratio at Room Temperature

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E456 Terminology Relating to Quality and Statistics

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard*—

NOTE 1—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 International standard symbology for fundamental dimensions, shown within square

[1] This test method is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.05 on Structural Test Methods.

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brackets: [M] for mass, [L] for length, [T] for time, [θ] for thermodynamic temperature, and [nd] for non-dimensional 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.

3.2.1 *nominal value, n*—a value, existing in name only, assigned to a measurable property for the purpose of convenient designation. Tolerances may be applied to a nominal value to define an acceptable range for the property.

3.3 *Symbols:*

A—cross-sectional area of a specimen

B_y—face-to-face percent bending in specimen

CV—sample coefficient of variation, in percent

E^c—laminate compressive modulus

$F^{unc}{}_x$—ultimate unnotched compressive strength in the test direction

h—specimen thickness

P^{max}—maximum force carried by test specimen prior to failure

P_1—load at ε_{x1}

P_2—load at ε_{x2}

w—specimen width

ε_{x1}—actual measured axial strain value nearest lower end of strain range used

ε_{x2}—actual measured axial strain value nearest upper end of strain range used

ε_{y1}—actual measured transverse strain value nearest lower end of strain range used

ε_{y2}—actual measured transverse strain value nearest upper end of strain range used

ε_{xg1}—indicated axial strain from Gage 1 (used in % bending equation)

ε_{xg2}—indicated axial strain from Gage 2 (used in % bending equation)

$\nu_{xy}{}^c$—Compressive Poisson's ratio

4. Summary of Practice

4.1 In accordance with Test Method D6484/D6484M, perform a uniaxial compression test of a balanced, symmetric laminate without a hole.

5. Significance and Use

5.1 This practice provides supplemental instructions for the use of Test Method D6484/D6484M to determine unnotched compressive strength data for material specifications, research and development, material design allowables, and quality assurance. Factors that influence compressive strengths and shall therefore be reported include the following: material, methods of material fabrication, accuracy of lay-up, laminate stacking sequence and overall thickness, specimen preparation, specimen conditioning, environment of testing, specimen alignment and gripping, speed of testing, time at temperature, void content, and volume percent reinforcement. Composite properties in the test direction that may be obtained from this test method include:

5.1.1 Unnotched compressive (UNC) strength, $F_x{}^{unc}$,

5.1.2 Ultimate compressive strain,

5.1.3 Compressive (linear or chord) modulus of elasticity, E^c, and

5.1.4 Poisson's ratio in compression.

5.2 This practice provides a compression test method for laminates containing fibers in multiple fiber directions, particularly those combining axial (0 degree) fibers and off-axis (± θ degree) fibers. Other compression strength test methods include SACMA SRM-1 (also known as the modified D695), D3410/D3410M, D5467/D5467M, D6641/D6641M, and D7249/D7249M. The SRM-1 test uses 12.6 mm [0.50 in.] wide specimens, which is only appropriate for unidirectional tape, cross-ply [0/90]ns tape, or small unit-cell-size fabrics (e.g. 3K-70-P). Larger cell-size fabrics (for example, spread-tow 12K fabrics) should be tested with wider specimens. The standard D3410/D3410M and D6641/D6641M test fixtures do permit the use of wider specimens, for example, 25.4 mm [1.0 in.] wide, and thus can be used to test laminates containing both axial and off-axis fibers; however their gage lengths are relatively short. Test Method D5467/D5467M is intended to obtain the compressive strength of unidirectional laminates, but is expensive due to the sandwich beam configuration. Test Method D7249/D7249M is intended to obtain the compressive strength of sandwich facesheets.

5.2.1 Advantages of this practice include:

5.2.1.1 Avoiding the use of tabs, which are typically required with the end-loaded SRM-1 specimen, which are often required with the shear loaded Test Method D3410/D3410M specimen, and sometimes required with the Test Method D6641/D6641M test specimen, in order to obtain valid failure modes, and

5.2.1.2 Longer and wider gage section imposing less constraint on in-plane transverse displacement.

5.2.2 Disadvantages of this practice include:

5.2.2.1 Longer and wider specimen, thus consuming more material than other standards noted above

6. Interferences

6.1 *Environment*—Results are affected by the environmental conditions under which the tests are conducted. Laminates tested in various environments can exhibit significant differences in both failure force and failure mode. Experience has demonstrated that elevated temperature, humid environments are generally critical for compressive strength. However, critical environments must be assessed independently for each material system and stacking sequence tested.

6.2 *Material Orthotropy*—The degree of laminate orthotropy strongly affects the failure mode and measured strengths. Valid strength results should only be reported when appropriate failure modes are observed, according to Section 12.

6.3 *Thickness Scaling*—Thick composite structures do not necessarily fail at the same strengths as thin structures with the same laminate orientation (that is, strength does not always scale linearly with thickness). Thus, data gathered using the test method described in this practice may not translate directly into equivalent thick-structure properties.

6.4 *Support Fixture*—Results are affected by the amount of lateral pressure applied to the test specimen by the support fixture. Sources of variation in this lateral pressure include fixture grip surface, fixture bolt torque, hydraulic gripping