Designation: D7248/D7248M – 21

Standard Test Method for High Bearing - Low Bypass Interaction Response of Polymer Matrix Composite Laminates Using 2-Fastener Specimens[1]

This standard is issued under the fixed designation D7248/D7248M; 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 bearing/bypass interaction response of multi-directional polymer matrix composite laminates reinforced by high-modulus fibers by either double-shear tensile loading (Procedure A) or single-shear tensile or compressive loading (Procedure B) of a two-fastener 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 each 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. Test methods for high bypass - low bearing response of polymer matrix composite materials, previously published under Procedure C of this test method, are now published in Test Method D8387/D8387M.

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 similar to those in Test Method D5961/D5961M as well as those used by industry to investigate the bearing 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. Should the test specimen fail in a bearing failure mode rather than the desired bypass mode, then the test should be considered to be a bearing dominated bearing/bypass test, and the data reduction and reporting procedures of Test Method D5961/D5961M should be used instead of those given in this test method.

1.4 *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.

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

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

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D883 Terminology Relating to Plastics

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.

Current edition approved May 15, 2021. Published June 2021. Originally approved in 2007. Last previous edition approved in 2017 as D7248/D7248M – 12(2017). DOI: 10.1520/D7248_D7248M-21.

[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
D8387/D8387M Test Method for High Bypass – Low Bearing Interaction Response of Polymer Matrix Composite Laminates
E4 Practices for Force 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]

Composite Materials Handbook, CMH-17 Polymer Matrix Composites, Volume 1, Chapter 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:*

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

3.2.2 *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.

3.2.3 *bearing force, P* $[MLT^{-2}]$, *n*—the in-plane force transmitted by a fastener to a specimen at the fastener hole.

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

3.2.5 *bearing strength,* $F_x^{br\_byp}$ $[ML^{-1}T^{-2}]$, *n*—the value of bearing stress occurring at the point of bypass (net section) failure.

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

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

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

3.2.8 *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.

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

3.2.9 *gross bypass stress,* f^{gr_byp} $[ML^{-1}T^{-2}]$, *n*—the gross bypass stress for tensile loadings is calculated from the total force bypassing the fastener hole.

3.2.10 *net bypass stress,* f^{net_byp} $[ML^{-1}T^{-2}]$, *n*—the net bypass stress for tensile loading is calculated from the force bypassing the fastener hole minus the force reacted in bearing at the fastener.

NOTE 2—For compressive loadings, the gross and net bypass stresses are equal and are calculated using the force that bypasses the fastener hole (since for the compressive loading case, the bearing stress reaction is on the same side of the fastener as the applied force, the force reacted in bearing does not bypass the fastener hole).

NOTE 3—Several alternate definitions for gross and net bypass stress have been used historically in the aerospace industry. Comparison of data from tests conforming to this test method with historical data may need to account for differences in the bypass definitions.

3.2.11 *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.

3.2.12 *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.

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

3.2.13 *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 force capability of a bearing specimen.

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

3.2.14 *ultimate gross bypass strength,* $F_x^{gr\_byp}$ $[ML^{-1}T^{-2}]$, *n*—the value of gross bypass stress, in the direction specified by the subscript, at the maximum force capability of the specimen.

3.2.15 *ultimate net bypass strength,* $F_x^{net\_byp}$ $[ML^{-1}T^{-2}]$, *n*—the value of net bypass stress, in the direction specified by the subscript, at the maximum force capability of the specimen.

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

3.2.16.1 *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.

3.3 *Symbols:*

A = cross-sectional area of a specimen

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

d = fastener or pin diameter

D = specimen hole diameter

d_{csk} = countersink depth

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

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

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

$F_x^{br\_byp}$ = bearing stress at the ultimate bypass strength in the test direction specified by the subscript

$F_x^{gr\_byp\_c}$ = ultimate compressive gross bypass strength in the test direction specified by the subscript

$F_x^{gr\_byp\_t}$ = ultimate tensile gross bypass strength in the test direction specified by the subscript

$F_x^{net\_byp\_c}$ = ultimate compressive net bypass strength in the test direction specified by the subscript

$F_x^{net\_byp\_t}$ = ultimate tensile net bypass strength in the test direction specified by the subscript

g = distance, parallel to applied force, from hole edge to end of specimen

h = specimen thickness

k = calculation factor used in net bypass strength calculations to determine net force portion

L_g = extensometer gage length

n = number of specimens per sample population

P = force carried by test specimen

P^f = force carried by test specimen at failure

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

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

w = specimen width

x_i = test result for an individual specimen from the sample population for a given property

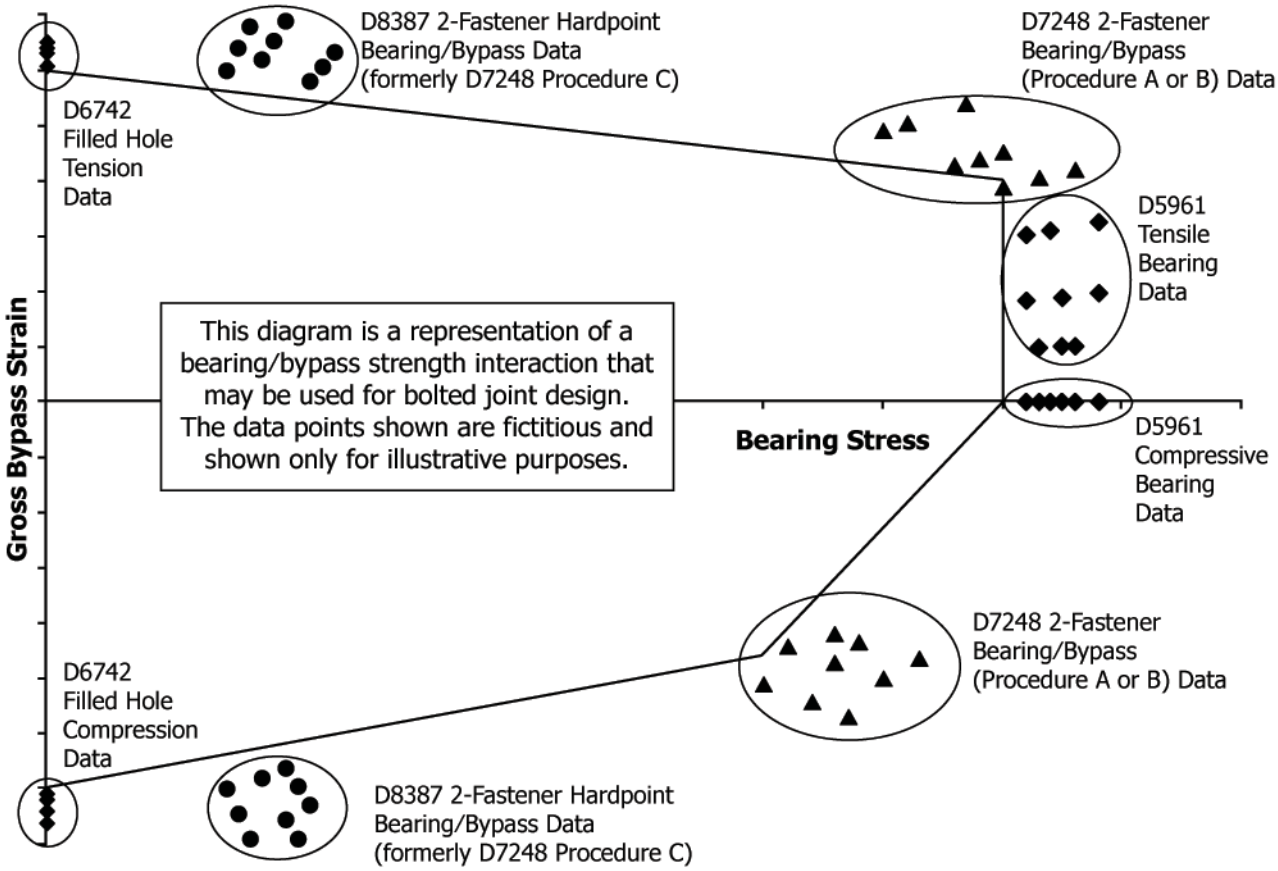

FIG. 1 Illustration of FHT, FHC, Bearing and Bearing/Bypass Bolted Joints Data and Bearing/Bypass Interaction Diagram (Refs 1-3)