INTERNATIONAL

Designation: D8387/D8387M – 23

Standard Test Method for High Bypass – Low Bearing Interaction Response of Polymer Matrix Composite Laminates[1]

This standard is issued under the fixed designation D8387/D8387M; 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 uniaxial high bypass - low bearing interaction response of multi-directional polymer matrix composite laminates reinforced by high-modulus fibers using a two-fastener hard point joint specimen. The scope of this test method is limited to net section (bypass) failure modes. Standard specimen configurations using fixed values of test parameters are described for this procedure. A number of test parameters may be varied within the scope of the standard, provided that the parameters are fully documented in the test report. 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. This test method was previously published under Test Method D7248/D7248M-17 Procedure C.

1.2 This test method is consistent with the recommendations of Composite Materials Handbook, CMH-17, which describes the desirable attributes of a bearing/bypass interaction response test method.

1.3 The two-fastener test configurations described in this test method are intended to provide data in the relatively high bypass, low bearing part of the composite bolted joint bearing-bypass interaction diagram. This data complements the data from filled hole tension and compression (Practice D6742/D6742M), bearing (Test Method D5961/D5961M), and low bypass/high bearing interaction (Test Method D7248/D7248M) tests.

1.4 This test method requires careful specimen design, instrumentation, data measurement, and data analysis. The use of this test method requires close coordination between the test requestor and the test lab personnel. Test requestors need to be familiar with the data analysis procedures of this test method and should not expect test labs who are unfamiliar with this test method to be able to produce acceptable results without close coordination.

1.5 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D883 Terminology Relating to Plastics
D2584 Test Method for Ignition Loss of Cured Reinforced Resins
D2734 Test Methods for Void Content of Reinforced Plastics
D3171 Test Methods for Constituent Content of Composite Materials
D3878 Terminology for Composite Materials
D5229/D5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials

[1] This test method is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.05 on Structural Test Methods.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D5687/D5687M Guide for Preparation of Flat Composite Panels with Processing Guidelines for Specimen Preparation
D5766/D5766M Test Method for Open-Hole Tensile Strength of Polymer Matrix Composite Laminates
D5961/D5961M Test Method for Bearing Response of Polymer Matrix Composite Laminates
D6484/D6484M Test Method for Open-Hole Compressive Strength of Polymer Matrix Composite Laminates
D6742/D6742M Practice for Filled-Hole Tension and Compression Testing of Polymer Matrix Composite Laminates
D7248/D7248M Test Method for High Bearing - Low Bypass Interaction Response of Polymer Matrix Composite Laminates Using 2-Fastener Specimens
D8509 Guide for Test Method Selection and Test Specimen Design for Bolted Joint Related Properties
E4 Practices for Force Calibration and Verification of Testing Machines
E6 Terminology Relating to Methods of Mechanical Testing
E83 Practice for Verification and Classification of Extensometer Systems
E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E251 Test Methods for Performance Characteristics of Metallic Bonded Resistance Strain Gages
E456 Terminology Relating to Quality and Statistics
E1237 Guide for Installing Bonded Resistance Strain Gages

2.2 *Other Document:*[3]
CMH-17 Composite Materials Handbook-17, Polymer Matrix Composites, Vol 1, Section 7

3. Terminology

3.1 *Definitions*—Terminology D3878 defines terms relating to high-modulus fibers and their composites. Terminology D883 defines terms relating to plastics. Terminology E6 defines terms relating to mechanical testing. Terminology E456 and Practice E177 define terms relating to statistics. In the event of a conflict between terms, Terminology D3878 shall have precedence over the other documents.

NOTE 1—If the term represents a physical quantity, its analytical dimensions are stated immediately following the term (or letter symbol) in fundamental dimension form, using the following ASTM standard symbology for fundamental dimensions, shown within square brackets: [*M*] for mass, [*L*] for length, [*T*] for time, [θ] for thermodynamic temperature, and [*nd*] for non-dimensional quantities. Use of these symbols is restricted to analytical dimensions when used with square brackets, as the symbols may have other definitions when used without the brackets.

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

3.3 *Symbols:*
A = gross cross-sectional area (disregarding hole) mm^2 [in.^{2}]
C_F = fastener flexibility (Ref **1**)[4]
C_P = plate (specimen) flexibility
C_S = doubler plate flexibility
CV = sample coefficient of variation, %
d = fastener diameter, mm [in.]
D = hole diameter, mm [in.]
e/D = actual edge distance ratio
E_F = fastener modulus, MPa [psi]
E_{xP} = test specimen laminate modulus, MPa [psi]
E_{xS} = doubler plate modulus in axial (x) direction, MPa [psi]
$F_x^{gr\_byp\_t}$ = ultimate tensile gross bypass strength, MPa [psi].
$F_x^{net\_byp\_t}$ = ultimate tensile net bypass strength, MPa [psi]
$F_x^{gr\_byp\_c}$ = ultimate compressive gross bypass strength, MPa [psi]
$F_x^{net\_byp\_c}$ = ultimate compressive net bypass strength, MPa [psi]
F^{br_byp} = bearing stress at ultimate bypass strength, MPa [psi]
g = distance from hole edge to specimen end, mm [in.]
h = specimen thickness near hole (nominal or actual, as specified), mm [in.]
k_D = proportion of total force transferred through doubler plates
k_E = estimate of proportion of total force transferred through fasteners to doubler plates
k_S = proportion of total force transferred through specimen
L = distance between fastener centerlines, mm [in.]
n = number of strain gages on the doubler plate
n = number of tested specimens
P = total force applied to specimen, N [lbf]
P_{D1}, P_{D2} = force in doubler plates, N [lbf]
P_i = force at i-th data point, N [lbf]
P_{max} = maximum force prior to failure, N [lbf]
P_S = force in specimen between fasteners, N [lbf]
s_{n-1} = sample standard deviation
t_P = test specimen laminate thickness, mm [in.]
t_S = doubler plate thickness, mm [in.]
ν_F = fastener Poisson's ratio
w = width of specimen across hole, mm [in.]
w_P = test specimen width, mm [in.]
w_S = doubler plate width, mm [in.]
$\bar{X}$ = sample mean (average)
x_i = measured or derived property
δ_{1i} = extensometer-1 displacement at i-th data point, mm [in.]
δ_{2i} = extensometer-2 displacement at i-th data point, mm [in.]
ε_i^{br} = bearing strain, microstrain
σ_i^{br} = bearing stress at i-th data point, MPa [psi]

4. Summary of Test Method

4.1 Refer to Guide D8509 for discussion of bearing/bypass test procedures.

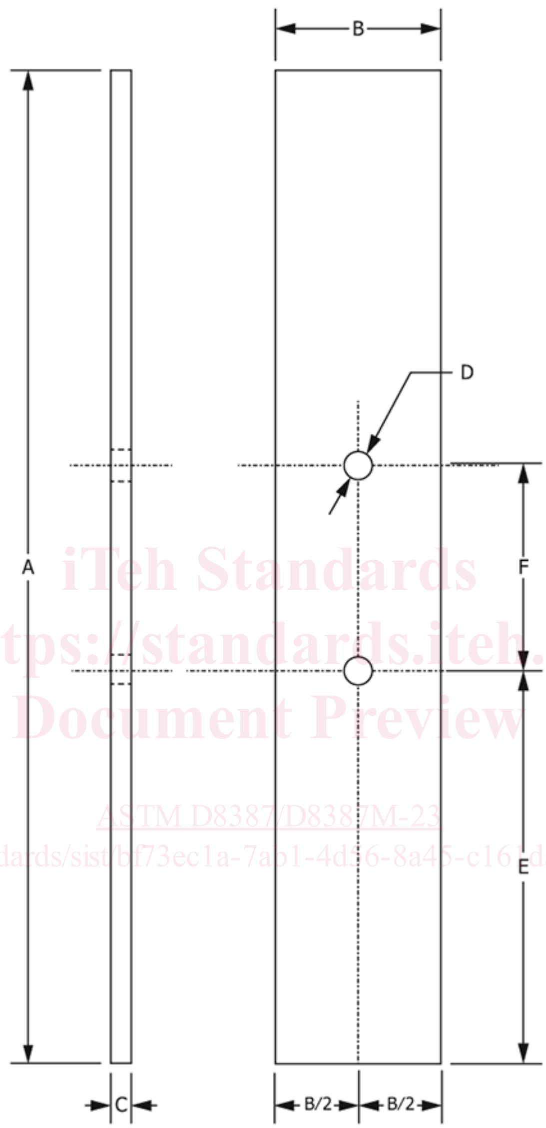
4.2 *High Bypass/Low Bearing Double Shear:*

[3] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

[4] The boldface numbers in parentheses refer to the list of references at the end of this standard.

4.2.1 A flat, constant rectangular cross-section test specimen with two centerline holes located in the middle of the specimen, as shown in the test specimen drawing of Fig. 1, is axially loaded. Two doubler plates, Fig. 2, are attached to the specimen as shown in Fig. 3 to act as a "hardpoint" which induces bearing forces in the test specimen and plates. The ends of the test specimen are gripped in the jaws of a test machine and loaded in tension or compression.

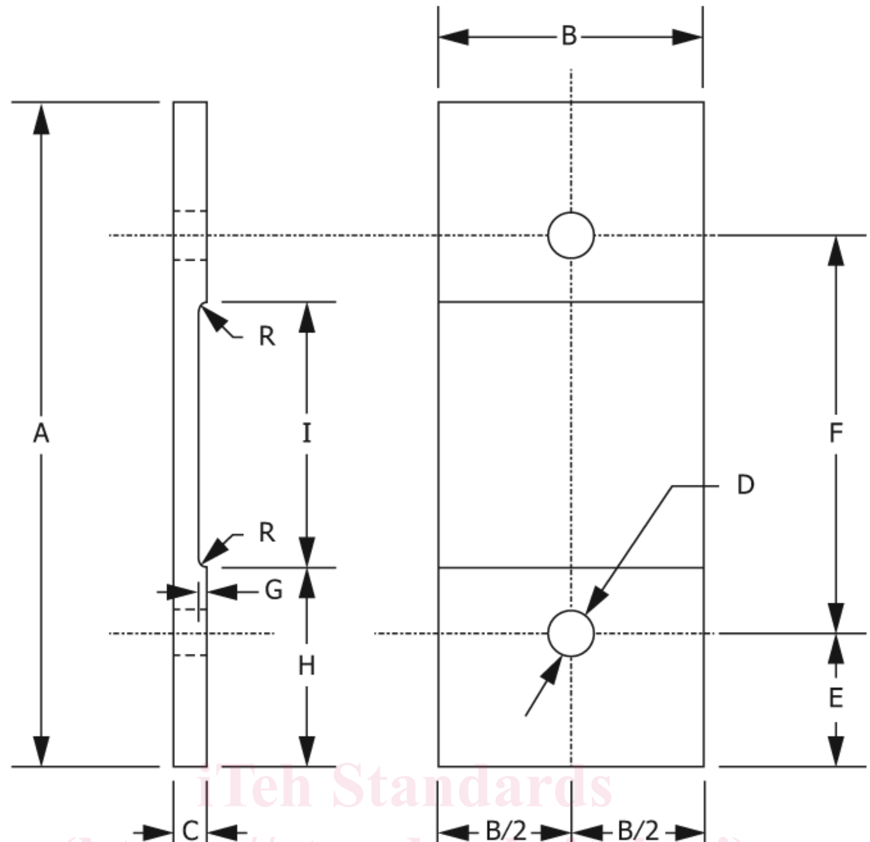
4.2.1.1 *Unstabilized Configuration (No Support Fixture)*—The ends of the test specimen are gripped in the jaws of a test machine and loaded in tension.



	A	B	C	D	E	F
mm	344	36	2 - 5	6.00	147	50
inch	13.50	1.50	0.08 - 0.20	0.250	5.75	2.00

Tolerances:
mm: X ± 1 ; D + 0.08 / −0.00
inch: X.XX ± 0.03 ; D + 0.003 / −0.000

FIG. 1 Double-Shear, 2-Fastener Hardpoint Test Specimen Drawing



Recommended Material: 17-4 PH Stainless Steel, 1.0 GPa [145 ksi] yield stress									
	A	B	C	D	E	F	G, R	H	I
mm	90	36.0	5.0	6.00	20.0	50.0	1.50	30.0	30.0
inch	3.5	1.50	0.20	0.250	0.75	2.00	0.060	1.17	1.17

(a) Tensile Loading

Recommended Material: 17-4 PH Stainless Steel, 1.0 GPa [145 ksi] yield stress									
	A	B	C	D	E	F	G, R	H	I
mm	90	21.0	5.0	6.00	20.0	50.0	1.50	30.0	30.0
inch	3.5	0.83	0.20	0.250	0.75	2.00	0.060	1.17	1.17

(b) Compressive Loading

Tolerances:
mm: X ± 2; X.X ± 0.8; X.XX ± 0.25; D + 0.08/ −0.00
inch: X.X ± 0.1; X.XX ± 0.03; X.XXX ± 0.010; D + 0.003 /−0.000

FIG. 2 Doubler Plate Drawing

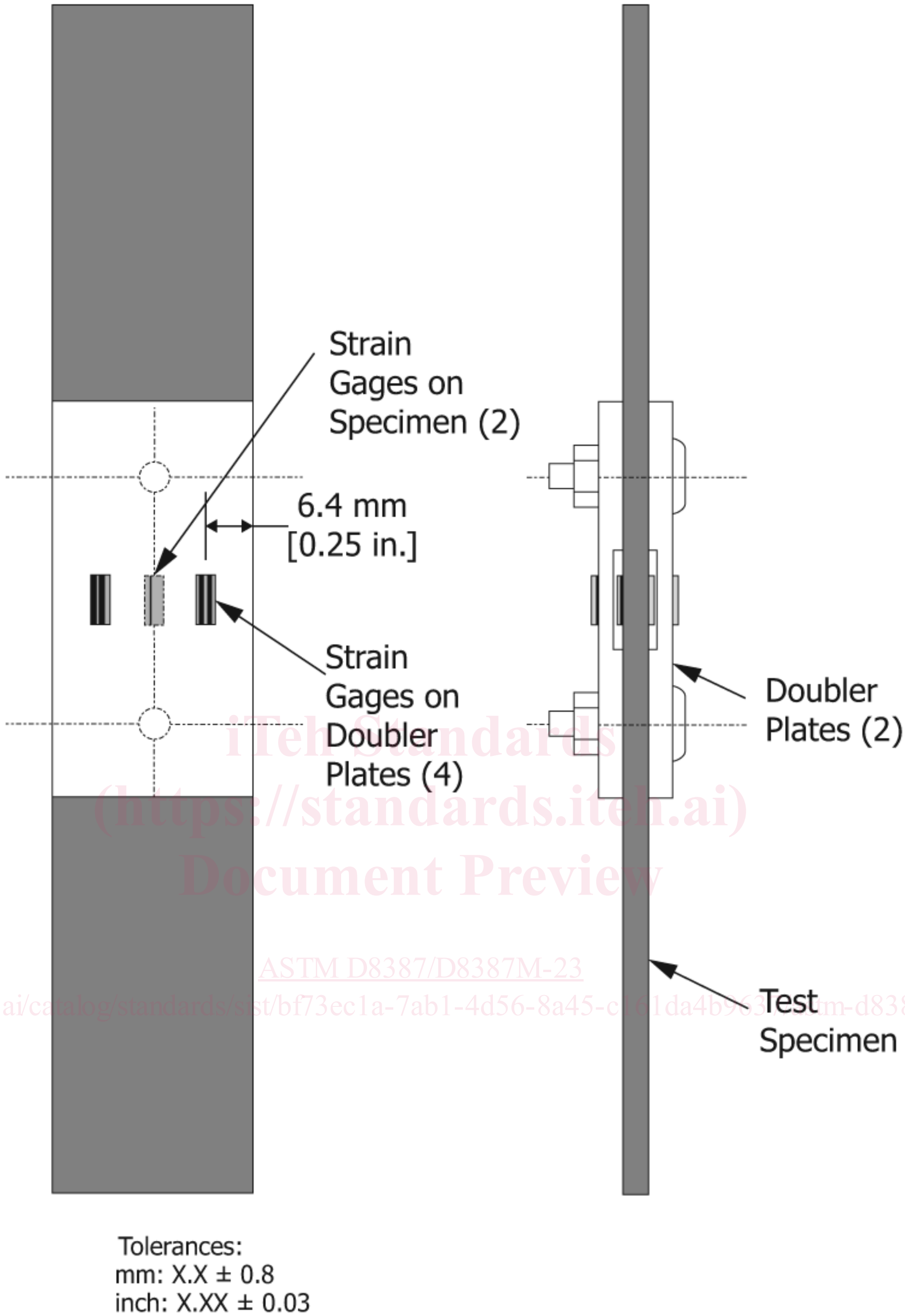


FIG. 3 (a) Tensile Loading—Test Specimen and Doubler Plate Assembly

4.2.1.2 *Stabilized Configuration (Using Support Fixture)*—The test specimen is face-supported in a multi-piece bolted support fixture, as shown in Fig. 4. The test specimen/fixture assembly is clamped in hydraulic wedge grips and the force is sheared into the support fixture and then sheared into the specimen. Tensile or compressive force is applied. The stabilization fixture is required for compressive loading and is optional for tensile loading.

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

5. Significance and Use

5.1 Refer to Guide D8509.

6. Interferences

6.1 Refer to Guide D8509.

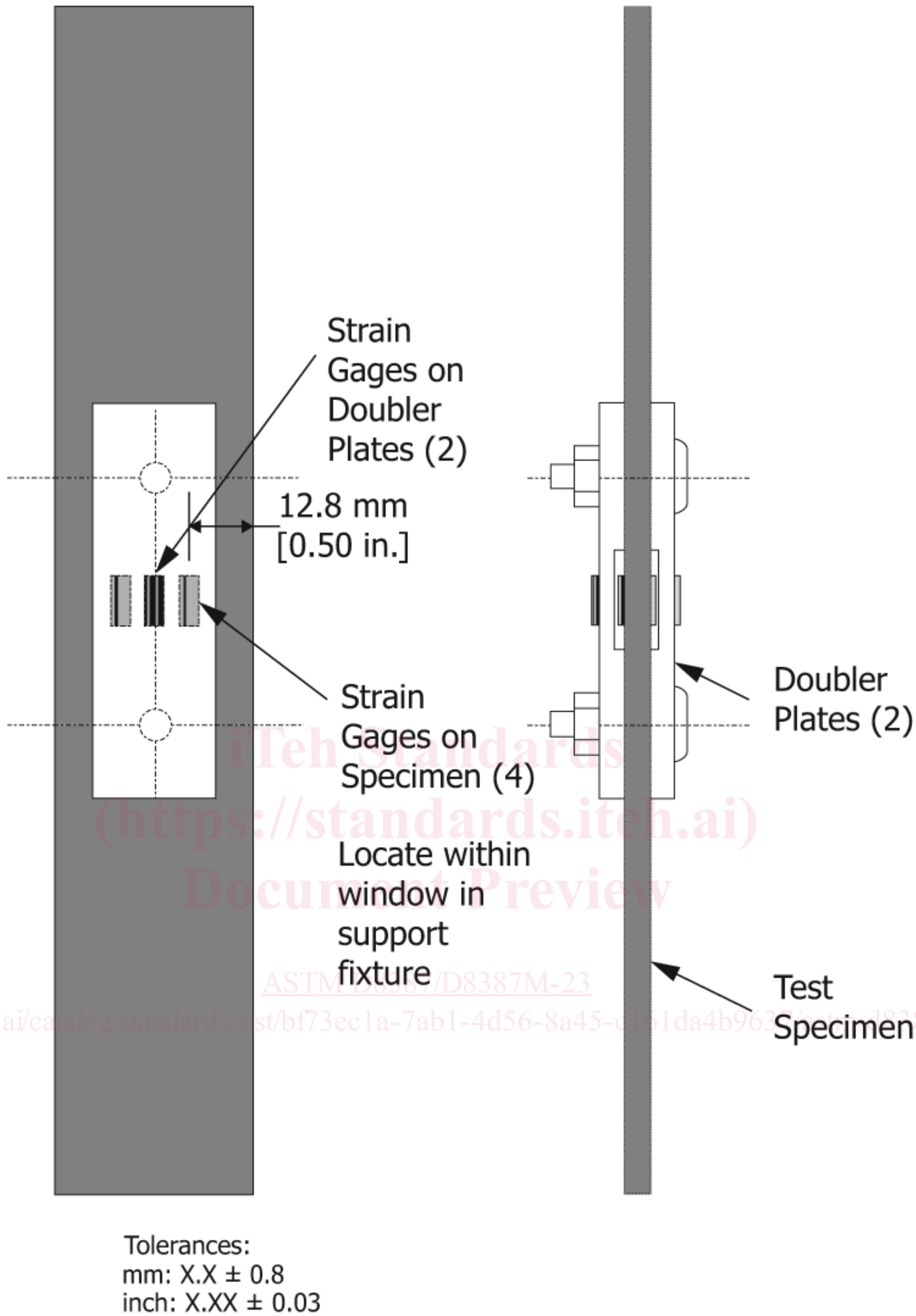


FIG. 3 (b) Compressive Loading—Test Specimen and Doubler Plate Assembly *(continued)*

7. Apparatus

7.1 *Micrometers*—A micrometer with a 4 mm to 8 mm [0.16 in. to 0.32 in.] nominal diameter ball interface shall be used to measure the specimen thickness when at least one surface is irregular (such as the bag-side of a laminate). A micrometer with a 4 mm to 8 mm [0.16 in. to 0.32 in.] nominal diameter ball interface or with a flat anvil interface shall be used to measure the specimen thickness when both surfaces are smooth (such as tooled surfaces). A micrometer or caliper, with a flat anvil interface, shall be used to measure the width of the specimen. The accuracy of the instruments shall be suitable for reading to within 1% of the sample dimensions. For typical specimen geometries, an instrument with an accuracy of ±0.0025 mm [±0.0001 in.] is adequate for the thickness measurement, while an instrument with an accuracy of ±0.025 mm [±0.001 in.] is adequate for the width measurement. Additionally, a micrometer or gage capable of determining the hole diameters to ±0.025 mm [±0.001 in.] shall be used.

NOTE 2—The accuracies given above are based on achieving measurements that are within 1 % of the sample width and thickness.

7.2 *Loading Fasteners or Pins*—The fastener (or pin) type shall be specified as an initial test parameter and reported. The

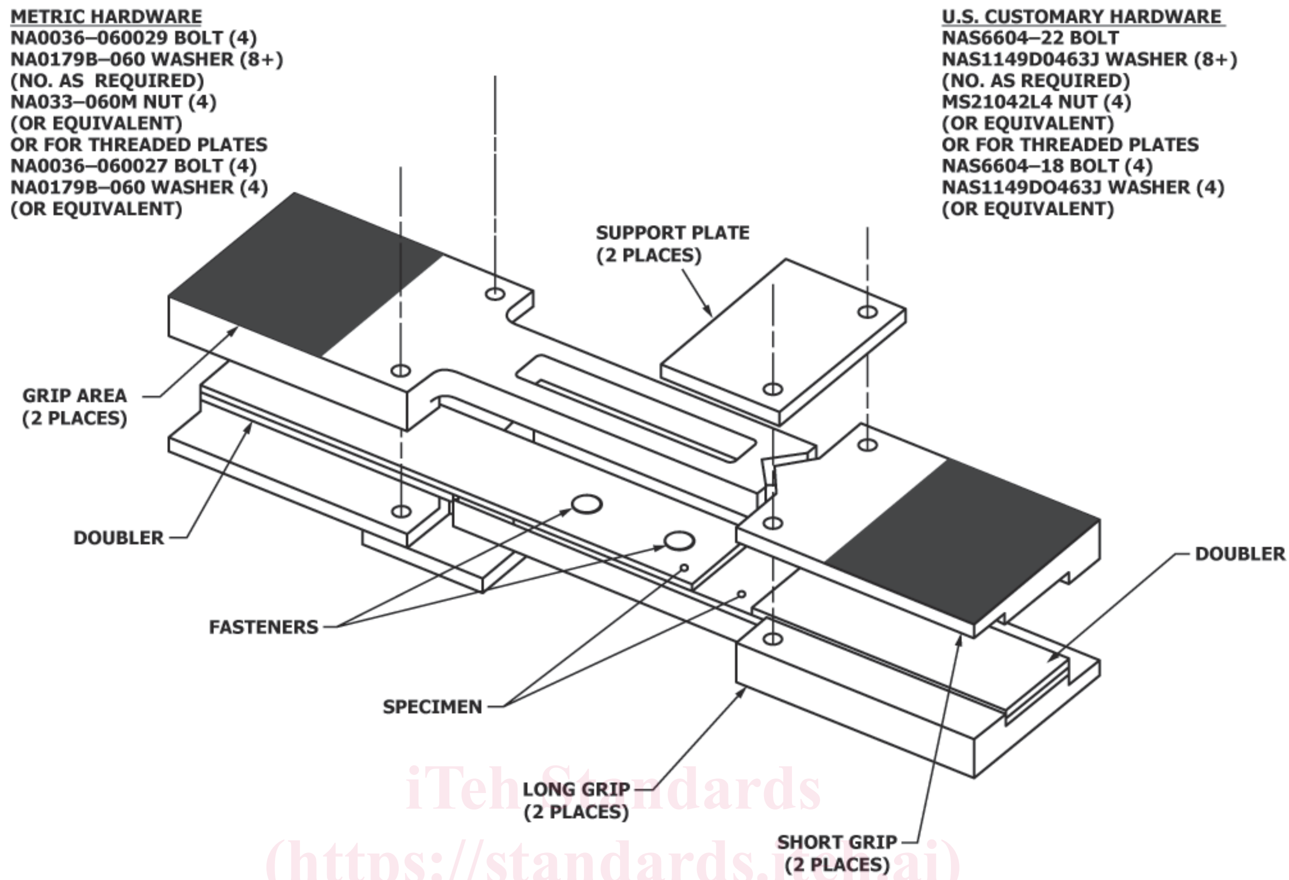


FIG. 4 Support Fixture Assembly (for Details of the Support Fixture, See Test Method D5961/D5961M)

assembly torque (if applicable) shall be specified as an initial test parameter and reported. This value may be a measured torque or a specification torque for fasteners with lock-setting features. If washers are utilized, the washer type, number of washers, and washer location(s) shall be specified as initial test parameters and reported. The reuse of fasteners is not recommended due to potential differences in through-thickness clamp-up for a given torque level, caused by wear of the threads or deformation of the locking features.

7.3 *Torque Wrench*—If using a torqued fastener, a torque wrench used to tighten the fastener shall be capable of determining the applied torque to within ±10 % of the desired value.

7.4 *Fixture*—Doubler plates, Fig. 2, are attached to the test specimen using two fasteners. In some cases, it may be desirable to use doubler plates that are more closely matched in stiffness to the test laminate, particularly when testing soft laminate materials or layups. These plates may typically be reused, as the force transferred into the plates should be relatively small. The holes in the plates should be examined for bearing deformation after each use and replaced if deformation is observed. If the doubler plates are replaced, the new plates shall be calibrated in accordance with 11.3.

7.4.1 For compressive tests, the doubler plates must be sized to fit into the support fixture window. See alternate described in 7.4.5.

7.4.2 For test laminates that are narrower than the standard specimen width, which may be required in some cases to obtain a bypass failure mode, the standard doubler plate widths may be used. Actual widths shall be used in the force proportion estimate calculations in 8.2.2.

7.4.3 *Strain Gages*—For tensile tests, two axial strain gages shall be mounted on each doubler plate at the locations shown in Fig. 3a. For compressive tests, one axial strain gage shall be mounted on each doubler plate at the location shown in Fig. 3b.

7.4.4 *Machining Precision*—Doubler plates and calibration loading plates require high machining quality, hole diameter tolerances, hole positioning, hole perpendicularity, flatness, etc.

7.4.5 For compressive tests, an alternate to doublers that fit within the support fixture window is to use full width doublers (same as for tensile tests). In this case, shims (4 total) equal to the doubler plate thickness will be required at each end of the specimen to provide a flat surface to interface with the support fixture. In some cases, test laminate failure may then occur at the gap between the doubler and shim; a mitigation for this situation is to modify the doublers and shims to have a chevron shape similar to the support fixture such that there is no unsupported laminate area across the specimen width.

7.5 *Support Fixture (Compressive Loading)*—If compressive loads are applied or if requested in the test plan, a support fixture shall be used to stabilize the specimen. The fixture is a face-supported test fixture as shown in Fig. 4. The fixture consists of two short-grip/long-grip assemblies, two support plates, and stainless steel shims as required to maintain a nominally zero (0.00-mm to 0.12-mm [0.000-in. to 0.005-in.] tolerance) gap between the support plates and the long grips. If this gap does not meet the minimum requirement, shim the contact area between the support plate and the short grip with stainless steel shim stock. If the gap is too large, shim between the support plate and the long grip, holding the shim stock on the support plate with tape. The fixture should be checked for conformity to engineering drawings. Each short-grip/long-grip assembly is line-drilled and must be used as a matched set. The threading of the support plate is optional. The fixture is hydraulically gripped on each end and the force is sheared by means of friction through the fixture and into the test specimen. A cutout exists on both faces of the fixture for a thermocouple, fastener(s), and surface-mounted extensometer. The long and short fixtures have an undercut along the corner of the specimen grip area so that specimens are not required to be chamfered and to avoid damage caused by the radius. The fixtures also allow a slight clearance between the fixture and the gage section of the specimen, in order to minimize grip failures and friction effects. This fixture does not allow specimens to be end loaded.

7.5.1 *Support Fixture Details*—The detailed drawings for manufacturing the support fixture are contained in Test Method D5961/D5961M. Other fixtures that meet the requirements of this section may be used.

NOTE 3—Experience has shown that fixtures may be damaged in use; thus, periodic re-inspection of the fixture dimensions and tolerances is important.

7.6 *Testing Machine*—The testing machine shall be in conformance with Practices E4, and shall satisfy the following requirements:

7.6.1 *Testing Machine Configuration*—The testing machine shall have both an essentially stationary head and a movable head. A short loading train and rigidly mounted hydraulic grips shall be used for Procedure B when using the support fixture.

7.6.2 *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.

7.6.3 *Force Indicator*—The testing machine force-sensing device shall be capable of indicating the total force 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 force with an accuracy over the force range(s) of interest of within ±1 % of the indicated value.

7.6.4 *Grips*—Each head of the testing machine shall be capable of holding one end of the test assembly so that the direction of force 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 test specimen or support fixture.

7.7 *Bearing Deformation Indicator*—Bearing deformation data shall be determined by an indicator device able to measure longitudinal hole deformation, as shown in Fig. 5. The arms of the indicator device must fit within the stabilization fixture when a specimen with a width less than 36 mm [1.5 in.] is tested in the standard fixture. Transducer gage lengths on the order of 50 mm [2.0 in.] are typically used. The transducers of the bearing deformation 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 deformation indicator to the specimen shall not cause damage to the specimen surface. Transducers shall satisfy, at a minimum, Practice E83, Class B-2 requirements for the displacement range of interest, and shall be calibrated over that range in accordance with Practice E83. The transducers shall be essentially free of inertia-lag at the specified speed of testing.

7.8 *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 humidity level to within ±3 %. Chamber conditions shall be monitored either on an automated continuous basis or on a manual basis at regular intervals.

7.9 *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 within ±3 °C or ±5 °F.

7.10 *Strain-Indicating Device*—Strain data, when required, shall be determined by means of bonded resistance strain gages.

7.10.1 *Bonded Resistance Strain Gage Selection*—Strain gage selection is based on the type of material to be tested. A minimum active gage length of 3 mm [0.125 in.] is recommended for composite laminates fabricated from unidirectional layers. Larger strain gage sizes may be more suitable for some textile fabrics. Gage calibration certification shall comply with Test Method E251. Strain gages with a minimum normal strain range of approximately 3 % are recommended. When testing textile fabric laminates, gage selection should consider the use of an active gage length that is at least as great as the characteristic repeating unit of the fabric. Some guidelines on the use of strain gages on composite materials follow.

7.10.1.1 Surface preparation of fiber-reinforced composites in accordance with Guide E1237 can penetrate the matrix material and cause damage to the reinforcing fibers, resulting in improper coupon failures. Reinforcing fibers should not be exposed or damaged during the surface preparation process. The strain gage manufacturer should be consulted regarding surface preparation guidelines and recommended bonding agents for composites, pending the development of a set of standard practices for strain gage installation surface preparation of fiber-reinforced composite materials.

7.10.1.2 Consideration should be given to the selection of gages having larger resistances to reduce heating effects on low conductivity materials. Resistances of 350 Ω or higher are

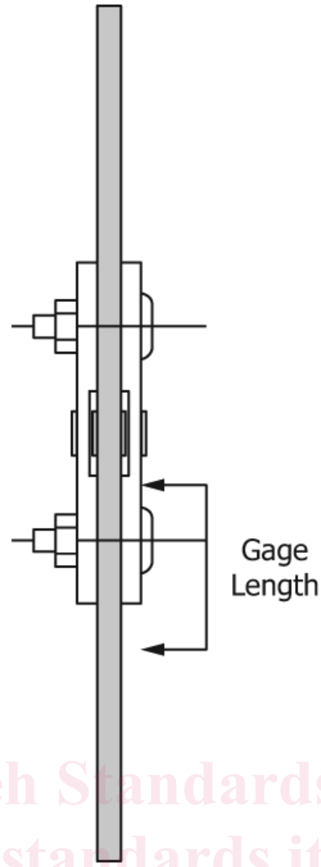


FIG. 5 Transducer Gage Length and Location

preferred. Additional consideration should be given to the use of the minimum possible gage excitation voltage consistent with the desired accuracy (1 V to 2 V is recommended) to reduce the power consumed by the gage. Heating of the coupon by the gage may affect the performance of the material directly or it may affect the indicated strain as a result of a difference between the gage temperature compensation factor and the coefficient of thermal expansion of the coupon material.

7.10.1.3 Consideration of some form of temperature compensation is recommended, even when testing at standard laboratory atmosphere. Temperature compensation may be required when testing in non-ambient temperature environments.

7.10.1.4 Consideration should be given to the transverse sensitivity of the selected strain gage. The strain gage manufacturer should be consulted for recommendations on transverse sensitivity corrections and effects on composites.

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 E122 should be consulted. The method of sampling shall be reported.

NOTE 4—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 specimen), then use a traveler specimen of the 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 multidirectional fiber orientations (fibers shall be oriented in a minimum of two directions), and balanced and symmetric stacking sequences. For tensile loaded specimens, nominal thickness shall be 2.5 mm [0.10 in.], with a permissible range of 2 mm to 5 mm [0.080 in. to 0.208 in.], inclusive. For compressive loaded specimens, nominal thickness shall be 4 mm [0.160 in.], with a permissible range of 2.5 mm to 5 mm [0.100 in. to 0.208 in.], inclusive. Fabric laminates containing satin-type weaves shall have symmetric warp surfaces, unless otherwise specified and noted in the report.

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

8.2.2 *Configuration*—The geometry of the specimen is shown in Fig. 1. Strain gages as shown in Fig. 3 are recommended to provide additional data to determine the proportion of force transferred to the doubler plates. The following equations may be used to estimate the proportion of force transferred to the doubler plates for test specimen design purposes. These equations assume the two fasteners and the two doubler plates are identical. The fastener flexibility equation is obtained from Ref (**2**). These equations shall not be used for test data calculations.

$$k = \frac{2C_P}{(2C_P + C_S + 2C_F)} \quad (1)$$

$$C_P = \frac{L}{t_P w_P E_{xP}} \quad (2)$$

$$C_S = \frac{L}{t_S w_S E_{xS}} \quad (3)$$

$$C_F = \frac{8(2t_S + t_P)(1 + v_F)}{3\pi E_F d^2} + \frac{(64)(8t_S^3 + 16t_S^2 t_P + 8t_S t_P^2 + t_P^3)}{192\pi E_F d^4} + \frac{2t_S + t_P}{t_S t_P E_F} + \frac{1}{t_S E_{xS}} + \frac{2}{t_P E_{xP}} \quad (4)$$

where:

k_E = estimate of proportion of total force transferred through fasteners to doubler plates,
C_P = plate (specimen) flexibility,
C_S = doubler plate flexibility,
C_F = fastener flexibility (Ref **1**),
t_P = test specimen laminate thickness, mm [in.],
t_S = doubler plate thickness, mm [in.],
w_P = test specimen width, mm [in.],
w_S = doubler plate width, mm [in.],
E_{xP} = test specimen laminate modulus, MPa [psi],
E_{xS} = doubler plate modulus in axial (x) direction, MPa [psi],
E_F = fastener modulus, MPa [psi],
v_F = fastener Poisson's ratio,
d = fastener diameter, mm [in.], and
L = distance between fastener centerlines, mm [in.].

8.3 *Specimen Preparation*—Guide D5687/D5687M provides recommended specimen preparation practices and should be followed where practical.

8.3.1 *Panel Fabrication*—Control of fiber alignment is critical. Improper fiber alignment will reduce the measured properties. The panel(s) must be flat and of uniform thickness to ensure even loading. 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 water-lubricated 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. Record and report the specimen cutting and hole preparation methods.

8.3.3 *Hole Drilling*—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. Specimens should be match drilled with the doubler straps to ensure that the fasteners can be installed.

8.3.4 *Labeling*—Label the specimens 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 Unless explicitly specified by the test requestor, no pre-test conditioning shall be performed and the test specimens shall be tested as prepared.

10.2 The pre-test specimen conditioning process, to include specified environmental exposure levels and resulting moisture content, shall be reported with the test data.

NOTE 6—The recommended pre-test specimen condition is effective moisture equilibrium at a specific relative humidity per Test Method D5229/D5229M.

NOTE 7—The term moisture, as used in Test Method D5229/D5229M, includes not only the vapor of a liquid and its condensate, but the liquid itself in large quantities, as for immersion.

10.3 If no explicit conditioning process is performed, the specimen conditioning process shall be reported as "unconditioned" and the moisture content as "unknown."

11. Procedure

11.1 *Parameters to Be Specified Prior to Test:*

11.1.1 The specimen sampling method, specimen type and geometry, fastener type and material, fastener torque (if appropriate), type of loading (tensile or compressive), support fixture (if appropriate), cleaning process, and conditioning travelers (if required).

11.1.2 The properties to report and data reporting format desired.

NOTE 8—Determine specific material property, accuracy, and data reporting requirements prior to test for proper selection of instrumentation and data recording equipment. Estimate specimen failure 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, extensometer requirements and related calculations.

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

11.2 *Before Test:*

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 D792. Volume percent of the constituents may be evaluated by one of the matrix digestion procedures of Test Method D3171, or, for certain reinforcement materials such as glass and ceramics, by the matrix burn-off technique of Test Method D2584. The void