Designation: D 5961/D 5961M – 05$^{\epsilon 1}$

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

This standard is issued under the fixed designation D 5961/D 5961M; 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.

ε[1] NOTE—The units of measurement in the last sentence of 7.1 were corrected editorially in April 2007.

1. Scope

1.1 This test method covers the bearing response of multi-directional polymer matrix composite laminates reinforced by high-modulus fibers by either double-shear (Procedure A) tensile loading or single-shear (Procedure B) tensile or compressive loading of a specimen. 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. While this test method may be referenced as guidance in bearing bypass test programs, the scope of this test method is limited to bearing failure modes.

1.4 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.

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

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D 883 Terminology Relating to Plastics
D 953 Test Method for Bearing Strength of Plastics
D 2584 Test Method for Ignition Loss of Cured Reinforced Resins
D 2734 Test Method for Void Content of Reinforced Plastics
D 3171 Test Method for Constituent Content of Composite Materials
D 3878 Terminology for Composite Materials
D 5229/D 5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
D 5687/D 5687M Guide for Preparation of Flat Composite Panels with Processing Guidelines for Specimen Preparation
E 4 Practices for Force Verification of Testing Machines
E 6 Terminology Relating to Methods of Mechanical Testing
E 83 Practice for Verification and Classification of Extensometer System
E 122 Practice for Calculating Sample Size to Estimate, With a Specified Tolerable Error, the Average for a Characteristic of a Lot or Process
E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E 238 Test Method for Pin-Type Bearing Test of Metallic Materials
E 456 Terminology Relating to Quality and Statistics
E 1309 Guide for Identification of Fiber-Reinforced

[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.

Current edition approved March 1, 2005. Published March 2005. Originally approved in 1996. Last previous edition approved in 2001 as D 5961/D 5961M – 01 ε1 .

[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.

Polymer-Matrix Composite Materials in Databases

E 1434 Guide for Recording Mechanical Test Data of Fiber-Reinforced Composite Materials in Databases

E 1471 Guide for Identification of Fibers, Fillers, and Core Materials in Computerized Material Property Databases

2.2 *Other Document:*

MIL-HDBK-17, *Polymer Matrix Composites*, Vol 1, Section 7[3]

3. Terminology

3.1 *Definitions*—Terminology D 3878 defines terms relating to high-modulus fibers and their composites. Terminology D 883 defines terms relating to plastics. Terminology E 6 defines terms relating to mechanical testing. Terminology E 456 and Practice E 177 define terms relating to statistics. In the event of a conflict between terms, Terminology D 3878 shall have precedence over the other documents.

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 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.

3.3 *bearing area,* [L^2], *n*—the area of that portion of a bearing specimen used to normalize applied loading into an effective bearing stress; equal to the diameter of the loaded hole multiplied by the thickness of the specimen.

3.4 *bearing chord stiffness,* E^{br}[*ML*-1*T*-2], *n*—the chord stiffness between two specific bearing stress or bearing strain points in the linear portion of the bearing stress/bearing strain curve.

3.5 *bearing load, P* [MLT^2], *n*—the total load carried by a bearing specimen.

3.6 *bearing strain,* $\epsilon,^{br}$[*nd*], *n*—the normalized hole deformation in a bearing specimen, equal to the deformation of the bearing hole in the direction of the bearing load, divided by the diameter of the hole.

3.7 *bearing strength,* F_x^{br}[*ML*-1*T*-2], *n*—the value of bearing stress occurring at a significant event on the bearing stress/bearing strain curve.

3.7.1 *Discussion*—Two types of bearing strengths are commonly identified, and noted by an additional superscript: offset strength and ultimate strength.

3.8 *bearing stress,* F^{br}[*ML*-1*T*-2], *n*—the bearing load divided by the bearing area.

3.9 *diameter to thickness ratio, D/h [nd], n—in a bearing specimen*, the ratio of the hole diameter to the specimen thickness.

3.9.1 *Discussion*—The diameter to thickness ratio may be either a nominal value determined from nominal dimensions or an actual value determined from measured dimensions.

3.10 *edge distance ratio, e/D [nd], n—in a bearing specimen*, the ratio of the distance between the center of the hole and the specimen end to the hole diameter.

3.10.1 *Discussion*—The edge distance ratio may be either a nominal value determined from nominal dimensions or an actual value determined from measured dimensions.

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

3.12 *offset bearing strength,* F_x^{bro}[*ML*-1*T*-2], *n*—the value of bearing stress, in the direction specified by the subscript, at the point where a bearing chord stiffness line, offset along the bearing strain axis by a specified bearing strain value, intersects the bearing stress/bearing strain curve.

3.12.1 *Discussion*—Unless otherwise specified, an offset bearing strain of 2 % is to be used in this test method.

3.13 *width to diameter ratio, w/D [nd], n—in a bearing specimen*, the ratio of specimen width to hole diameter.

3.13.1 *Discussion*—The width to diameter ratio may be either a nominal value determined from nominal dimensions or an actual value, determined as the ratio of the actual specimen width to the actual hole diameter.

3.14 *ultimate bearing strength,* F_x^{bru}[*ML*-1*T*-2], *n*—the value of bearing stress, in the direction specified by the subscript, at the maximum load capability of a bearing specimen.

3.15 *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

e = distance, parallel to load, from hole center to end of specimen; the edge distance

E_x^{br} = bearing chord stiffness in the test direction specified by the subscript

f = distance, parallel to load, 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 load, 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 single-shear tests from double-shear tests in a single bearing strain equation

L_g = extensometer gage length

n = number of specimens per sample population

P = load carried by test specimen

P^f = load carried by test specimen at failure

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

[3] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

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

°δ = extensional displacement

ϵ = general symbol for strain, whether normal strain or shear strain

ϵ^{br} = bearing strain

σ^{br} = *bearing stress*

w = specimen width

d_{csk} = countersink depth

d_{fl} = countersink flushness (depth or protrusion of the fastener in a countersunk hole)

4. Summary of Test Method

4.1 *Procedure A, Double Shear*:

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 load 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 Figs. 3 and 4. The bearing load is created by pulling the assembly in tension in a testing machine.

4.1.2 Both the applied load and the associated deformation of the hole are monitored. The hole deformation is normalized by the hole diameter to create an effective bearing strain. Likewise, the applied load is normalized by the projected hole area to create an effective bearing stress. The specimen is loaded until a load maximum has clearly been reached, whereupon the test is terminated so as to prevent masking of the true failure mode by large-scale hole distortion, in order to provide a more representative failure mode assessment. Bearing stress versus bearing strain for the entire loading regime is plotted, and failure mode noted. The ultimate bearing strength of the material is determined from the maximum load carried prior to test termination.

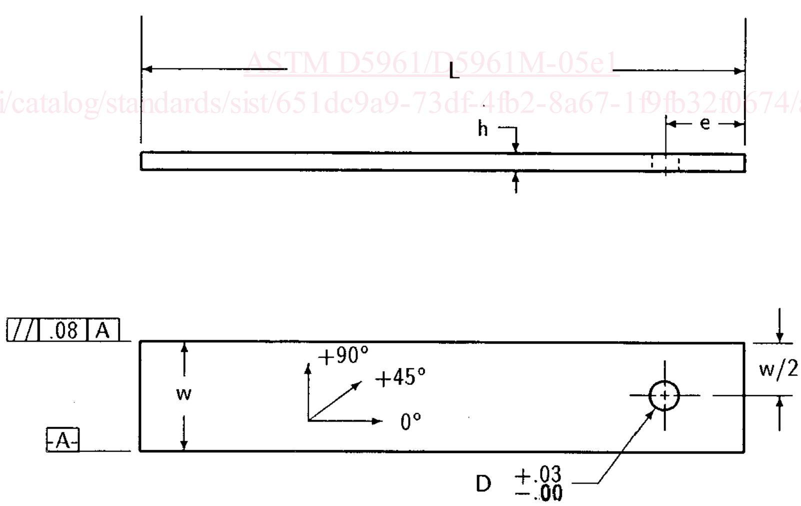
4.1.3 The standard test configuration for this procedure does not allow any variation of the major test parameters. However,

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
± 3	± 1	± .3

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.



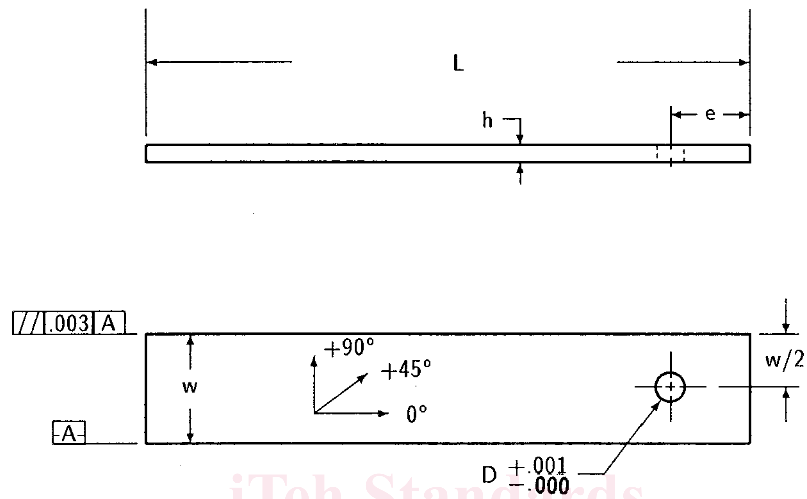
Parameter	Standard Dimension, mm
fastener or pin diameter, d	6 +0.00/−0.03
hole diameter, D	6 +0.03/−0.00
thickness range, h	3-5
length, L	135
width, w	36 ±1
edge distance, e	18 ±1
countersink	none

FIG. 1 Double-Shear Test Specimen Drawing (SI)

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

.X	.XX	.XXX
± .1	± .03	± .01

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 64√ (SYMBOLOGY IN ACCORDANCE WITH ASA B46.1, WITH ROUGHNESS HEIGHT IN MICROINCHES.)
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.



Parameter	Standard Dimension, in.
fastener or pin diameter, d	0.250 +0.000/−0.001
hole diameter, D	0.250 +0.001/−0.000
thickness range, h	0.125-0.208
length, L	5.5
width, w	1.5 ±0.03
edge distance, e	0.75 ±0.03
countersink	none

FIG. 2 Double-Shear Test Specimen Drawing (Inch-Pound)

the following variations in configuration are allowed, but can be considered as being in accordance with this test method only as long as the values of all variant test parameters are prominently documented with the results.

Parameter	Standard	Variation
Loading condition:	double-shear	none
Mating material:	steel fixture	none
Number of holes:	1	none
Countersink:	none	none
Fit:	tight	any, if documented
Fastener torque:	2.2-3.4 N·m [20-30 lbf-in.]	any, if documented
Laminate:	quasi-isotropic	any, if documented
Fastener diameter:	6 mm [0.250 in.]	any, if documented
Edge distance ratio:	3	any, if documented
w/D ratio:	6	any, if documented
D/h ratio:	1.2-2	any, if documented

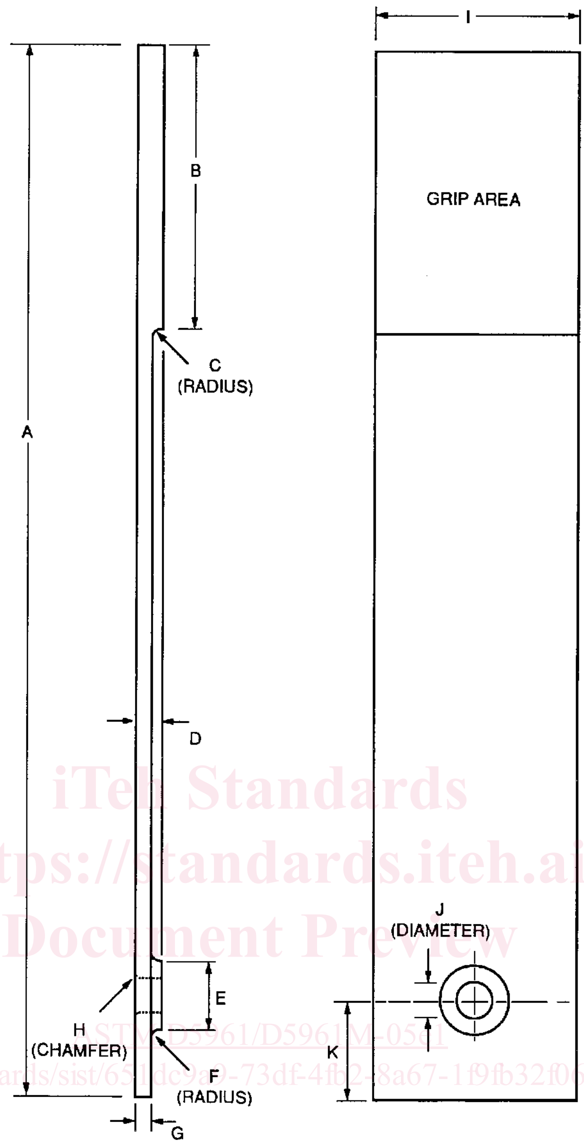
4.2 *Procedure B, Single Shear*:

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. 5-8. The eccentricity in applied load that would otherwise result is minimized by a doubler bonded to each grip end of the specimen, resulting in a load 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 multipiece bolted support fixture, as shown in Fig. 9. The test specimen/fixture assembly is clamped in hydraulic wedge grips and the load is sheared into the support fixture and then 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 Both the applied load and the associated deformation of the hole(s) are monitored. The deformation of the hole(s) is normalized by the hole diameter (a factor of two used to adjust for hole deformation occurring in the two halves) to result in an effective bearing strain. Likewise, the applied load is normalized by the projected hole area to yield an effective bearing



Recommended Material: 17-4PH Stainless Steel, 1 GPa [145 ksi] yield											
	A	B	C	D	E	F	G	H	I	J	K
mm	200	50	2	5	13	2	3	1	36	6	20
inch	7.75	2.00	0.06	0.20	0.50	0.06	0.12	0.04	1.50	0.25	0.75

FIG. 3 Fixture Loading Plate for Procedure A (2 Required)

stress. The specimen is loaded until a load maximum has clearly been reached, whereupon the test is terminated so as to prevent masking of the true failure mode by large-scale hole distortion, in order to provide a more representative failure mode assessment. Bearing stress versus bearing strain for the entire loading regime is plotted, and failure mode noted. The ultimate bearing strength of the material is determined from the maximum load carried prior to test termination.

4.2.3 The standard test configuration for this procedure does not allow any variation of the major test parameters. However, the following variations in configuration are allowed, but can be considered as being in accordance with this test method only as long as the values of all variant test parameters are prominently documented with the results.

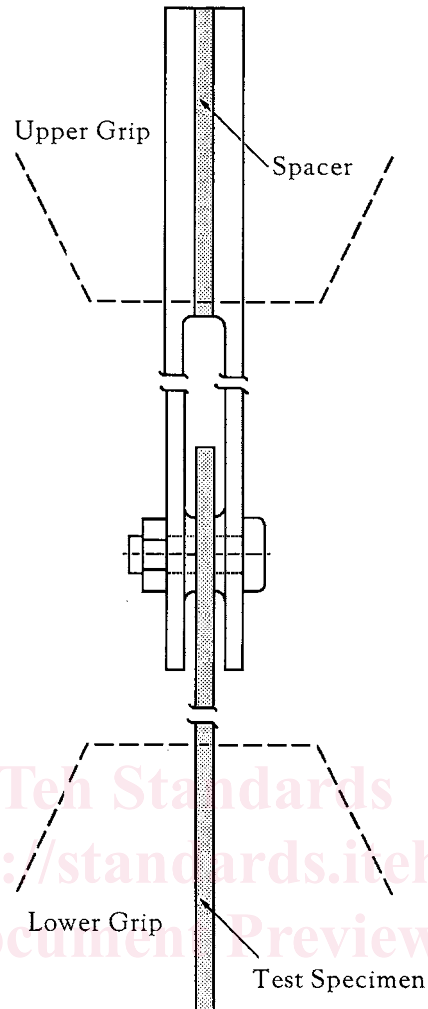


FIG. 4 Fixture Assembly for Procedure A

Parameter	Standard	Variation
Loading condition:	single-shear	none
Support fixture:	no	yes, if documented
Number of holes:	1	1 or 2
Countersunk holes:	no	yes, if documented
Grommets:	no	yes, if documented
Mating material:	same laminate	any, if documented
Fit:	tight	any, if documented
Fastener torque:	2.2-3.4 N·m [20-30 lbf-in.]	any, if documented
Laminate:	quasi-isotropic	any, if documented
Fastener diameter:	6 mm [0.250 in.]	any, if documented
Edge distance ratio:	3	any, if documented
w/D ratio:	6	any, if documented
D/h ratio:	1.2-2	any, if documented

5. Significance and Use

5.1 This test method is designed to produce bearing response data for material specifications, research and development, quality assurance, and structural design and analysis. The standard configuration for each procedure is very specific and is intended primarily for development of quantitative double- and single-shear bearing response data for material comparison and specification. Procedure A, the double-shear configuration, with a single fastener, is particularly recommended for basic material evaluation and comparison. Procedure B, the single-shear, single- or double-fastener configuration is more useful in evaluation of specific joint configurations. The specimen may be tested in either an unstabilized (no support fixture) or stabilized configuration. The unstabilized configuration is intended for tensile loading and the stabilized configuration is intended for compressive loading (although tensile loading is permitted). These configurations have been extensively used in the development of design allowables data. The variants of either procedure provide flexibility in the conduct of the test, allowing adaptation of the test setup to a specific application. However, the flexibility of test parameters allowed by the variants makes meaningful comparison between datasets difficult if the datasets were not tested using identical test parameters.

5.2 General factors that influence the mechanical response of composite laminates and should therefore be reported include the following: material, methods of material preparation and lay-up, specimen stacking sequence, specimen preparation, specimen conditioning, environment of testing, specimen alignment and gripping, speed of testing, time at temperature, void content, and volume percent reinforcement.

DRAWING NOTES:
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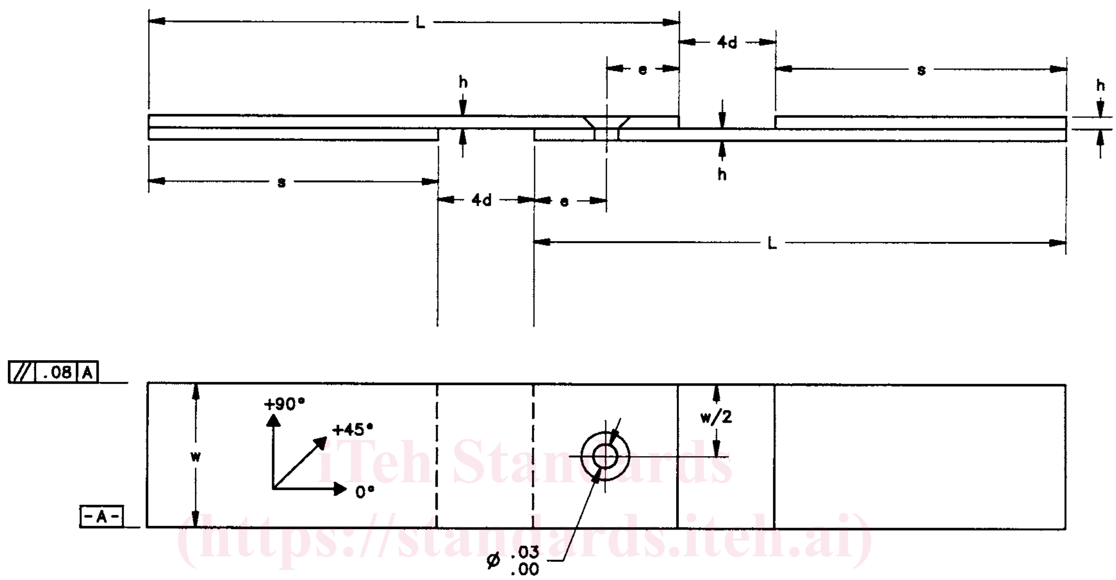
2. ALL DIMENSIONS IN MILLIMETRES WITH DECIMAL TOLERANCES AS FOLLOWS:

NO DECIMAL	.X	.XX
+/-3	+/-1	+/-.3

3. ALL ANGLES HAVE TOLERANCE OF +/- .5°.
4. PLY ORIENTATION DIRECTION TOLERANCE RELATIVE TO -A- WITHIN +/- .5°.
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, COUNTERSINK DETAILS, COUPON THICKNESS, DOUBLER MATERIAL, DOUBLER ADHESIVE.



Parameters	Standard Dimensions of Specimen (mm) without support fixture	with support fixture
fastener diameter, d	6+0.00/-0.03	6+0.00/-0.03
hole diamteter, ø	6+0.03/-0.00	6+0.03/-0.00
thickness range, h	3-5	3-5
length, L	135	189
width, w	36 +/-1	36 +/-1
edge distance, e	18 +/-1	18 +/-1
countersink	none(optional)	none (optional)
doubler length, s	75	129

FIG. 5 Single-Shear, Single-Fastener Test Specimen Drawing (SI) (See Fig. 7 for details of double-fastener version.)

5.3 Specific factors that influence the bearing response of composite laminates and should therefore be reported include not only the loading method (either Procedure A or B) but the following: (for both procedures) edge distance ratio, width to diameter ratio, diameter to thickness ratio, fastener torque, fastener or pin material, fastener or pin clearance; and (for Procedure B only) tensile or compressive loading, countersink angle and depth of countersink, type of grommet (if used), type of mating material, number of fasteners, and type of support fixture (if used). Properties, in the test direction, which may be obtained from this test method include the following:

5.3.1 Ultimate bearing strength, F^{bru},

5.3.2 Bearing chord stiffness, E^{br},

5.3.3 Offset bearing strength, F^{bro} and

5.3.4 Bearing stress/bearing strain curve.

6. Interferences

6.1 *Material and Specimen Preparation*—Bearing response is sensitive to poor material fabrication practices (including lack of control of fiber alignment), damage induced by improper specimen machining (hole preparation is especially critical), and torqued fastener installation. Fiber alignment relative to the specimen coordinate axis should be maintained as carefully as possible, although there is currently no standard procedure to ensure or determine this alignment. A practice that has been found satisfactory for many materials is the addition

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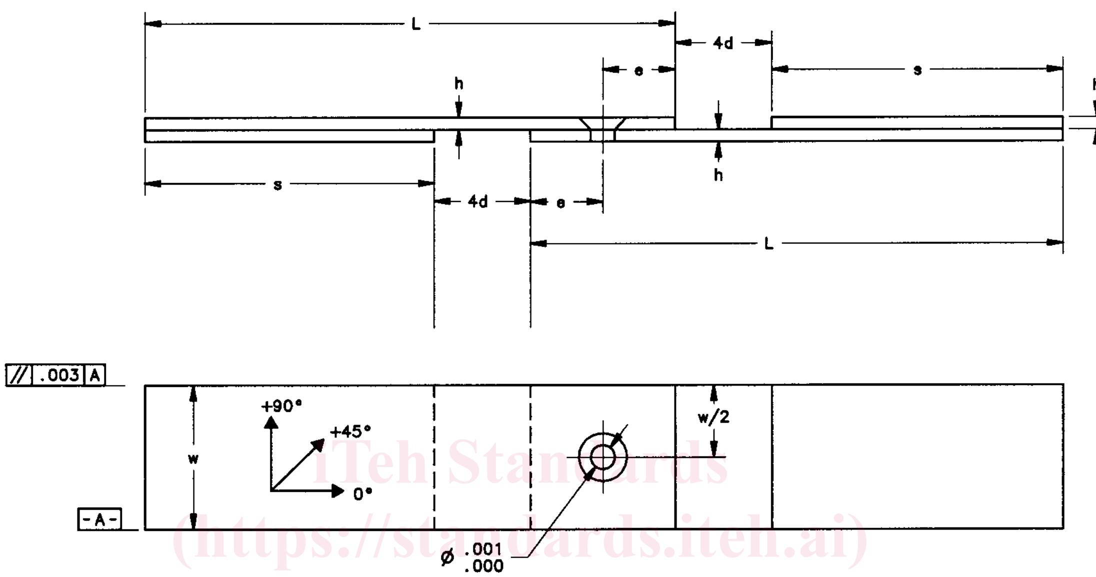
.X	.XX	.XXX
+/-.1	+/-.03	+/-.003

3. ALL ANGLES HAVE TOLERANCE OF +/- .5°.
4. PLY ORIENTATION DIRECTION TOLERANCE RELATIVE TO -A- WITHIN +/- .5°.
5. FINISH ON MACHINED EDGES NOT TO EXCEED 64√ (SYMBOLOGY IN ACCORDANCE WITH ASA B46.1, WITH ROUGHNESS HEIGHT IN MICROINCHES.)
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, COUNTERSINK DETAILS, COUPON THICKNESS, DOUBLER MATERIAL, DOUBLER ADHESIVE.



Parameters	Standard Dimensions of Specimen (inches)	
	without support fixture	with support fixture
fastener diameter, d	0.250+0.000/-0.001	0.250 +0.000/-0.001
hole diameter, ø	0.250+0.001/-0.000	0.250 +0.001/-0.000
thickness range, h	0.125-0.208	0.125-0.208
length, L	5.5	7.5
width, w	1.5+/-0.03	1.5+/-0.03
edge distance, e	0.75+/-0.03	0.75+/-0.03
countersink	none(optional)	none (optional)
doubler length, s	3.0	5.0

FIG. 6 Single-Shear Test Specimen Drawing (Inch-Pound) (See Fig. 8 for details of double-fastener version.)

of small amounts of tracer yarn to the prepreg parallel to the 0° direction, added either as part of the prepreg production or as part of panel fabrication. See Guide D 5687/D 5687M for further information on recommended specimen preparation practices.

6.2 *Restraining Surfaces*—The degree to which out-of-plane hole deformation is possible, due to lack of restraint by the fixture or the fastener, has been shown to affect test results.

6.3 *Cleanliness*—The degree of cleanliness of the mating surfaces has been found to produce significant variations in test results.

6.4 *Eccentricity (Procedure B only)*—A loading eccentricity is created in single-shear tests by the offset, in one plane, of the line of action of load between each half of the test specimen. This eccentricity creates a moment that, particularly in clearance hole tests, rotates the fastener, resulting in an uneven contact stress distribution through the thickness of the specimen. The effect of this eccentricity upon test results is strongly dependent upon the degree of clearance in the hole, the size of the fastener head, the mating area, the coefficient of friction between the specimen and the mating material, the thickness and stiffness of the specimen, the thickness and stiffness of the mating material, and the configuration of the support fixture. Consequently, results obtained from this procedure where the support fixture is used may not accurately replicate behavior in other structural configurations.

6.5 *Hole Preparation*—Due to the dominating presence of the filled hole(s), results from this test method are relatively insensitive to parameters that would be of concern in an unnotched tensile or compressive property test. However, since

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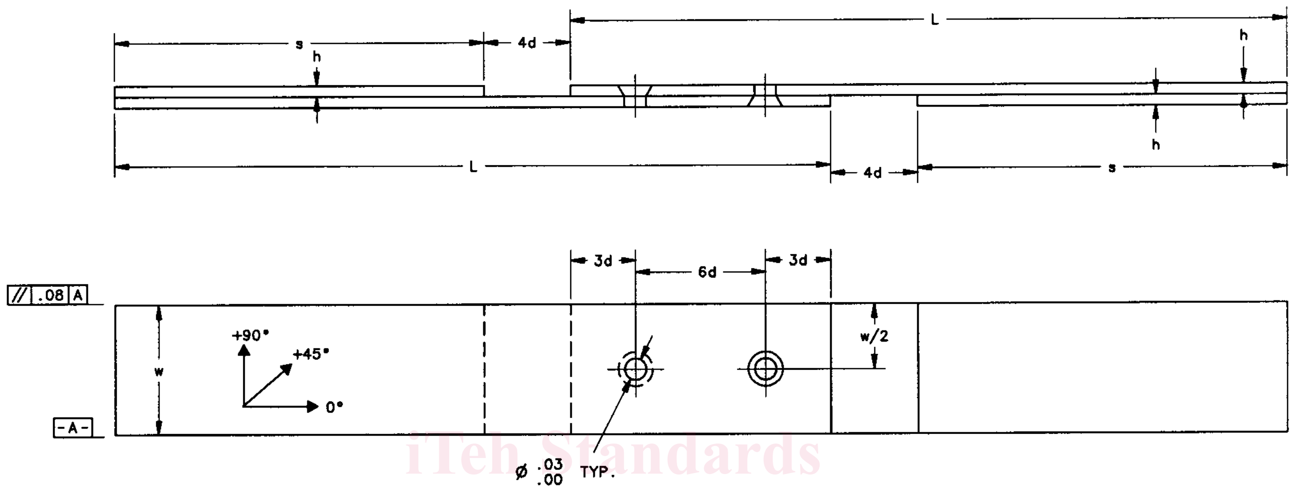
NO DECIMAL	.X	.XX X
+/-3	+/-1	+/-.3

3. ALL ANGLES HAVE TOLERANCE OF +/- .5°.
4. PLY ORIENTATION DIRECTION TOLERANCE RELATIVE TO -A- WITHIN +/- .5°.
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, COUNTERSINK DETAILS, COUPON THICKNESS, DOUBLER MATERIAL, DOUBLER ADHESIVE.



Parameters	Standard Dimensions of Specimen (mm) without support fixture	with support fixture
fastener diameter, d	6 + 0.00/−0.03	6 + 0.00/−0.03
hole diameter, Ø	6 + 0.03/−0.00	6 + 0.03/−0.00
thickness range, h	3–5	3–5
length, L	210	210
width, w	36 +/− 1	36 +/− 1
edge distance, e	18 +/− 1	18 +/− 1
countersink	none(optional)	none (optional)
doubler length, s	108	108

FIG. 7 Single-Shear, Double-Fastener Test Specimen Drawing (SI)

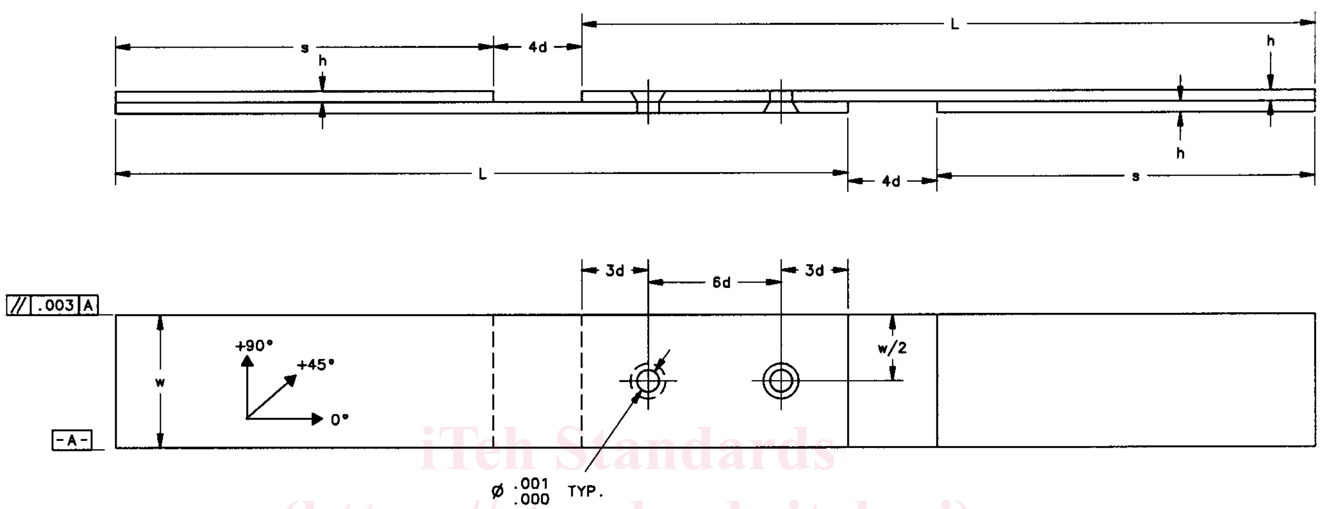
the filled hole(s) dominates the strength, consistent preparation of the hole(s) without damage to the laminate is important to meaningful results. Damage due to hole preparation will affect strength results and can reduce the calculated strength.

6.6 *Fastener-Hole Clearance*—Results are affected by the clearance arising from the difference between hole and fastener diameters. Clearance can change the observed specimen behavior by delaying the onset of bearing damage. Damage due to insufficient clearance during fastener installation will affect strength results. Countersink flushness (depth or protrusion of the fastener head in a countersunk hole) will affect strength results and may affect the observed failure mode. For these reasons, both the hole and fastener diameters must be accurately measured and recorded. A typical aerospace tolerance on fastener-hole clearance is +75/-0 µm [+0.003/-0.000 in.] for structural fastener holes.

6.7 *Fastener Torque/Pre-load*—Results are affected by the installed fastener pre-load (clamping pressure). Laminates can exhibit significant differences in both failure load and failure mode due to changes in fastener pre-load under bearing loading. The critical pre-load condition (that is, either high or low clamping pressure) can vary depending upon the type of loading, the laminate stacking sequence and the desired failure mode. The nominal test configuration uses a relatively low level of fastener installation torque to give conservative bearing stress results. For specimens that produce bearing failure modes, bearing strengths for specimens with high clamping pressure fasteners are almost always higher than the corresponding low clamping pressure bearing strengths. Valid bearing strength results should only be reported when appropriate failure modes are observed, in accordance with 11.5.

6.8 *Specimen Geometry*—Results are affected by the ratio of specimen width to hole diameter; this ratio should be maintained at 6, unless the experiment is investigating the influence of this ratio, or invalid (bypass) failure modes occur. Results may also be affected by the ratio of hole diameter to

DRAWING NOTES:
1. INTERPRET DRAWING IN ACCORDANCE WITH ANSI Y14.5M-1982, SUBJECT TO THE FOLLOWING:
2. ALL DIMENSIONS IN INCHES WITH DECIMAL TOLERANCES AS FOLLOWS:
   .X +/-.1   .XX +/-.03   .XXX +/-.003
3. ALL ANGLES HAVE TOLERANCE OF +/- .5°.
4. PLY ORIENTATION DIRECTION TOLERANCE RELATIVE TO [-A-] WITHIN +/- .5°.
5. FINISH ON MACHINED EDGES NOT TO EXCEED 64√ SYMBOLOGY IN ACCORDANCE WITH ASA B46.1, WITH ROUGHNESS HEIGHT IN MICROINCHES.)
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, COUNTERSINK DETAILS, COUPON THICKNESS, DOUBLER MATERIAL, DOUBLER ADHESIVE.



Parameters	Standard Dimensions of Specimen (inches)	
	without support fixture	with support fixture
fastener diameter, d	0.250+0.000/–0.001	0.250 +0.000/–0.001
hole diameter,Ø	0.250+0.001/–0.000	0.250 +0.001/–0.000
thickness range, h	0.125–0.208	0.125–0.208
length, L	8.25	8.25
width, w	1.5+/–0.03	1.5+/–0.03
edge distance, e	0.75+/–0.03	0.75+/–0.03
countersink	none(optional)	none (optional)
doubler length, s	4.25	4.25

FIG. 8 Single-Shear, Double Fastener Test Specimen Drawing (Inch-Pound)

thickness; the preferred ratio is the range from 1.5-3.0 unless the experiment is investigating the influence of this ratio. Results may also be affected by the ratio of countersunk (flush) head depth to thickness; the preferred ratio is the range from 0.0-0.7 unless the experiment is investigating the influence of this ratio. Results may also be affected by the ratio of ungripped specimen length to specimen width; this ratio should be maintained as shown, unless the experiment is investigating the influence of this ratio.

6.9 *Material Orthotropy*—The degree of laminate orthotropy strongly affects the failure mode and measured bearing strengths. Bearing strength results should only be reported when appropriate and valid failure modes are observed, in accordance with 11.5.

6.10 *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 properly). Thus, data gathered using these procedures may not translate directly into equivalent thick-structure properties.

6.11 *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 bearing strength and failure mode. Experience has demonstrated that elevated temperature and humid environments are generally critical for bearing failure modes. However, critical environments must be assessed independently for each material system, stacking sequence, and torque condition tested.

6.12 *Type of Loading*—Results for Procedure B are affected by the type of loading (tensile versus compressive) applied to the specimen fixture/assembly. Generally, the initial bearing stress/strain behavior and damage modes exhibited are independent of the type of loading, as response is governed by