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Standard Test Method for Static Energy Absorption Properties of Honeycomb Sandwich Core Materials[1]

This standard is issued under the fixed designation D7336/D7336M; 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 static energy absorption properties (compressive crush stress and crush stroke) of honeycomb sandwich core materials. These properties are usually determined for design purposes in a direction normal to the plane of the face sheets (also referred to as the facing plane) as the honeycomb core material would be placed in a structural sandwich construction.

1.2 Permissible core materials are limited to those in honeycomb form.

1.3 This test method is not intended for use in crush testing of stabilized honeycomb core materials (for which the facing plane surfaces of the honeycomb core material are dipped in resin to resist local crushing) or sandwich specimens (for which facings are bonded to the honeycomb core material).

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]

C271/C271M Test Method for Density of Sandwich Core Materials
D883 Terminology Relating to Plastics
D3878 Terminology for Composite Materials
D5229/D5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
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

3. Terminology

3.1 *Definitions*—Terminology D3878 defines terms relating to high-modulus fibers and their composites, as well as terms relating to sandwich constructions. 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 terminologies.

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.

[1] This test method is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.09 on Sandwich Construction.

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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.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cell size [L], n—in a honeycomb core*, the distance between two parallel and opposite cell walls at node bond areas, measured transverse to the ribbon direction.

3.2.2 *node bond area, n—in a honeycomb core*, the area between two cells at which the component walls of the cells are bonded or attached.

3.3 *Symbols:*

A = cross-sectional area of a test specimen prior to compressive crush testing
CV = coefficient of variation statistic of a sample population for a given property (in percent)
K_A = initial chord slope of the force versus displacement/deformation curve
K_B = post-crush slope of the force versus displacement/deformation curve
P_{cr} = average force carried by test specimen during compressive crushing
s_{cr} = crush stroke in percent
S_{n-1} = standard deviation statistic of a sample population for a given property
t_i = thickness of a test specimen prior to compressive crush testing
x_1 = 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 = recorded displacement/deflection
δ_A = displacement/deflection at which the initial chord slope intersects the displacement/deformation axis
δ_B = displacement/deflection at which the post-crushing slope equals the initial chord slope
δ_{cr} = crush stroke
Δ = normalized displacement/deflection
σ_{cr} = average compressive crush stress

4. Summary of Test Method

4.1 This test method consists of subjecting a sandwich honeycomb core material to a uniaxial compressive force normal to the plane of the face sheets as the honeycomb core material would be placed in a structural sandwich construction. The force is transmitted to the sandwich honeycomb core material using loading platens attached to the testing machine. Compressive force is applied past the initial failure force, such that the honeycomb core material is crushed under continuous displacement of the loading platens. Force versus loading platen displacement data are recorded and used to determine the crush stress and crush stroke.

5. Significance and Use

5.1 Sandwich honeycomb core materials are used extensively in energy absorption applications, due to their ability to sustain compressive loading while being crushed. Proper design of energy absorption devices utilizing sandwich honeycomb core materials requires knowledge of the compressive crush stress and crush stroke properties of the honeycomb core material.

5.2 The procedures contained within this test method are intended to assess the crush stress and crush stroke properties of the sandwich honeycomb core material under static compressive loading. The dynamic crush stress of the honeycomb core material may vary from that measured under static loading, depending upon factors such as honeycomb core material thickness, core material density, impact velocity, etc.

5.3 This test method provides a standard method of obtaining the compressive crush stress and crush stroke for sandwich honeycomb core material structural design properties, material specifications, research and development applications, and quality assurance.

5.4 This test method is not intended for use in crush testing of stabilized honeycomb core materials (for which the facing plane surfaces of the honeycomb core material are dipped in resin to resist local crushing) or sandwich specimens (for which face sheets are bonded to the honeycomb core material).

5.5 Factors that influence the compressive crush stress and crush stroke and shall therefore be reported include the following: honeycomb core material, methods of material fabrication, core material geometry (nominal cell size), core material density, specimen geometry, specimen preparation, specimen conditioning, environment of testing, specimen alignment, pre-crush procedure, pre-crush depth, loading procedure, and speed of testing.

6. Interferences

6.1 *Material and Specimen Preparation*—Poor material fabrication practices and damage induced by improper specimen machining are known causes of high data scatter in composites and sandwich structures in general. Important aspects of sandwich core material specimen preparation that contribute to data scatter include the existence of joints, voids or other core material discontinuities, out-of-plane curvature/warpage, and surface roughness.

6.2 *System Alignment*—Non-uniform loading over the surface of the test specimen may cause premature or uneven crushing. This may occur as a result from non-uniform thickness, failing to locate the specimen concentrically in the fixture, or system or fixture misalignment.

6.3 *Geometry*—Specific geometric factors that affect compressive crush stress and crush stroke include honeycomb core material cell geometry, core material thickness, and specimen shape (square or circular). Thicker specimens are generally desirable, as the crush stroke is greater for thick specimens compared to thin specimens.

6.4 *Pre-Crushing*—It is recommended to pre-crush honeycomb core material specimens prior to test, as historical crush force versus displacement data for pre-crushed specimens have displayed greater uniformity (consistency of the crush force level for varying crush stroke) than have similar data for non pre-crushed specimens. If tests are performed using analog equipment to record force versus displacement data, pre-crushing may be necessary to ensure the crush force is recorded on a high sensitivity force scale (if not pre-crushed, the peak force to initially fail the specimen may be substantially higher