Designation: D6484/D6484M – 23

Standard Test Method for Open-Hole Compressive Strength of Polymer Matrix Composite Laminates[1]

This standard is issued under the fixed designation D6484/D6484M; 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 test method determines the open-hole compressive strength of multidirectional polymer matrix composite laminates reinforced by high-modulus fibers. The composite material forms are limited to continuous-fiber or discontinuous-fiber (tape or fabric, or both) reinforced composites in which the laminate is balanced and symmetric with respect to the test direction. The range of acceptable test laminates and thicknesses are described in 8.2.1.

1.2 Several related ASTM standards reference the procedures and apparatus described within this test method. In particular, the support fixture described in 7.2 is used by several other standards to stabilize compression-loaded test specimens. These include Practice D6742/D6742M, which covers filled-hole compression testing; Practice D7615/D7615M, which covers open-hole fatigue testing; and Practice D8066/D8066M, which covers unnotched laminate compression testing.

1.3 *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.

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

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.*

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]

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

D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials

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

D5687/D5687M Guide for Preparation of Flat Composite Panels with Processing Guidelines for Specimen Preparation

D6742/D6742M Practice for Filled-Hole Tension and Compression Testing of Polymer Matrix Composite Laminates

D7615/D7615M Practice for Open-Hole Fatigue Response of Polymer Matrix Composite Laminates

D8066/D8066M Practice Unnotched Compression Testing of Polymer Matrix Composite Laminates

D8509 Guide for Test Method Selection and Test Specimen Design for Bolted Joint Related Properties

E4 Practices for Force Calibration and Verification of Testing Machines

E6 Terminology Relating to Methods of Mechanical Testing

E83 Practice for Verification and Classification of Extensometer Systems

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

[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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[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.

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E456 Terminology Relating to Quality and Statistics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

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 define terms relating to statistics. In the event of a conflict between terms, Terminology D3878 shall have precedence over the other terminologies.

3.2 *Definitions of Terms Specific to This Standard*—Refer to Guide D8509.

3.3 *Symbols:*

A—cross-sectional area of a specimen

CV—coefficient of variation statistic of a sample population for a given property (in percent)

B_z—edgewise percent bending

D—hole diameter

h—specimen thickness

n—number of specimens per sample population

N—number of plies in laminate under test

F_x^{ohcu}—ultimate open hole (notched) compressive strength in the test direction

P_{max}—maximum force carried by test specimen before failure

r—95 % repeatability confidence limit, equal to 2.8 times the repeatability standard deviation

R—95 % reproducibility confidence limit, equal to 2.8 times the reproducibility standard deviation

S_{n-1}—standard deviation statistic of a sample population for a given property

S_r—repeatability (within laboratory precision) standard deviation, calculated in accordance with Practice E691

S_R—reproducibility (between laboratory precision) standard deviation, calculated in accordance with Practice E691

w—specimen width

x_1—test result for an individual specimen from the sample population for a given property

$\bar{x}$—mean or average (estimate of mean) of a sample population for a given property

σ—normal stress

4. Summary of Test Method

4.1 A uniaxial compression test of a balanced, symmetric laminate is performed with a centrally located hole. Edge-mounted extensometer displacement transducers are optional. Refer to Guide D8509 for additional test details.

4.2 The test specimen is face-supported in a multi-piece bolted support fixture. Two acceptable test procedures are provided. In Procedure A, the specimen/fixture assembly is clamped in hydraulic wedge grips. The force is transmitted by shear into the support fixture and then is transmitted by shear into the test specimen. In Procedure B, the specimen/fixture assembly is placed between flat platens, such that the specimen and fixture are end-loaded. The portion of the force initially transferred into the support fixture is transmitted by shear into the test specimen.

5. Significance and Use

5.1 Refer to Guide D8509.

6. Interferences

6.1 Refer to Guide D8509.

7. Apparatus

7.1 *Micrometers and Calipers*—A micrometer with a 4 mm to 8 mm [0.16 in. to 0.32 in.] nominal diameter ball interface or a flat anvil interface shall be used to measure the specimen thickness. A ball interface is recommended for thickness measurements when at least one surface is irregular (for example, a coarse peel ply surface which is neither smooth nor flat). A micrometer or caliper with a flat anvil interface shall be used for measuring length, width, and other machined surface dimensions. The use of alternative measurement devices is permitted if specified (or agreed to) by the test requestor and reported by the testing laboratory. The accuracy of the instruments shall be suitable for reading to within 1 % of the specimen dimensions. For typical specimen geometries, an instrument with an accuracy of ±0.0025 mm [±0.0001 in.] is adequate for the thickness measurement, while an instrument with an accuracy of ±0.025 mm [±0.001 in.] is adequate for measurement of length, width, and other machined surface dimensions. Additionally, a micrometer or gauge capable of determining the hole diameter to ±0.025 mm [±0.001 in.] shall be used.

7.2 *Support Fixture*—The fixture is a face-supported compressive test fixture as shown in Fig. 1. The fixture consists of two short-grip/long-grip assemblies, two support plates, and steel shims as required to maintain a nominally zero (0.00 mm to 0.12 mm [0.000 in. to 0.005 in.] tolerance) gap between support plates and long grips. If this gap does not meet the minimum requirement, shim the contact area between the support plate and the short grip with steel shim stock. If the gap is too large, shim between the support plate and the long grip, holding the shim stock on the support plate with tape. Fig. 2 shows shim requirements. The fixture should be checked for conformity to engineering drawings. Each short-grip/long-grip assembly is line-drilled as shown in Figs. A2.1 and A1.1 and must be used as a matched set. The threading of the support plate is optional. Standard test specimens are 36 mm by 300 mm [1.5 in. by 12 in.]. In Procedure A, the fixture is hydraulically gripped on each end and the compressive force is transmitted by means of friction through the fixture and into the test specimen. In Procedure B, the fixture is placed between flat platens and loaded in compression at each end; force introduced into the fixture is transmitted by means of friction into the test specimen. A cutout exists on both faces of the fixture for a thermocouple, fastener, or extensometer, if required by the requesting organization. The long and short fixtures have an undercut along the corner of the specimen grip area so that specimens are not required to be chamfered and to avoid damage caused by the radius. The fixtures also allow a slight