Designation: D7332/D7332M – 23

Standard Test Method for Measuring the Fastener Pull-Through Resistance of a Fiber-Reinforced Polymer Matrix Composite[1]

This standard is issued under the fixed designation D7332/D7332M; 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 fastener pull-through resistance of multidirectional polymer matrix composites reinforced by high-modulus fibers. Fastener pull-through resistance is characterized by the force-versus-displacement response exhibited when a mechanical fastener is pulled through a composite plate, with the force applied perpendicular to the plane of the plate. The composite material forms are limited to continuous-fiber or discontinuous-fiber (tape or fabric, or both) reinforced composites for which the laminate is symmetric and balanced with respect to the test direction. The range of acceptable test laminates and thicknesses is defined in 8.2.

1.2 Two test procedures and configurations are provided. The first, Procedure A, is suitable for screening and fastener development purposes. The second, Procedure B, is configuration-dependent and is suitable for establishing design values. Both procedures can be used to perform comparative evaluations of candidate fasteners/fastener system designs.

1.3 The specimens described herein may not be representative of actual joints which may contain one or more free edges adjacent to the fastener, or may contain multiple fasteners that can change the actual boundary conditions.

1.4 This test method is consistent with the recommendations of CMH-17, which describes the desirable attributes of a fastener pull-through test method.

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
D3410/D3410M Test Method for Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading
D3878 Terminology for Composite Materials
D5229/D5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
D5687/D5687M Guide for Preparation of Flat Composite Panels with Processing Guidelines for Specimen Preparation
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
E18 Test Methods for Rockwell Hardness of Metallic 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 Sept. 1, 2023. Published October 2023. Originally approved in 2007. Last previous edition approved in 2022 as D7332/D7332M – 22. DOI: 10.1520/D7332_D7332M-23.

[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.

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
E456 Terminology Relating to Quality and Statistics
2.2 *Industry Documents:*[3]
CMH-17-1G Composite Materials Handbook, Volume 1—Polymer Matrix Composites Guidelines for Characterization of Structural Materials

3. Terminology

3.1 *Definitions*—Terminology D3878 defines terms relating to composite materials. 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 standards.

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 Refer to Guide D8509.

3.2.2 *failure force, n*—the maximum force magnitude achieved prior to the first significant (greater than 10 %) drop in applied force, as observed in force versus displacement data.

3.2.3 *initial sub-critical failure, n*—discontinuity observed in force versus displacement data prior to attaining the failure force. Sub-critical failures are characterized by minor (less than 10 %) drops in applied force, or by compliance changes (greater than 10 % change in slope), prior to attaining the failure force.

3.2.4 *rupture, n*—separation of the fastener and test laminate, caused by failure of the fastener, the composite plate, or both. Rupture is characterized by an extreme force drop, such that the specimen is incapable of carrying significant applied force.

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 shank diameter
d_{csk} = countersink depth
D = specimen hole diameter
h = specimen thickness
l = specimen length
n = number of specimens per sample population
N = number of plies in laminate under test
P_f = failure force
P_i = force carried by test specimen at initial failure
P_m = maximum force carried by test specimen during test
s_{n-1} = standard deviation statistic of a sample population for a given property
w = specimen width
x_i = test result for an individual specimen from the sample population for a given property
$\bar{x}$ = mean or average (estimate of mean) of a sample population for a given property
δ_i = displacement at initial failure
δ_r = displacement at rupture

4. Summary of Test Method

4.1 *Procedure A, Compressive-Loaded Fixture:*

4.1.1 Two flat square, constant rectangular cross-section composite plates, each containing a centrally located fastener hole, are placed in a multi-piece fixture that has been aligned to minimize loading eccentricities. Each plate contains four additional holes on the periphery to accommodate the test fixture components. The two plates are joined together by the fastener, with one plate being rotated 45° with respect to the second plate.

4.1.2 The plates are pried apart by the application of compressive force transmitted through the fixture, producing a tensile loading through the fastener and a compressive loading through the composite plates. Force is applied until failure of the composite specimen, the fastener, or both occurs. Applied force and crosshead displacement are recorded while loading.

4.2 *Procedure B, Tensile-Loaded Fixture:*

4.2.1 A flat square, constant rectangular cross-section composite plate containing a centrally located fastener hole is placed in a multi-piece fixture that has been aligned to minimize loading eccentricities. The plate is joined by the fastener to a yoke, which is designed to rotate as to avoid imparting a moment to the fastener.

4.2.2 A uniaxial tensile force is applied to the yoke, imparting a tensile loading on the fastener and an out-of-plane compressive loading on the composite plate. Force is applied until failure of the composite specimen, the fastener, or both occurs. Applied force and crosshead displacement are recorded while loading.

4.3 Refer to Guide D8509 for additional test details and acceptable failure modes.

5. Significance and Use

5.1 Refer to Guide D8509.

6. Interferences

6.1 Refer to Guide D8509.

7. Apparatus

7.1 *Micrometers and Calipers*—A micrometer with a 4 mm to 8 mm [0.16 in. to 0.32 in.] nominal diameter ball-interface or a flat anvil interface shall be used to measure the specimen thickness. A ball interface is recommended for thickness measurements when at least one surface is irregular (for example, a coarse peel ply surface, which is neither smooth nor

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