



Designation: D6264/D6264M – 23

Standard Test Method for Measuring the Damage Resistance of a Fiber-Reinforced Polymer-Matrix Composite to a Concentrated Quasi-Static Indentation Force¹

This standard is issued under the fixed designation D6264/D6264M; 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 damage resistance of multidirectional polymer matrix composite laminated plates subjected to a concentrated indentation force (Fig. 1). Procedures are specified for determining the damage resistance for a test specimen supported over a circular opening and for a rigidly-backed test specimen. The composite material forms are limited to continuous-fiber reinforced polymer matrix composites, with the range of acceptable test laminates and thicknesses defined in 8.2. This test method may prove useful for other types and classes of composite materials.

1.1.1 Instructions for modifying these procedures to determine damage resistance properties of sandwich constructions are provided in Practice D7766/D7766M.

1.2 A flat, square composite plate is subjected to an out-of-plane, concentrated force by slowly pressing a hemispherical indenter into the surface. The damage resistance is quantified in terms of a critical contact force to cause a specific size and type of damage in the specimen.

1.3 The test method may be used to screen materials for damage resistance, or to inflict damage into a specimen for subsequent damage tolerance testing. The indented plate can be subsequently tested in accordance with Test Method D7137/D7137M to measure residual strength properties. Drop-weight impact per Test Method D7136/D7136M may be used as an alternate method of creating damage from an out-of-plane force and measuring damage resistance properties.

1.4 The damage resistance properties generated by this test method are highly dependent upon several factors, which include specimen geometry, layup, indenter geometry, force, and boundary conditions. Thus, results are generally not scalable to other configurations, and are particular to the combination of geometric and physical conditions tested.

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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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

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

D5687/D5687M Guide for Preparation of Flat Composite Panels with Processing Guidelines for Specimen Preparation

D7136/D7136M Test Method for Measuring the Damage Resistance of a Fiber-Reinforced Polymer Matrix Composite to a Drop-Weight Impact Event

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.

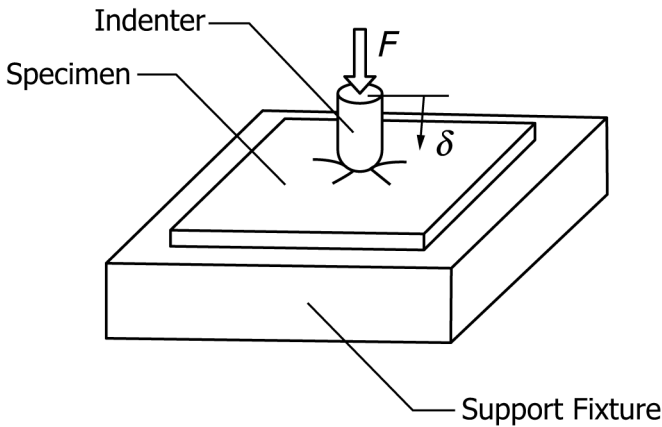


FIG. 1 Quasi-Static Indentation Test

D7137/D7137M Test Method for Compressive Residual Strength Properties of Damaged Polymer Matrix Composite Plates

D7766/D7766M Practice for Damage Resistance Testing of Sandwich Constructions

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

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

E2533 Guide for Nondestructive Examination of Polymer Matrix Composites Used in Aerospace Applications

2.2 Military Standards:

CMH-17-3G Composite Materials Handbook, Volume 3—Polymer Matrix Composites Materials Usage, Design and Analysis³

MIL-HDBK-728/1 Nondestructive Testing⁴

MIL-HDBK-731A Nondestructive Testing Methods of Composite Materials—Thermography⁴

MIL-HDBK-732A Nondestructive Testing Methods of Composite Materials—Acoustic Emission⁴

MIL-HDBK-733A Nondestructive Testing Methods of Composite Materials—Radiography⁴

MIL-HDBK-787A Nondestructive Testing Methods of Composite Materials—Ultrasonics⁴

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.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 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.

3.2.2 *contact force*, F $[MLT^{-2}]$, n —the force exerted by the indenter on the specimen during the test, as recorded by a force indicator.

3.2.3 *dent depth*, d $[L]$, n —residual depth of the depression formed by an indenter after removal of applied force. The dent depth shall be defined as the maximum distance in a direction normal to the face of the specimen from the lowest point in the dent to the plane of the surface that is undisturbed by the dent.

3.2.4 *indenter displacement*, $δ$ $[L]$, n —the displacement of the indenter relative to the specimen support.

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

3.3 Symbols:

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

D = damage diameter (see Fig. 6)

d = dent depth (see 3.2.3)

E = energy calculated by integrating the contact force and indenter displacement curve

E_a = energy absorbed (inelastically) by the specimen during the test

E_{max} = energy at maximum indenter displacement

F = contact force (see 3.2.2)

F_{max} = the maximum contact force exerted on the specimen during a test

n = number of specimens per sample population

N = number of plies in laminate under test

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

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

$δ$ = indenter displacement (see 3.2.4)

$δ_o$ = indenter displacement at initial specimen contact

$δ_f$ = indenter displacement at the end of the unloading cycle

$δ_{max}$ = maximum indenter displacement during the test

4. Summary of Test Method

4.1 A quasi-static indentation (QSI) test is used to measure the damage resistance on a balanced, symmetric laminated

³ Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.

⁴ Available from U.S. Army Materials Technology Laboratory, Watertown, MA 02471.