Designation: D8510/D8510M – 23

# Standard Test Method for Local Buckling and Crippling under Axial Compressive Loading[1]

This standard is issued under the fixed designation D8510/D8510M; 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 covers the local buckling and crippling stresses for one-edge-free and no-edge-free cross section configurations using solid laminate composite material construction. Design of test specimens is covered in Guide D8511/D8511M. 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, fabric, braids or hybrids of these forms) reinforced composites.

1.2 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 Guide D8511/D8511M and CMH-17 Volume 3 Chapter 9[2](**1**).

1.3 *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.

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

1.4 *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.*

1.5 *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:*[3]

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
D5687/D5687M Guide for Preparation of Flat Composite Panels with Processing Guidelines for Specimen Preparation
D7137/D7137M Test Method for Compressive Residual Strength Properties of Damaged Polymer Matrix Composite Plates
D8511/D8511M
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
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

## 3. Terminology

3.1 *Definitions:*

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

[3] 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.

3.1.1 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, [$\theta$] 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 *crippling force, $P^{cc}$ [$MLT^{-2}$], n*—the applied compressive force at or above the local buckling force at which specimen failure occurs.

3.2.2 *crippling stress, $F^{cc}$ [$ML^{-1}T^{-2}$], n*—the average stress in the test specimen cross-section at failure (maximum force).

3.2.3 *local buckling force, $P^{lcr}$ [$MLT^{-2}$], n*—the applied compressive force at which buckling of a compression element within the cross-section initiates.

3.2.4 *local buckling stress, $F^{lcr}$ [$ML^{-1}T^{-2}$], n*—the average stress in the test specimen cross-section at which buckling of a compression element within the cross-section initiates.

3.2.5 *width to thickness ratio, b/t [nd], n*—the ratio of the width of the buckling critical section of the specimen cross-section to the specimen thickness.

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

3.3 *Symbols:*

3.3.1 *A*—cross-sectional area, $mm^2$ [$in.^2$].

3.3.2 *b*—width of buckling critical segment of specimen cross-section, relative to laminate centerline, mm [in.].

3.3.3 $F^{lcr}$—local buckling stress, MPa [psi].

3.3.4 $F^{cc}$—crippling stress, MPa [psi].

3.3.5 *L1*—specimen length between end potting or fixture inner surfaces, mm [in.].

3.3.6 *L2*—total specimen length, mm [in.].

3.3.7 *n*—number of tested specimens.

3.3.8 *P*—total compressive force applied to specimen, N [lbf].

3.3.9 $P^{lcr}$—applied compressive force at which buckling initiates, N [lbf].

3.3.10 $P^{cc}$—maximum applied compressive force, N [lbf].

3.3.11 *t*—specimen thickness (nominal or actual, as specified), mm [in.].

3.3.12 *w*—overall width of buckling critical segment of specimen cross-section, mm [in.].

3.3.13 $\bar{X}$—sample mean (average).

3.3.14 $S_{n-1}$—sample standard deviation.

3.3.15 *CV*—sample coefficient of variation, %.

3.3.16 $x_i$—measured or derived property.

## 4. Summary of Test Method

4.1 This test standard establishes the procedure for determining the local instability (buckling) force in one or more cross-section segments and the post-buckled force sustained by a composite specimen. The test involves applying an axial compressive force to an unsupported specimen until local buckling and subsequent catastrophic failure ("crippling") occurs. The test frame head travel, force and cross-sectional strains are recorded during the test. Still or video images, or both, of the specimen deformations under force are recorded and reported.

4.1.1 This test standard does not provide an explicit specimen geometry or data reduction methodology. The specimen geometry is to be provided by the test requestor. Refer to Guide D8511/D8511M for specimen design and analysis information. The three test procedures in Fig. 1 are covered in this standard.

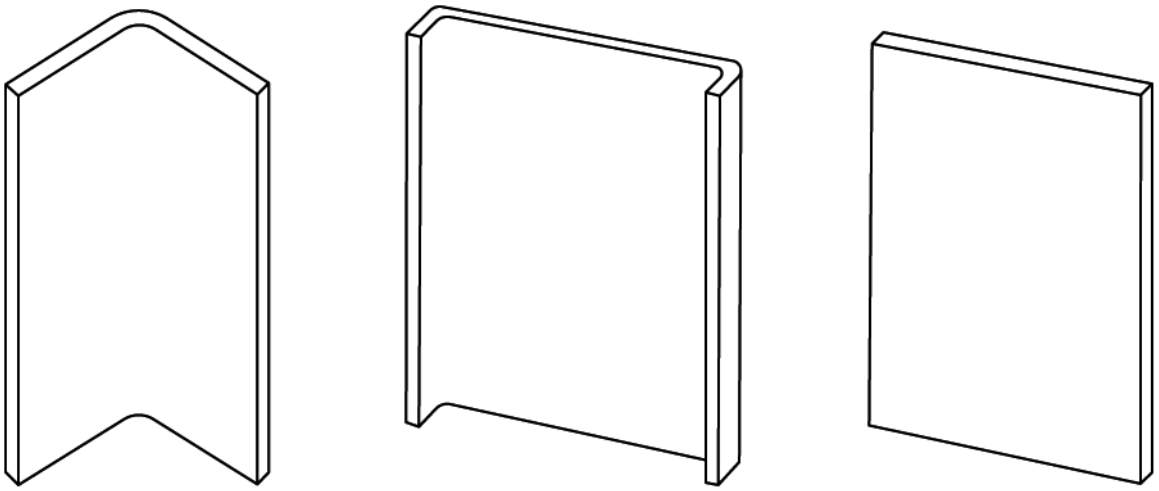


FIG. 1 Specimen Types