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.

Designation: D5961/D5961M – 23

# Standard Test Method for Bearing Response of Polymer Matrix Composite Laminates[1]

This standard is issued under the fixed designation D5961/D5961M; 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 covers the bearing response of pinned or fastened joints using multi-directional polymer matrix composite laminates reinforced by high-modulus fibers by double-shear tensile loading (Procedure A), single-shear tensile or compressive loading of a two-piece specimen (Procedure B), single-shear tensile loading of a one-piece specimen (Procedure C), or double-shear compressive loading (Procedure D). Standard specimen configurations using fixed values of test parameters are described for each procedure. However, when fully documented in the test report, a number of test parameters may be optionally varied. The composite material forms are limited to continuous-fiber or discontinuous-fiber (tape or fabric, or both) reinforced composites for 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 This test method is consistent with the recommendations of MIL-HDBK-17, which describes the desirable attributes of a bearing response test method.

1.3 The multi-fastener test configurations described in this test method are similar to those used by industry to investigate the bypass portion of the bearing bypass interaction response for bolted joints, where the specimen may produce either a bearing failure mode or a bypass failure mode. Note that the scope of this test method is limited to bearing and fastener failure modes. Use Test Method D7248/D7248M for by-pass testing.

1.4 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.

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

1.5 *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.*

1.6 *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

D953 Test Method for Pin-Bearing Strength of 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

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

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

D7248/D7248M Test Method for High Bearing - Low Bypass Interaction Response of Polymer Matrix Composite Laminates Using 2-Fastener Specimens

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

[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.

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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
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E238 Test Method for Pin-Type Bearing Test of Metallic Materials
E456 Terminology Relating to Quality and Statistics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 *Other Document:*
MIL-HDBK-17, *Polymer Matrix Composites*, Vol 1, Section 7[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 documents.

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 standard symbology for fundamental dimensions, shown within square brackets: [*M*] for mass, [*L*] for length, [*T*] for time, [*I*] 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.

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

3.3 *Symbols:*

$A$ = minimum cross-sectional area of a specimen
$CV$ = coefficient of variation statistic of a sample population for a given property (in percent)
$d$ = fastener or pin diameter
$D$ = specimen hole diameter
$d_{csk}$ = countersink depth
$d_{fl}$ = countersink flushness (depth or protrusion of the fastener in a countersunk hole)
$e$ = distance, parallel to force, from hole center to end of specimen; the edge distance
$E_x^{br}$ = bearing chord stiffness in the test direction specified by the subscript (for determination of offset bearing strength)
$f$ = distance, parallel to force, from hole edge to end of specimen
$F_x^{bru}$ = ultimate bearing strength in the test direction specified by the subscript
$F_x^{bro}$ ($e$ %) = offset bearing strength (at $e$ % bearing strain offset) in the test direction specified by the subscript
$g$ = distance, perpendicular to force, from hole edge to shortest edge of specimen
$h$ = specimen thickness
$k$ = calculation factor used in bearing equations to distinguish single-fastener tests from double-fastener tests
$K$ = calculation factor used in bearing equations to distinguish hole deformation in one member of the assembly from hole deformation shared between two members of the assembly in a strain equation
$L_g$ = extensometer gage length
$n$ = number of specimens per sample population
$P$ = force carried by test specimen
$P^f$ = force carried by test specimen at failure
$P^{max}$ = maximum force carried by test specimen prior to failure
$s_{n-1}$ = standard deviation statistic of a sample population for a given property
$w$ = 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
$\delta$ = extensional displacement
$\varepsilon$ = general symbol for strain, whether normal strain or shear strain
$\varepsilon^{br}$ = bearing strain
$\sigma^{br}$ = bearing stress

## 4. Summary of Test Method

4.1 *Procedure A, Double Shear, Tension:*

4.1.1 A flat, constant rectangular cross-section test specimen with a centerline hole located near the end of the specimen, as shown in the test specimen drawings of Figs. 1 and 2, is loaded at the hole in bearing. The bearing force is normally applied through a close-tolerance, lightly torqued fastener (or pin) that is reacted in double shear by a fixture similar to that shown in Fig. 3 and Fig. A1.1. The bearing force is created by loading the assembly in tension in a testing machine.

4.1.2 Refer to Guide D8509 for additional test details and for the standard test configuration.

4.2 *Procedure B, Single Shear, Two-Piece Specimen:*

4.2.1 The flat, constant rectangular cross-section test specimen is composed of two like halves fastened together through one or two centerline holes located near one end of each half, as shown in the test specimen drawings of Figs. 4-7. The eccentricity in applied force that would otherwise result is minimized by a doubler bonded to, or frictionally retained against each grip end of the specimen, resulting in a force line-of-action along the interface between the specimen halves, through the centerline of the hole(s).

4.2.1.1 *Unstabilized Configuration (No Support Fixture)*—The ends of the test specimen are gripped in the jaws of a test machine and loaded in tension.

4.2.1.2 *Stabilized Configuration (Using Support Fixture)*—The test specimen is face-supported in a multi-piece bolted support fixture, similar to that shown in Fig. 8. The test specimen/fixture assembly is clamped in hydraulic wedge grips and the force is sheared into the support fixture and then

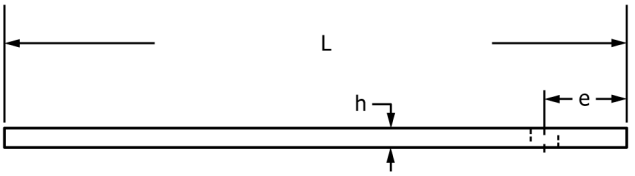
[3] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.

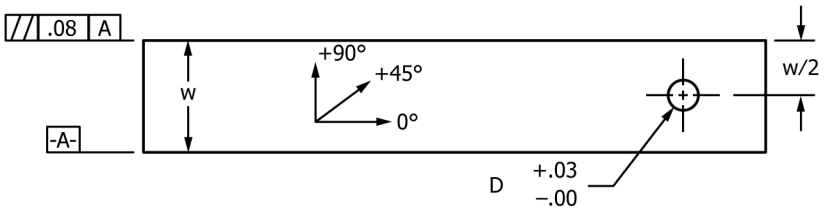
DRAWING NOTES:

1. INTERPRET DRAWING IN ACCORDANCE WITH ANSI Y14.5M-1982, SUBJECT TO THE FOLLOWING:
2. ALL DIMENSIONS IN MILLIMETRES WITH DECIMAL TOLERANCES AS FOLLOWS:

| NO DECIMAL | .X | .XX |
|---|---|---|
| ±1 | ±0.3 | ±0.1 |

3. ALL ANGLES HAVE TOLERANCE OF ± .5°.
4. PLY ORIENTATION DIRECTION TOLERANCE RELATIVE TO -A- IS RECOMMENDED TO BE WITHIN ± .5°. (See Section 6.1.)
5. FINISH ON MACHINED EDGES NOT TO EXCEED 1.6 (SYMBOLOGY IN ACCORDANCE WITH ASA B46.1, WITH ROUGHNESS HEIGHT IN MICROMETRES.)
6. VALUES TO BE PROVIDED FOR THE FOLLOWING, SUBJECT TO ANY RANGES SHOWN ON THE FIELD OF DRAWING: MATERIAL, LAY-UP, PLY ORIENTATION REFERENCE RELATIVE TO -A-, OVERALL LENGTH, HOLE DIAMETER, AND COUPON THICKNESS
7. FOR PROCEDURE D, REDUCE LENGTH, L, AS REQUIRED IN ORDER TO PREVENT BUCKLING




| Parameter | Standard Dimension, mm |
|---|---|
| fastener or pin diameter, d | 6 + 0.00/–0.03 |
| hole diameter, D | 6 + 0.03/–0.00 |
| thickness range, h | 2-4 |
| length, L | 135 |
| width, w | 36 ± 1 |
| edge distance, e | 18 ± 1 |
| countersink | none |

**FIG. 1 Double-Shear and Single-Shear One-Piece Test Specimen Drawing (SI)**

sheared into the specimen. The stabilized configuration is primarily intended for compressive loading, although the specimen/fixture assembly may be loaded in either tension or compression.

4.2.2 Refer to Guide D8509 for additional test details and for the standard test configuration.

4.3 *Procedure C, Single Shear, One-Piece Specimen:*

4.3.1 A flat, constant rectangular cross-section test specimen with a centerline hole located near the end of the specimen, as shown in the test specimen drawings of Figs. 1 and 2, is loaded at the hole in bearing. The bearing force is normally applied, by a fixture similar to that shown in Fig. A2.1, through a close-tolerance, lightly torqued fastener that is reacted in single shear, as shown in Fig. 9. The bearing force is created by loading the assembly in tension in a testing machine.

4.3.2 Refer to Guide D8509 for additional test details and for the standard test configuration.

4.4 *Procedure D, Double Shear, Compression:*

4.4.1 A flat, constant rectangular cross-section test specimen with a centerline hole located near the end of the specimen, as shown in the test specimen drawings of Figs. 1 and 2, is loaded at the hole in bearing. The bearing force is normally applied, by a fixture similar to that shown in Fig. A3.1, through a close-tolerance, lightly torqued fastener (or pin) that is reacted in double shear, as shown in Fig. 10. The bearing force is created by loading the assembly in compression in a testing machine.

4.4.2 Refer to Guide D8509 for additional test details and for the standard test configuration.

## 5. Significance and Use

5.1 Refer to Guide D8509.

## 6. Interferences

6.1 Refer to Guide D8509.