



Designation: D5766/D5766M – 23

Standard Test Method for Open-Hole Tensile Strength of Polymer Matrix Composite Laminates¹

This standard is issued under the fixed designation D5766/D5766M; 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 tensile 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 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

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:*²

D792 Test Methods for Density and Specific Gravity (Rela-

tive 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

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

E6 Terminology Relating to Methods of Mechanical Testing

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

E1309 Guide for Identification of Fiber-Reinforced Polymer-Matrix Composite Materials in Databases (Withdrawn 2015)³

E1434 Guide for Recording Mechanical Test Data of Fiber-Reinforced Composite Materials in Databases (Withdrawn 2015)³

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 standards.

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

3.3 *Symbols:*

A = cross-sectional area of a specimen

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.

³ The last approved version of this historical standard is referenced on www.astm.org.

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

D = hole diameter

h = specimen thickness

n = number of specimens per sample population

N = number of plies in laminate under test

F_x^{OHTu} = ultimate open-hole (notched) tensile strength in the test direction

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

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_i = 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 tension test of a balanced, symmetric laminate is performed in accordance with Test Method D3039/D3039M, although with a centrally located hole. Edge-mounted extensometer displacement transducers are optional. Refer to Guide D8509 for additional test details.

5. Significance and Use

5.1 Refer to Guide D8509.

6. Interferences

6.1 Refer to Guide D8509.

7. Apparatus

7.1 Apparatus shall be in accordance with Test Method D3039/D3039M. Additionally, a micrometer or gauge capable of determining the hole diameter to ± 0.025 mm [± 0.001 in.] is required.

8. Sampling and Test Specimens

8.1 *Sampling*—Sampling shall be in accordance with Test Method D3039/D3039M.

8.2 *Geometry*—The specimen geometry shall be in accordance with Test Method D3039/D3039M, as modified by the following, and illustrated by the schematic of Fig. 1. Any variation of the stacking sequence, specimen width or length, or hole diameter from that specified shall be clearly noted in the report.

8.2.1 *Stacking Sequence*—The standard laminate shall have multidirectional fiber orientations (fibers shall be oriented in a minimum of two directions), and balanced and symmetric stacking sequences. Nominal thickness shall be 2.5 mm [0.10 in.], with a permissible range of 2 mm to 4 mm [0.080 in.

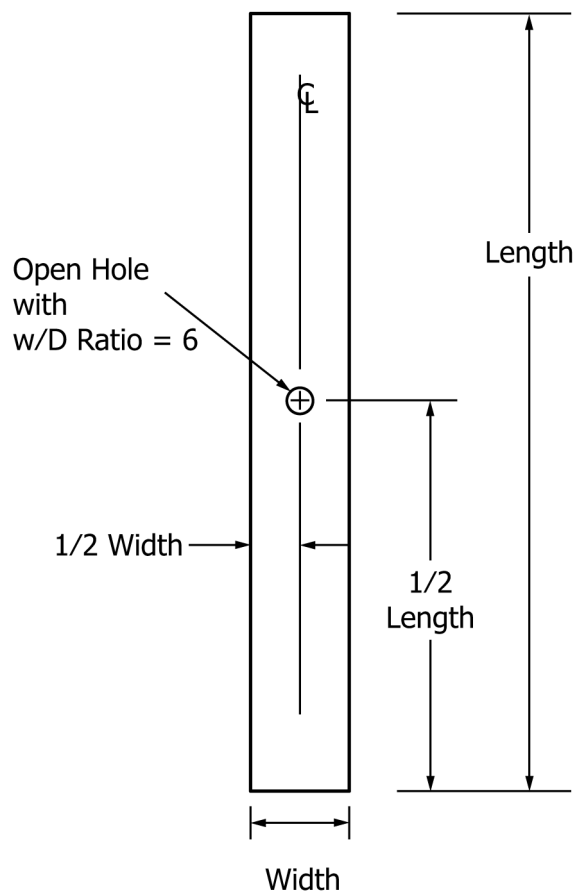


FIG. 1 Schematic of Open-Hole Tension Test Specimen

to 0.160 in.], inclusive. Fabric laminates containing satin-type weaves shall have symmetric warp surfaces, unless otherwise noted in the report.

NOTE 1—Typically a $[45_i/-45_j/0_k/90_k]_{\text{ms}}$ tape or $[45_i/0_j]_{\text{ms}}$ fabric laminate should be selected such that a minimum of 5 % of the fibers lay in each of the four principal orientations. This laminate design has been found to yield the highest likelihood of acceptable failure modes.

8.2.2 Configuration:

8.2.2.1 *Configuration A*—The width of the specimen is $36 \text{ mm} \pm 1 \text{ mm}$ [$1.50 \text{ in.} \pm 0.05 \text{ in.}$] and the length range is 200 mm to 300 mm [8.0 in. to 12.0 in.]. The notch consists of a centrally located hole, $6 \text{ mm} \pm 0.06 \text{ mm}$ [$0.250 \text{ in.} \pm 0.003 \text{ in.}$] in diameter, centered by length to within 0.12 mm [0.005 in.] and by width to within 0.05 mm [0.002 in.]. While tabs may be used, they are not required and generally not needed, since the open hole acts as sufficient stress riser to force failure in the notched region. Configuration A is preferred for the general laminate stacking sequences defined in 8.2.1 because it is long enough to ensure a uniform strain field is achieved in the specimen outside of the influence of the hole.

8.2.2.2 *Configuration B*—The width of the specimen is $36 \text{ mm} \pm 1 \text{ mm}$ [$1.50 \text{ in.} \pm 0.05 \text{ in.}$] and the length range is 150 mm to 200 mm [6.0 in. to 8.0 in.]. The notch consists of a centrally located hole, $6 \text{ mm} \pm 0.06 \text{ mm}$ [$0.250 \text{ in.} \pm 0.003 \text{ in.}$] in diameter, centered by length to within 0.12 mm [0.005 in.] and by width to within 0.05 mm [0.002 in.]. While tabs may be used, they are not required and generally not