Designation: D 5961/D 5961M – 96

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.

1. Scope

1.1 This test method determines the bearing response of polymer matrix composite laminates by either double shear (Procedure A) or single shear (Procedure B) tensile loading of a coupon. 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 material form is limited to high-modulus continuous-fiber or discontinuous-fiber reinforced composites for which the elastic properties are balanced and symmetric with respect to the test direction.

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 *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.*

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.

2. Referenced Documents

2.1 *ASTM Standards:*

D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement[2]

D 883 Terminology Relating to Plastics[2]

D 953 Test Method for Bearing Strength of Plastics[2]

D 2584 Test Method for Ignition Loss of Cured Reinforced Resins[3]

D 2734 Test Methods for Void Content of Reinforced Plastics[3]

D 3171 Test Method for Fiber Content of Resin-Matrix Composites by Matrix Digestion[4]

D 3878 Terminology of High-Modulus Reinforcing Fibers and Their Composites[4]

D 5229/D 5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials[4]

D 5687/D 5687M Guide for Preparation of Flat Composite Panels with Processing Guidelines for Specimen Preparation[4]

E 4 Practices for Force Verification of Testing Machines[5]

E 6 Terminology Relating to Methods of Mechanical Testing[5]

E 83 Practice for Verification and Classification of Extensometers[5]

E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process[6]

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods[6]

E 238 Test Method for Pin-Type Bearing Test of Metallic Materials[5]

E 456 Terminology Relating to Quality and Statistics[6]

E 1309 Guide for the Identification of Composite Materials in Computerized Material Property Databases[4]

E 1434 Guide for Development of Standard Data Records for Computerization of Mechanical Test Data for High-Modulus Fiber-Reinforced Composite Materials[4]

E 1471 Guide for the Identification of Fibers, Fillers, and Core Materials in Computerized Material Property Databases[4]

2.2 *Other Document:*

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

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

[1] This test method is under the jurisdiction of ASTM Committee D-30 on High Modulus Fibers and Their Composites and is the direct responsibility of Subcommittee D30.05 on Structural Test Methods.

Current edition approved May 10, 1996. Published July 1996.

[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.02.

[4] *Annual Book of ASTM Standards*, Vol 15.03.

[5] *Annual Book of ASTM Standards*, Vol 03.01.

[6] *Annual Book of ASTM Standards*, Vol 14.02.

[7] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

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, [Θ] 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.

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

3.2.2 *bearing load*, *P* $[MLT^{-2}]$, *n*—the total load carried by a bearing coupon.

3.2.3 *bearing strain*, ϵ^{br} [*nd*], *n*—the normalized hole deformation in a bearing coupon, equal to the deformation of the bearing hole in the direction of the bearing load, divided by the diameter of the hole.

3.2.4 *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.

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

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

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

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

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

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

3.2.8 *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.

3.2.9 *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.

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

3.2.10 *orthotropic material*, *n*—a material with a property of interest that, at a given point, possesses three mutually perpendicular planes of symmetry defining the principal material coordinate system for that property.

3.2.10.1 *Discussion*—As viewed from the principal material coordinate system of an orthotropic elastic material, extensional stresses are totally uncoupled from shear strains and the shear moduli are totally independent of the other elastic constants (unlike a metal, which is isotropic and that has a shear modulus that is dependent upon Young's modulus and Poisson's ratio). An orthotropic material has 9 independent elastic constants. The general concept of orthotropy also applies to material properties other than elastic, such as thermal, electromagnetic, or optical, although the number of independent constants and the type of mathematical transformation may differ, depending upon the order of the tensor of the property. The behavior of an orthotropic material as viewed from the principal material coordinate system is called *specially orthotropic*. However, if the material behavior is evaluated from another coordinate system coupling terms may appear in the stress/strain relation. While the material itself remains specially orthotropic, from this other coordinate system the material behavior is then called *generally orthotropic*.

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

3.2.11.1 *Discussion*—The pitch distance ratio may be either a nominal value determined from nominal dimensions or an actual value, determined as the ratio of the actual distance between the center of the hole and the nearest side-edge to the actual hole diameter.

3.2.12 *ply orientation*, θ, *n*—the angle between the reference axis and the ply principal axis, expressed in degrees, with a range of $-90° < \theta \leq 90°$. The ply orientation is expressed as a positive quantity when taken from the reference direction to the ply principal axis, following a right-handed Cartesian coordinate system.

3.2.12.1 *Discussion*—The reference direction is usually related to a direction of load application or a major geometric feature of a component.

3.2.13 *ply principal axis*, *n*—the coordinate axis in the plane of a lamina that is used as the reference direction for that lamina.

3.2.13.1 *Discussion*—The ply principal axis will, in general, be different for each ply of a laminate. The angle made by this axis relative to the reference axis is the ply orientation. The convention is to align the ply principal axis with a material feature that is the direction of maximum stiffness (such as the fiber direction for unidirectional tape or the warp direction for fabric-reinforced material). Conventions for other laminated material forms have not yet been established.

3.2.14 *principal material coordinate system*, *n*—a coordinate system with axes that are normal to the planes of symmetry inherent to a material.

3.2.14.1 *Discussion*—Common usage, at least for Cartesian axes (123, *xyz*, etc.), generally assigns the coordinate system axes to the normal directions of planes of symmetry in order that the highest property value in a normal direction (for elastic properties, the axis of greatest stiffness would be 1 or *x*, and the lowest (if applicable) would be 3 or *z*). Anisotropic materials do not have a principal material coordinate system due to the total lack of symmetry, while, for isotropic materials, any coordinate system is a principal material coordinate system. In laminated composites the principal material coordinate system has meaning only with respect to an individual orthotropic lamina. The related term for laminated composites is reference coordinate system.

3.2.15 *quasi-isotropic laminate, n*—a balanced and symmetric laminate for which a constitutive property of interest, at a given point, displays isotropic behavior in the plane of the laminate. Common quasi-isotropic laminates are [0/±60]s and [0/±45/90]s.

3.2.15.1 *Discussion*—Usually a quasi-isotropic laminate refers to elastic properties, for which case, the laminate contains equal numbers of identical plies at k orientations such that the angles between the plies are $180i/k$, ($i = 0, 1, \ldots, k - 1$); $k \geq 3$. Other material properties may follow different rules. For example, thermal conductivity becomes quasi-isotropic for $k \geq 2$, while strength properties generally are not capable of true quasi-isotropy, only approximating this behavior.

3.2.16 *reference coordinate system, n*—a coordinate system for laminated composites used to define ply orientations. One of the reference coordinate system axes (normally the Cartesian x-axis) is designated the reference axis, assigned a position, and the ply principal axis of each ply in the laminate is referenced relative to the reference axis to define the ply orientation for that ply.

3.2.17 *specially orthotropic, adj*—a description of an orthotropic material as viewed in its principal material coordinate system. In laminated composites a specially orthotropic laminate is a balanced and symmetric laminate of the [0:i/90:j]*ns* family as viewed from the reference coordinate system, such that the membrane-bending coupling terms of the stress/strain relation are zero.

3.2.18 *tracer yarn, n*—a small filament-count tow of a fiber type that has a color that contrasts with the surrounding material form, used for directional identification in composite material fabrication.

3.2.18.1 *Discussion*—Aramid tracer yarns are commonly used in carbon fiber composites and carbon tracer yarns are commonly used in aramid or glass fiber composites.

3.2.19 *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 coupon.

3.3 *Symbols:*

3.3.1 A—minimum cross-sectional area of a coupon.

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

3.3.3 d—fastener or pin diameter.

3.3.4 D—coupon hole diameter.

3.3.5 e—distance, parallel to load, from hole center to end of coupon; the edge distance.

3.3.6 E_x^{br}—bearing chord stiffness in the test direction specified by the subscript.

3.3.7 f—distance, parallel to load, from hole edge to end of coupon.

3.3.8 F_x^{bru}—ultimate bearing strength in the test direction specified by the subscript.

3.3.9 $F_x^{bro}(e\%)$—offset bearing strength (at e % bearing strain offset) in the test direction specified by the subscript.

3.3.10 g—distance, perpendicular to load, from hole edge to shortest edge of coupon.

3.3.11 h—coupon thickness.

3.3.12 k—calculation factor used in bearing equations to distinguish single-fastener tests from double-fastener tests.

3.3.13 K—calculation factor used in bearing equations to distinguish single-shear tests from double-shear tests in a single bearing strain equation.

3.3.14 L_g—extensometer gage length.

3.3.15 n—number of coupons per sample population.

3.3.16 P—load carried by test coupon.

3.3.17 P^f—load carried by test coupon at failure.

3.3.18 P^{max}—maximum load carried by test coupon prior to failure.

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

3.3.20 w—coupon width.

3.3.21 x_i—test result for an individual coupon from the sample population for a given property.

3.3.22 $\bar{x}$—mean or average (estimate of mean) of a sample population for a given property.

3.3.23 δ—extensional displacement.

3.3.24 ϵ—general symbol for strain, whether normal strain or shear strain.

3.3.25 ϵ^{br}—bearing strain.

3.3.26 σ^{br}—bearing stress.

4. Summary of Test Method

4.1 *Procedure A, Double Shear*:

4.1.1 A flat, constant rectangular cross-section coupon with a centerline hole located near the end of the coupon, as shown in the coupon 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)[8] 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 coupon 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, 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.

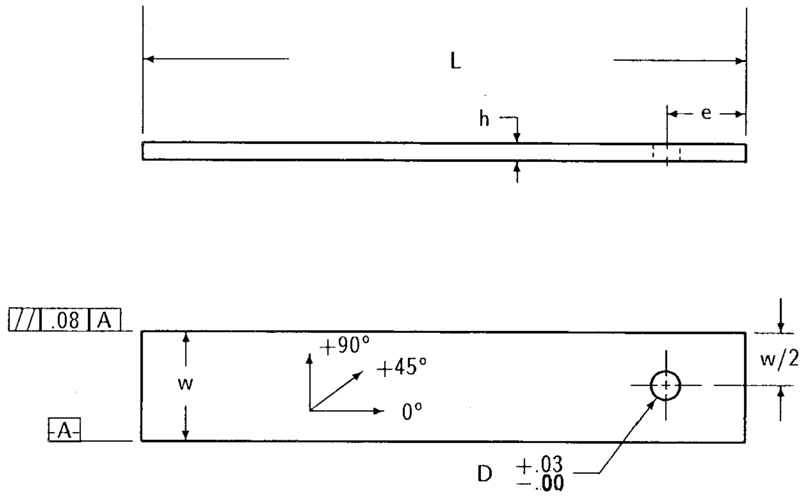
[8] Variations in hole clearance and fastener torque are allowed if recorded.

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)

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
Pitch distance 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 coupon 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 coupon drawings of Figs. 5 and 6. The ends of the coupon are gripped in the jaws of a test machine and loaded in tension. The eccentricity in applied load that would otherwise result is minimized by a doubler bonded to each grip end of the coupon, resulting in a load line-of-action along the interface between the coupon halves, through the centerline of the hole(s).

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 stress. The coupon 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.

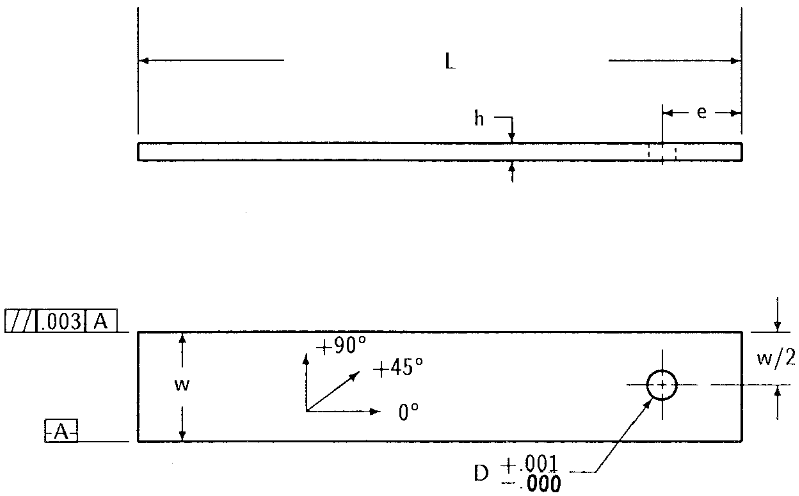
4.2.3 The standard test configuration for this procedure does not allow any variation of the major test parameters. However, the following variations in configuration are allowed, but can be considered as being in accordance with this test method only as long as the values of all variant test parameters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

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)

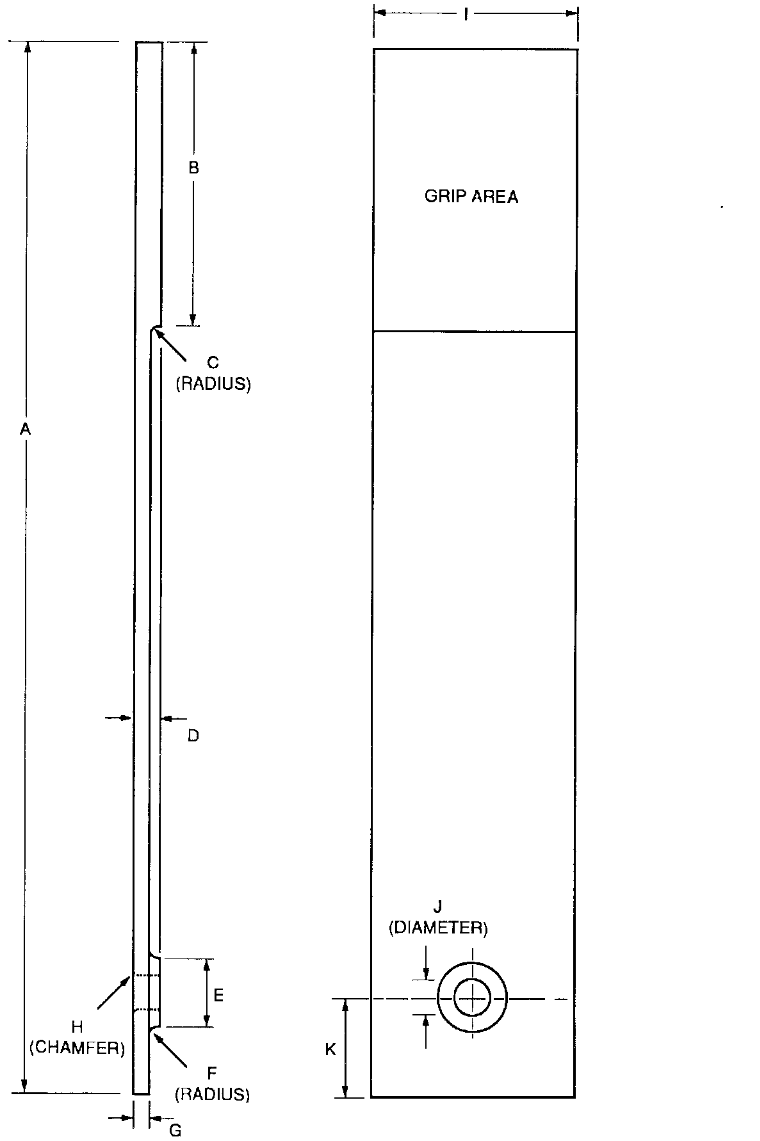
Parameter	Standard	Variation
Loading condition:	single-shear	none
Number of holes:	1	1 or 2
Countersunk holes:	no	yes, if documented
Grommets:	no	yes, if documented
Mating material:	same laminate	any, if documented
Fit:	tight	any, if documented
Fastener torque:	2.2–3.4 N·m [20–30 lbf-in.]	any, if documented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

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, pitch distance ratio, diameter to thickness ratio, fastener torque, fastener or pin material, fastener or pin clearance; and (for Procedure B only) countersink angle and depth of countersink,



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 Req'd)

type of grommet (if used), type of mating material, and number of fasteners. Properties, in the test direction, which may be obtained from this test method include the following:

5.3.1 Ultimate bearing strength,

5.3.2 Bearing chord stiffness,

5.3.3 Offset bearing strength, 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 coupon machining (especially critical is hole preparation), 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 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 in some material types.

6.3 *Cleanliness*—The degree of cleanliness of the mating

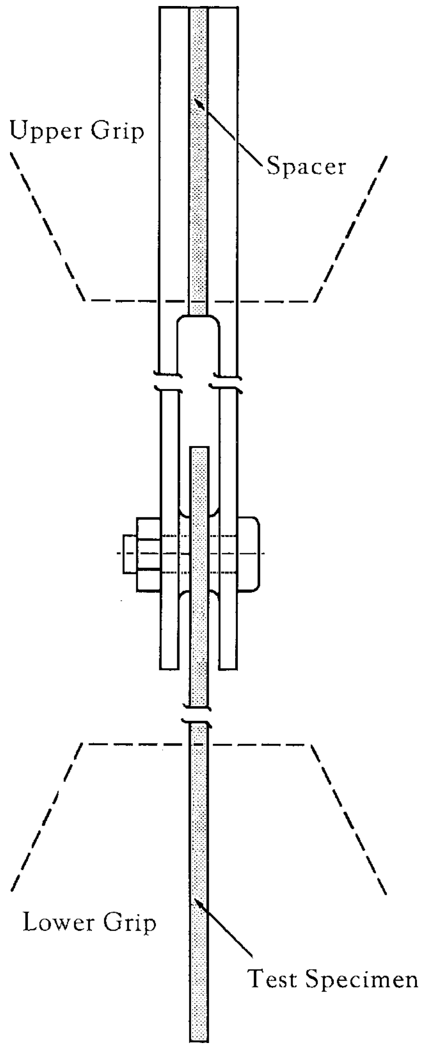


FIG. 4 Fixture Assembly for Procedure A

surfaces has been found to produce significant variations in test results in some material types.

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 coupon. 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 coupon. 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 coupon and the mating material, the thickness and stiffness of the coupon, and the thickness and stiffness of the mating material.

6.5 *Other*—Test Methods E 238 and D 953 contain further discussions of other variables affecting bearing-type testing.

7. Apparatus

7.1 *Micrometers*—The micrometer(s) shall use a 4 to 5-mm [0.16 to 0.20-in.] nominal diameter ball-interface on irregular surfaces such as the bag-side of a laminate, and a flat anvil interface on machined edges or very smooth tooled surfaces. The accuracy of the instrument(s) shall be suitable for reading to within 1 % of the sample width and thickness. For typical specimen geometries, an instrument with an accuracy of ±2.5 µm [±0.0001 in.] is desirable for thickness measurement, while an instrument with an accuracy of ±25 µm [±0.001 in.] is desirable for width measurement.

7.2 *Loading Fastener or Pin*—The fastener (or pin) type shall be specified as an initial test parameter and reported. The assembly torque (if applicable) shall be specified as an initial test parameter and reported. The fastener or pin shall be visually inspected after each test, and replaced, if damage to the fastener or pin is evident.

7.3 *Fixture*:

7.3.1 *Procedure A*—The load shall be applied to the specimen by means of a double-shear clevis similar to that shown in Figs. 3 and 4, using the loading fastener or pin. For torqued tests the clevis shall allow a torqued fastener to apply a transverse compressive load to the coupon around the periphery of the hole. The fixture shall allow a bearing strain indicator to monitor the hole deformation relative to the fixture, over the length from the centerline of the fastener or pin to the end of the specimen.

7.3.2 *Procedure B*—The load shall be applied to the specimen by means of a mating single-shear attachment (normally identical to the specimen) using the fastener or pin. The mating material, thickness, edge distance, length, and hole clearance shall be specified as part of the test parameters. The line of action of the load shall be adjusted by specimen doublers to be coincident and parallel to the interface between the test specimen and the joint mate. If the mating attachment is permanently deformed by the test it shall be replaced after each test, as required. The fixture will allow a bearing strain indicator to measure the required hole deformation relative to the fixture.

7.4 *Testing Machine*—The testing machine shall be in conformance with Practices E 4, and shall satisfy the following requirements:

7.4.1 *Testing Machine Heads*—The testing machine shall have both an essentially stationary head and a movable head.

7.4.2 *Drive Mechanism*—The testing machine drive mechanism shall be capable of imparting to the movable head a controlled velocity with respect to the stationary head. The velocity of the movable head shall be capable of being regulated as specified in 11.4.

7.4.3 *Load Indicator*—The testing machine load-sensing device shall be capable of indicating the total load being carried by the test specimen. This device shall be essentially free from inertia-lag at the specified rate of testing and shall indicate the load with an accuracy over the load range(s) of interest of within ±1 % of the indicated value.

7.4.4 *Grips*—Each head of the testing machine shall be capable of holding one end of the test assembly so that the direction of load applied to the specimen is coincident with the longitudinal axis of the specimen. Wedge grips shall apply sufficient lateral pressure to prevent slippage between the grip face and the coupon.

7.5 *Bearing Strain Indicator*—Bearing strain data shall be determined by a bearing strain indicator able to measure

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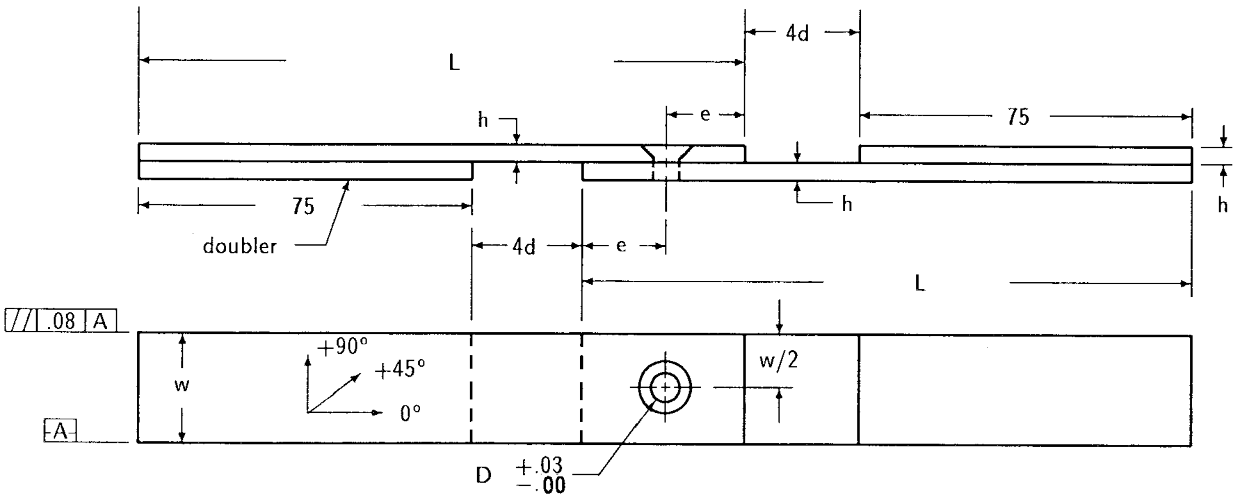
NO DECIMAL	.X	.XX
± 3	± 1	± .3

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.



Parameter	Standard Dimension, mm
fastener 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 (optional)

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

longitudinal hole deformation simultaneously on opposite edges of the specimen (the average of which corrects for joint rotation). The transducers of the bearing strain indicator may provide either individual signals to be externally averaged or an electronically averaged signal. The indicator may consist of two matched strain-gage extensometers or displacement transducers such as LVDTs or DCDTs. Attachment of the bearing strain indicator to the coupon shall not cause damage to the specimen surface. Transducers shall satisfy, at a minimum, Practice E 83, Class B-2 requirements for the bearing strain/displacement range of interest, and shall be calibrated over that range in accordance with Practice E 83. The transducers shall be essentially free of inertia lag at the specified speed of testing.

7.5.1 *Torque Wrench*—A torque wrench used to tighten a joint fastener shall be capable of determining the applied torque to within ±10 % of the desired value.

7.6 *Conditioning Chamber*—When conditioning materials at non-laboratory environments, a temperature-/vapor-level controlled environmental conditioning chamber is required that shall be capable of maintaining the required temperature to within ±3°C [±5°F] and the required relative vapor level to within ±3 %. Chamber conditions shall be monitored either on an automated continuous basis or on a manual basis at regular intervals.

7.7 *Environmental Test Chamber*—An environmental test chamber is required for test environments other than ambient testing laboratory conditions. This chamber shall be capable of maintaining the gage section of the test specimen at the required test environment during the mechanical test.

8. Sampling and Test Specimens

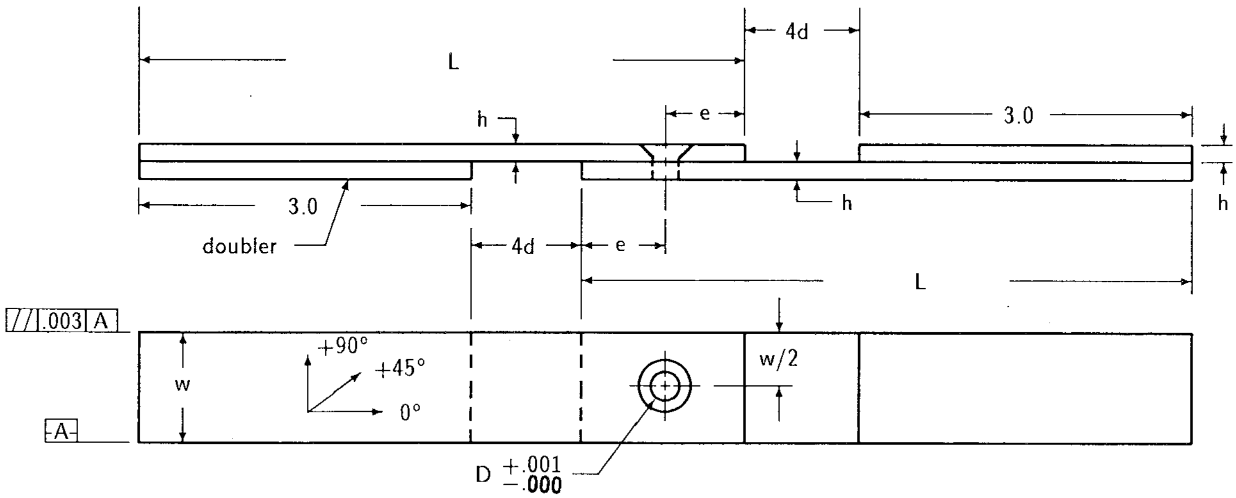
8.1 *Sampling*—Test at least five specimens per test condition unless valid results can be gained through the use of fewer specimens, as in the case of a designed experiment. For statistically significant data the procedures outlined in Practice E 122 should be consulted. The method of sampling shall be reported.

NOTE 2—If specimens are to undergo environmental conditioning to equilibrium, and are of such type or geometry that the weight change of the material cannot be properly measured by weighing the specimen itself (such as a tabbed mechanical coupon), then use a traveler coupon of the

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- 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.



Parameter	Standard Dimension, in.
fastener 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 (optional)

FIG. 6 Single-Shear Test Specimen Drawing (inch-pound) (See Fig. 7 for details of double-fastener version.)

same nominal thickness and appropriate size (but without tabs) to determine when equilibrium has been reached for the specimens being conditioned.

8.2 *Geometry*:

8.2.1 *Stacking Sequence*—The standard laminate shall have a balanced and symmetric stacking sequence of [45/0/−45/90]*ns*, where *n* is selected to keep the laminate thickness as close as possible to 4 mm [0.160 in.], with a permissible range from 3 to 5 mm [0.125 to 0.208 in.], inclusive.
Laminates containing satin-type weaves shall have symmetric warp surfaces, unless otherwise specified and noted in the report.

8.2.2 *Configuration*:

8.2.2.1 *Procedure A*—The geometry of the coupon for Procedure A is shown in Figs. 1 and 2.

8.2.2.2 *Procedure B*—The geometry of the coupon for Procedure B is shown in Figs. 5 and 6. Note that the countersink(s) shown in the drawings is optional. For a double-fastener configuration, extend the length of each coupon half by the required distance and place a second bearing hole in line with the first, as shown in the schematic of Fig. 7. If the double-fastener coupon is using countersunk fasteners, one countersink should be located on each side of the coupon, as shown.

8.2.3 *Doubler Material*—The most consistently used doubler material has been continuous E-glass fiber-reinforced polymer matrix materials (woven or unwoven) in a [0/90]*ns* laminate configuration. The doubler material is commonly applied at 45° to the loading direction to provide a soft interface. Other configurations that have reportedly been successfully used have incorporated steel doublers, or doublers made of the same material as is being tested.

8.2.4 *Adhesive*—Any high-elongation (tough) adhesive system that meets the environmental requirements may be used when bonding doublers to the material under test. A uniform bondline of minimum thickness is desirable to reduce undesirable stresses in the assembly.

8.3 *Specimen Preparation*—Guide D 5687/D 5687M provides recommended specimen preparation practices and should be followed where practical.

8.3.1 *Panel Fabrication*—Control of fiber alignment is

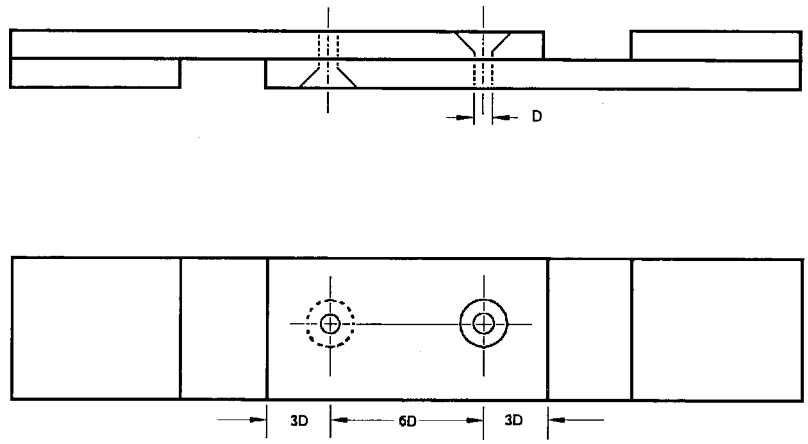


FIG. 7 Single-Shear, Double-Fastener Test Coupon Schematic

critical. Improper fiber alignment will reduce the measured properties. Erratic fiber alignment will also increase the coefficient of variation. Report the panel fabrication method.

8.3.2 *Machining Methods*—Specimen preparation is extremely important for this specimen. Take precautions when cutting specimens from plates to avoid notches, undercuts, rough or uneven surfaces, or delaminations due to inappropriate machining methods. Obtain final dimensions by waterlubricated precision sawing, milling, or grinding. The use of diamond tooling has been found to be extremely effective for many material systems. Edges should be flat and parallel within the specified tolerances. Holes should be drilled undersized and reamed to final dimensions. Special care shall be taken to ensure that creation of the specimen hole does not delaminate or otherwise damage the material surrounding the hole. Record and report the specimen cutting and hole preparation methods.

8.3.3 *Labeling*—Label the coupons so that they will be distinct from each other and traceable back to the raw material, and in a manner that will both be unaffected by the test and not influence the test.

9. Calibration

9.1 The accuracy of all measuring equipment shall have certified calibrations that are current at the time of use of the equipment.

10. Conditioning

10.1 *Standard Conditioning Procedure*—Unless a different environment is specified as part of the experiment, condition the test specimens in accordance with Procedure C of Test Method D 5229/D 5229M, and store and test at standard laboratory atmosphere (23 ± 3°C [73 ± 5°F] and 50 ± 10 % relative humidity).

11. Procedure

11.1 *Parameters to Be Specified Prior to Test*:

11.1.1 The bearing coupon sampling method, coupon type and geometry, fastener type and material, fastener torque, cleaning process, and conditioning travelers (if required).

11.1.2 The bearing properties, offset bearing strain value and data reporting format desired.

NOTE 3—Unless otherwise specified, an offset bearing strain of 2 % shall be used.

NOTE 4—Determine specific material property, accuracy, and data reporting requirements prior to test for proper selection of instrumentation and data recording equipment. Estimate operating bearing stress and bearing strain levels to aid in transducer selection, calibration of equipment, and determination of equipment settings.

11.1.3 The environmental conditioning test parameters.

11.1.4 If performed, the sampling method, coupon geometry, and test parameters used to determine density and reinforcement volume.

11.2 *General Instructions*:

11.2.1 Report any deviations from this test method, whether intentional or inadvertent.

11.2.2 If specific gravity, density, reinforcement volume, or void volume are to be reported, then obtain these samples from the same panels being bearing tested. Specific gravity and density may be evaluated by means of Test Methods D 792. Volume percent of the constituents may be evaluated by one of the matrix digestion procedures of Test Method D 3171, or, for certain reinforcement materials such as glass and ceramics, by the matrix burn-off technique of Test Method D 2584. The void content equations of Test Methods D 2734 are applicable to both Test Method D 2584 and the matrix digestion procedures.

11.2.3 Condition the specimens as required. Store the specimens in the conditioned environment until test time, if the test environment is different than the conditioning environment.

11.2.4 Following final specimen machining and any conditioning, but before bearing testing, measure the specimen width, w, and the specimen thickness, h, in the vicinity of the hole. Measure the hole diameter, D, distance from hole edge to closest coupon side, f, and distance from hole edge to coupon end, g. Measure the fastener or pin diameter at the bearing contact location. The accuracy of all measurements shall be within 1 % of the dimension. Record the dimensions to three significant figures in units of millimetres [inches].

11.2.5 *Cleaning*—Clean the specimen hole, surrounding clamping area, and fastener or pin shank. If the fastener threads are required to be lubricated, apply the lubricant to the nut threads instead of the fastener threads and take extreme care not to accidentally transfer any of the lubricant to the fastener shank, the specimen hole, or to the clamping area during assembly and torquing. Record and report cleaning method.

11.2.6 *Specimen Assembly*—Assemble test specimen to mating attachment or to double-shear fixture, as appropriate for the procedure, with fastener or pin.

11.3 *Fastener Torquing*—If using a torqued fastener, tighten the fastener to the required value using a calibrated torque wrench. Record and report the actual torque value.

NOTE 5—Take care not to work the joint after torquing. Joint rotation after torquing and before and during insertion into the testing machine may relax the initial torque. Final torquing of the fastener may be necessary after the specimen is inserted into the test machine.

11.4 *Speed of Testing*—Set the speed of testing so as to produce failure within 1 to 10 min. If the ultimate bearing strain of the material cannot be reasonably estimated, initial trials should be conducted using standard speeds until the ultimate bearing strain of the material and the compliance of the system are known, and speed of testing can be adjusted. The suggested standard speeds are:

11.4.1 *Bearing Strain-Controlled Tests*—A standard bearing-strain rate of 0.01 min^{-1}.

11.4.2 *Constant Head-Speed Tests*—A standard head displacement rate of 2 mm/min [0.05 in./min].

11.5 *Test Environment*—If possible, test the specimen under the same fluid exposure level used for conditioning. However, cases such as elevated temperature testing of a moist specimen place unrealistic requirements on the capabilities of common testing machine environmental chambers. In such cases the mechanical test environment may need to be modified, for example, by testing at elevated temperature with no fluid exposure control, but with a specified limit on time to failure from withdrawal from the conditioning chamber. Record any modifications to the test environment.

11.6 *Insert Specimen*—Insert specimen into the test machine, attaching loading interfaces or tightening grips as required.

11.7 *Complete Bearing Strain Indicator Installation*—Attach the bearing strain indicator to the edges of the specimen as shown in Fig. 8 to provide the average displacement across the loaded hole(s) at the edge of the specimen. Attach the recording instrumentation to the indicator. Remove any remaining pre-load and zero the indicator. For Procedure B double-fastener specimens, one end of the indicator shall be on the edge of the specimen between the two fasteners and the other end on the edge of the mating coupon.

11.8 *Loading*—Apply the load to the specimen at the specified rate while recording data. The coupon is loaded until a load maximum is reached and load has dropped off about 30 % from the maximum. Unless coupon rupture is specifically desired, 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.

11.9 *Data Recording*—Record load versus bearing strain (or hole displacement) continuously, or at frequent regular intervals. If a transition region or initial ply failures are noted, record the load, bearing strain, and mode of damage at such points. If the specimen is to be failed, record the maximum load, the failure load, and the bearing strain (or hole displacement) at, or as near as possible to, the moment of rupture.

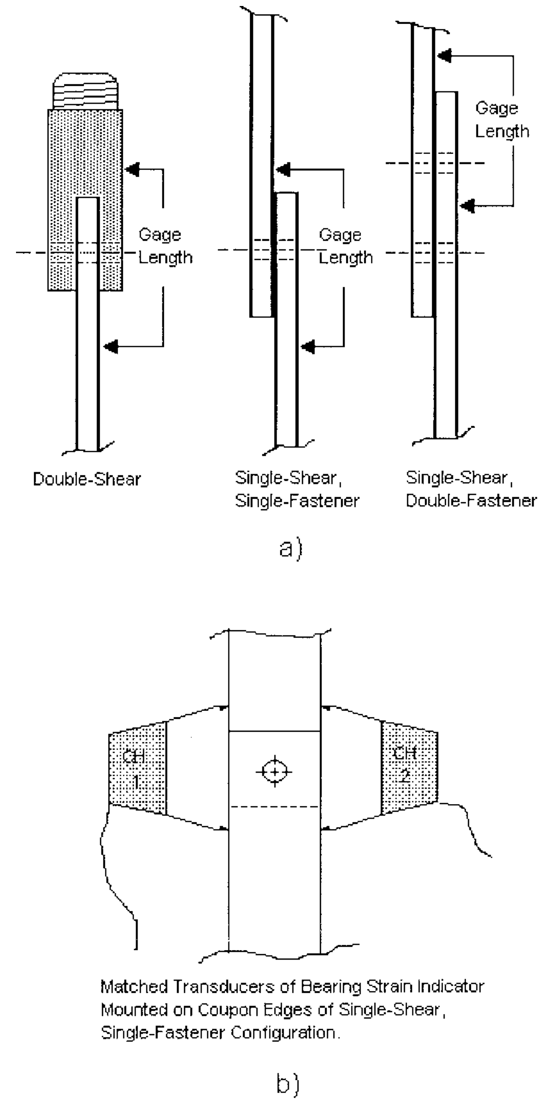


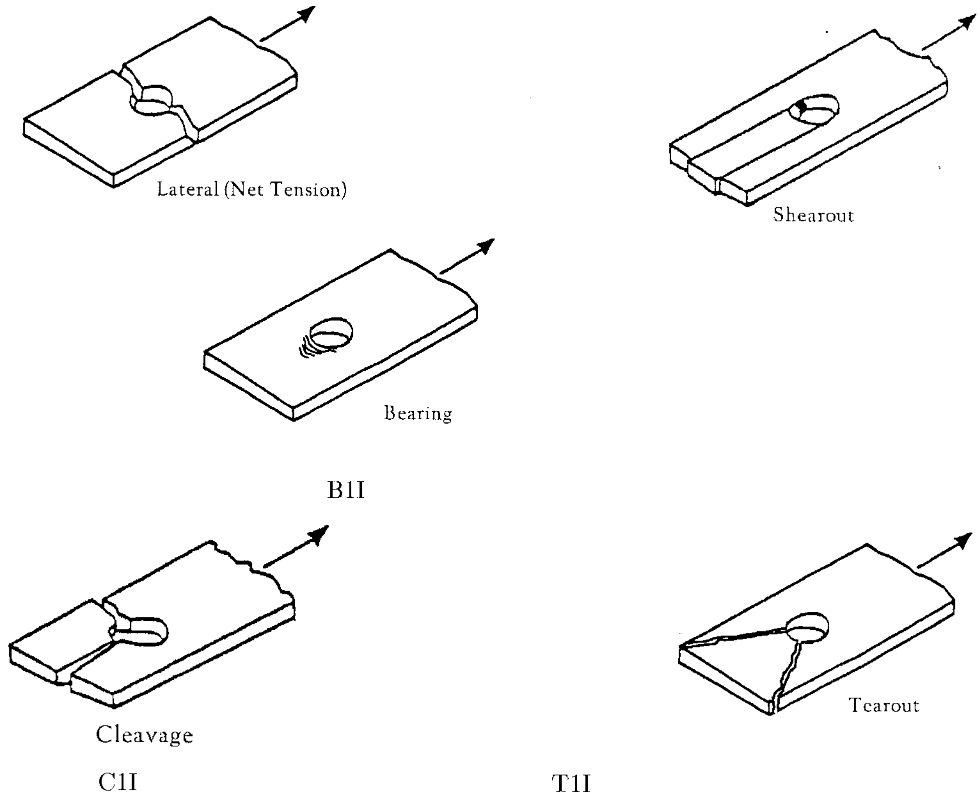
FIG. 8 Transducer Gage Length and Location

NOTE 6—Other valuable data that can be useful in understanding testing anomalies and gripping or specimen slipping problems includes load versus head displacement data and load versus time data.

NOTE 7—A difference in the bearing stress/bearing strain or load/bearing strain slope between bearing strain readings on the opposite sides of the specimen indicates joint rotation in the specimen.

11.10 *Failure Mode*—Record the mode and location of failure of the specimen. Choose, if possible, a standard description using the three-part failure mode code shown in Fig. 9. A multimode failure can be described by including each of the appropriate failure-type codes between the parens of the M failure-type code. For example, a typical failure for a [45/0/−45/90]*ns* laminate having elements of both local bearing and cleavage might have a failure mode code of M(BC)1I.

NOTE 8—The final physical condition of the test coupon following testing depends upon whether or not the test was stopped soon after reaching maximum load. If the test is not so stopped, the test machine will continue to deform the coupon and disguise the primary failure mode by producing secondary failures, making determination of the primary failure mode difficult. In some cases it may be necessary to examine the bearing stress/bearing strain curve to determine the primary failure mode; in other cases the failure mode may not be determinable.



First Part

Failure Type	Code
Bearing	B
Cleavage	C
Fastener or pin	F
Lateral (net tension)	L
Multi-mode	M(xyz)
Shearout	S
Tearout	T
Other	O

Second Part

Failure Area	Code
First Hole	1
Second Hole	2
Both Holes	B
Fastener or pin	F
Unknown	U

Third Part

Failure Location	Code
Bolt Head Side	B
Nut Side	N
Inapplicable	I
Unknown	U

FIG. 9 Bearing Test Failure Codes With Illustrations of Common Modes

12. Calculation

NOTE 9—Presentation and calculation of results by this test method is based on normalizing total joint load and overall joint displacement to the response at a single hole. In the case of a double-shear test there is no adjustment necessary in either load or displacement. However, for a single-shear test (assuming like coupon halves, and whether for one fastener or two), the total joint displacement is approximately twice the elongation of a given hole. For a double-fastener test, the hole load is one half the total load. This is the source of the k load factor and the K displacement factor used in the following equations.

12.1 *Pitch Distance Ratio*—Calculate the actual specimen pitch distance ratio using measured values with Eq 1, and report the result to three significant digits.

$$w/D = 2 \times \frac{f + D/2}{D} \quad (1)$$

where:

w/D = actual pitch distance ratio,
f = shortest distance from hole edge to coupon side, mm [in.], and
D = hole diameter, mm [in.].

12.2 *Edge Distance Ratio*—Calculate the actual specimen edge distance ratio using measured values with Eq 2, and report the result to three significant digits.

$$e/D = \frac{g + D/2}{D} \quad (2)$$

where:

e/D = actual edge distance ratio, and
g = distance from hole edge to coupon end, mm [in.].

12.3 *Bearing Stress/Strength*—Determine the bearing stress at each required data point with Eq 3. Calculate the ultimate bearing strength using Eq 4. Report the results to three significant digits.

$$\sigma_i^{br} = P_i/(k \times D \times h) \quad (3)$$

$$F^{bru} = P^{max}/(k \times D \times h) \quad (4)$$

where:
F^{bru} = ultimate bearing strength, MPa [psi],
P^{max} = maximum load prior to failure, N [lbf],
σ_i^{br} = bearing stress at *i*-th data point, MPa [psi],
P_i = load at *i*-th data point, N [lbf],
h = coupon thickness, mm [in.], and
k = load per hole factor: 1.0 for single-fastener or pin tests and 2.0 for double-fastener tests.

12.4 *Bearing Strain*—Determine the average bearing strain for each displacement value recorded using Eq 5 and report the results to three significant digits.

$$\epsilon_i^{br} = \frac{(\delta_{1_i} + \delta_{2_i})/2}{K \times D} \quad (5)$$

where:
ϵ_i^{br} = bearing strain, microstrain,
δ_{1_i} = extensometer-1 displacement at *i*-th data point, mm [in.],
δ_{2_i} = extensometer-2 displacement at *i*-th data point, mm [in.], and
K = 1.0 for double-shear tests, 2.0 for single-shear tests.

NOTE 10—The *K* factors for single-shear tests may not be appropriate if the mating coupon-half is significantly different in bearing stiffness.

12.5 *Bearing Chord Stiffness*—Calculate the chord stiffness between two specific bearing stress or bearing strain points in the essentially linear portion of the bearing stress/bearing strain curve. Report the result to three significant digits. Report whether bearing stress points or bearing strain points were used, as well as the value of the two end points.

$$E^{br} = \frac{\Delta\sigma^{br}}{\Delta\epsilon^{br}} \quad (6)$$

where:
E^{br} = bearing chord stiffness, MPa [psi],
$\Delta\sigma^{br}$ = change in bearing stress over chord stiffness range, MPa [psi], and
$\Delta\epsilon^{br}$ = change in bearing strain over chord stiffness range, mm/mm [in./in.].

NOTE 11—The initial portion of the bearing stress/bearing strain curve will usually have substantial variations in the bearing stress/bearing strain response due to combinations of joint straightening, overcoming of joint friction, and joint translation due to hole tolerance. The chord stiffness points should be determined after this behavior has dissipated. Because of these variations it is often most practical to use bearing stress end points to determine the chord stiffness.

12.6 *Determination of Effective Origin*—Intersect the chord stiffness line with the bearing strain axis to define an effective origin for use in determining offset bearing strength and ultimate bearing strain.

12.7 *Ultimate Bearing Strain*—After correcting the bearing stress/bearing strain data for the new effective origin, record the bearing strain at maximum load, to three significant digits, as the ultimate bearing strain.

12.8 *Offset Bearing Strength*—After correcting the bearing stress/bearing strain data for the new effective origin, translate the chord stiffness line along the bearing strain axis from the origin by the specified offset amount of bearing strain. Determine the intersection of this line with the bearing stress/bearing strain curve. Assess if an offset bearing strength is appropriate for this coupon from the discussion on initial peak bearing strength in 12.9. If an offset bearing strength is appropriate, report, to three significant digits, the bearing stress value at this point as the offset bearing strength, F_x^{bro} (*e* %), where *e* is the value of the offset bearing strain expressed in percent. (See Note 3.)

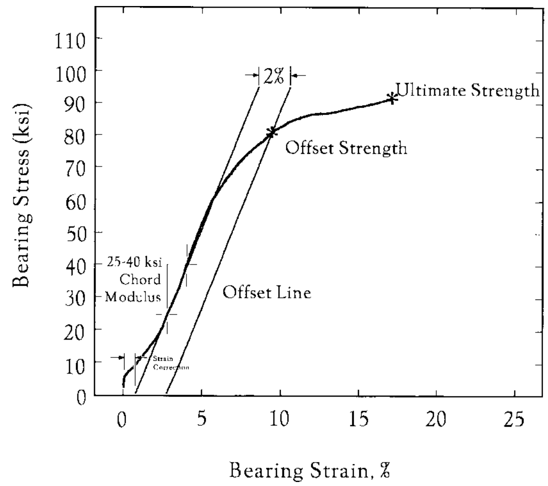


FIG. 10 Example of Bearing Stress/Bearing Strain Curve

12.9 *Initial Peak Bearing Strength*—Some bearing test configurations will show an initial peak bearing stress followed by a sharp drop in bearing stress and subsequent hole deformation such that the offset bearing strength will be lower than the initial peak bearing stress. If after further hole deformation the coupon resumes loading to bearing stress levels higher than the initial peak, report the initial peak bearing stress as an initial peak bearing strength, in addition to the offset and ultimate bearing strengths. However, if the initial peak bearing stress is the ultimate bearing strength of the coupon, do not report either a initial peak bearing strength or an offset chord bearing strength.

12.10 *Statistics*—For each series of tests calculate the average value, standard deviation, and coefficient of variation (in percent) for each property determined:

$$\bar{x} = (\sum_{i=1}^{n} x_i)/n \quad (7)$$

$$s_{n-1} = \sqrt{(\sum_{i=1}^{n} x_i^2 - n\bar{x}^2)/(n-1)} \quad (8)$$

$$CV = 100 \times s_{n-1}/\bar{x} \quad (9)$$

where:
$\bar{x}$ = sample mean (average),
s_{n-1} = sample standard deviation,
CV = sample coefficient of variation, %,
n = number of specimens, and
x_i = measured or derived property.

13. Report

13.1 Report the following information, or references pointing to other documentation containing this information, to the maximum extent applicable (reporting of items beyond the control of a given testing laboratory, such as might occur with material details or panel fabrication parameters, shall be the responsibility of the requestor):

NOTE 12—Guides E 1309, E 1434, and E 1471 contain data reporting recommendations for composite materials and composite material mechanical tests. While these guides do not yet cover bearing response testing, they remain a valuable resource that should be consulted. A revision to the guides that adds the necessary additional fields is underway.

13.1.1 The test method and revision level or date of issue.

13.1.2 The procedure used and whether the coupon configuration was standard or variant.

13.1.3 The date(s) and location(s) of the test.

13.1.4 The name(s) of the test operator(s).

13.1.5 Any variations to this test method, anomalies noticed during testing, or equipment problems occurring during testing.

13.1.6 Identification of the material tested including: material specification, material type, material designation, manufacturer, manufacturer's lot or batch number, source (if not from manufacturer), date of certification, expiration of certification, filament diameter, tow or yarn filament count and twist, sizing, form or weave, fiber areal weight, matrix type, prepreg matrix content, and prepreg volatiles content.

13.1.7 Description of the fabrication steps used to prepare the laminate including: fabrication start date, fabrication end date, process specification, cure cycle, consolidation method, and a description of the equipment used.

13.1.8 Ply orientation stacking sequence of the laminate.

13.1.9 If requested, report density, volume percent reinforcement, and void content test methods, specimen sampling method and geometries, test parameters, and test results.

13.1.10 Average ply thickness of the material.

13.1.11 Results of any nondestructive evaluation tests.

13.1.12 Method of preparing the test specimen, including specimen labeling scheme and method, specimen geometry, sampling method, coupon cutting method, identification of tab geometry, tab material, and tab adhesive used.

13.1.13 Fastener or pin type and material, fastener or pin diameter, fastener torque, hole clearance, countersink angle and depth, grommet, mating material, and number of fasteners.

13.1.14 Fastener or pin and coupon cleaning method.

13.1.15 Calibration dates and methods for all measurement and test equipment.

13.1.16 Type of test machine, grips, jaws, grip pressure, alignment results, and data acquisition sampling rate and equipment type.

13.1.17 Dimensions of each test specimen.

13.1.18 Actual values of coupon hole diameter, coupon edge distance ratio, coupon pitch distance ratio, and coupon diameter to thickness ratio.

13.1.19 Conditioning parameters and results, use of travelers and traveler geometry, and the procedure used if other than that specified in the test method.

13.1.20 Relative humidity and temperature of the testing laboratory.

13.1.21 Environment of the test machine environmental chamber (if used) and soak time at environment.

13.1.22 Number of specimens tested.

13.1.23 Speed of testing.

13.1.24 Bearing strain indicator placement on the specimen, and transducer type for each transducer used.

13.1.25 Bearing stress/bearing strain curves and tabulated data of bearing stress versus bearing strain for each specimen.

13.1.26 Individual ultimate bearing strengths and average value, standard deviation, and coefficient of variation (in percent) for the population. Note if the failure load was less than the maximum load prior to failure.

13.1.27 Individual bearing strains at failure and the average value, standard deviation, and coefficient of variation (in percent) for the population.

13.1.28 Bearing stress or bearing strain range used for bearing chord stiffness determination.

13.1.29 If another definition of bearing stiffness is used in addition to chord stiffness, describe the method used, the resulting correlation coefficient (if applicable), and the bearing stress or bearing strain range used for the evaluation.

13.1.30 Individual values of bearing stiffness and the average value, standard deviation, and coefficient of variation (in percent) for the population.

13.1.31 If offset bearing strength is determined, the method of linear fit (if used), the bearing stress or bearing strain ranges over which the linear fit or chord lines were determined, and the offset bearing strain value.

13.1.32 Individual values of offset bearing strength (if applicable), and the average value, standard deviation, and coefficient of variation (in percent) for the population.

13.1.33 If initial peak bearing strength is determined, the individual values of initial peak bearing strength and the average value, standard deviation, and coefficient of variation (in percent) for the population.

13.1.34 Failure mode and location of failure for each specimen.

14. Precision and Bias

14.1 *Precision*—The data required for the development of a precision statement is not available for this test method. Committee D-30 is currently planning a round-robin test series for this test method in order to determine precision.

14.2 *Bias*—Bias cannot be determined for this test method as no acceptable reference standard exists.

15. Keywords

15.1 bearing properties; bearing strength; composite materials