



Designation: C1292 – 22

Standard Test Method for Shear Strength of Continuous Fiber-Reinforced Advanced Ceramics at Ambient Temperatures¹

This standard is issued under the fixed designation C1292; 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 determination of shear strength of continuous fiber-reinforced ceramic composites (CFCCs) at ambient temperature. The test methods addressed are (1) the compression of a double-notched test specimen to determine interlaminar shear strength, and (2) the Iosipescu test method to determine the shear strength in any one of the material planes of laminated composites. Test specimen fabrication methods, testing modes (load or displacement control), testing rates (load rate or displacement rate), data collection, and reporting procedures are addressed.

1.2 This test method is used for testing advanced ceramic or glass matrix composites with continuous fiber reinforcement having unidirectional (1D) or bidirectional (2D) fiber architecture. This test method does not address composites with 3D fiber architecture or discontinuous fiber-reinforced, whisker-reinforced, or particulate-reinforced ceramics.

1.3 The values stated in SI units are to be regarded as the standard and are in accordance with [IEEE/ASTM SI 10](#).

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.* Specific hazard statements are given in [8.1](#) and [8.2](#).

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.*

¹ This test method is under the jurisdiction of ASTM Committee [C28](#) on Advanced Ceramics and is the direct responsibility of Subcommittee [C28.07](#) on Ceramic Matrix Composites.

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2. Referenced Documents

2.1 *ASTM Standards*:²

- [C1145 Terminology of Advanced Ceramics](#)
- [D695 Test Method for Compressive Properties of Rigid Plastics](#)
- [D3846 Test Method for In-Plane Shear Strength of Reinforced Plastics](#)
- [D3878 Terminology for Composite Materials](#)
- [D5379/D5379M Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method](#)
- [E4 Practices for Force Calibration and Verification of Testing Machines](#)
- [E6 Terminology Relating to Methods of Mechanical Testing](#)
- [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](#)
- [E337 Test Method for Measuring Humidity with a Psychrometer \(the Measurement of Wet- and Dry-Bulb Temperatures\)](#)
- [E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method](#)
- [IEEE/ASTM SI 10 American National Standard for Metric Practice](#)

3. Terminology

3.1 *Definitions*:

3.1.1 The definitions of terms relating to shear strength testing appearing in Terminology [E6](#) apply to the terms used in this test method. The definitions of terms relating to advanced ceramics appearing in Terminology [C1145](#) apply to the terms used in this test method. The definitions of terms relating to fiber-reinforced composites appearing in Terminology [D3878](#)

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.

apply to the terms used in this test method. Additional terms used in conjunction with this test method are defined in the following.

3.1.2 *advanced ceramic*—a highly engineered, high-performance, predominately nonmetallic, inorganic, ceramic material having specific functional attributes.

3.1.3 *continuous fiber-reinforced ceramic matrix composite (CFCC)*—a ceramic matrix composite in which the reinforcing phase(s) consists of continuous filaments, fibers, yarn, braid, or knitted or woven fabric.

3.1.4 *shear breaking force (F)*—maximum force required to fracture a shear-loaded test specimen.

3.1.5 *shear strength (F/L^2)*—maximum shear stress that a material is capable of sustaining. Shear strength is calculated from breaking force in shear and shear area.

4. Summary of Test Method

4.1 This test method addresses two methods to determine the shear strength of CFCCs: (1) the compression test method to determine interlaminar shear strength of a double-notched test specimen,³ and (2) the Iosipescu test method to determine the shear strength in any one of the material planes of laminated CFCCs.⁴

4.1.1 *Shear Test by Compression Loading of Double-Notched Test Specimens*—The interlaminar shear strength of CFCCs, as determined by this method, is measured by compressively loading a double-notched test specimen of uniform width. Failure of the test specimen occurs by shear between two centrally located notch tips machined halfway through the thickness and spaced a fixed distance apart on opposing faces. Schematics of the test setup and the test specimen are shown in Figs. 1 and 2.

4.1.2 *Shear Test By the Iosipescu Method*—The shear strength of one of the different material shear planes of laminated CFCCs may be determined by loading a test specimen in the form of a rectangular flat strip with symmetric centrally located V-notches using a mechanical testing machine and a four-point asymmetric fixture. The loading can be idealized as asymmetric flexure by the shear and bending diagrams in Fig. 3. Failure of the test specimen occurs by shear between the V-notches. Different test specimen configurations are addressed for this test method. Schematics of the test setup and test specimen are shown in Figs. 4 and 5. The determination of shear properties of polymer matrix composites by the Iosipescu method has been presented in Test Method D5379/D5379M.

5. Significance and Use

5.1 Continuous fiber-reinforced ceramic composites can be candidate materials for structural applications requiring high degrees of wear and corrosion resistance, and damage tolerance at high temperatures.

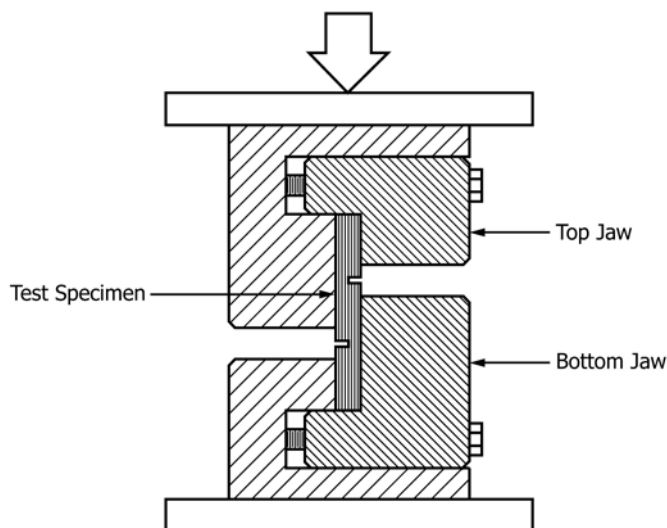


FIG. 1 Schematic of Test Fixture for the Double-Notched Compression Test Specimen

5.2 Shear tests provide information on the strength and deformation of materials under shear stresses.

5.3 This test method may be used for material development, material comparison, quality assurance, characterization, and design data generation.

5.4 For quality control purposes, results derived from standardized shear test specimens may be considered indicative of the response of the material from which they were taken for given primary processing conditions and post-processing heat treatments.

6. Interferences

6.1 Test environment (vacuum, inert gas, ambient air, etc.), including moisture content (for example, relative humidity), may have an influence on the measured shear strength. In particular, the behavior of materials susceptible to slow crack growth fracture will be strongly influenced by test environment and testing rate. Testing to evaluate the maximum strength potential of a material shall be conducted in inert environments or at sufficiently rapid testing rates, or both, so as to minimize slow crack growth effects. Conversely, testing can be conducted in environments and testing modes and rates representative of service conditions to evaluate material performance under those conditions. When testing is conducted in uncontrolled ambient air with the intent of evaluating maximum strength potential, relative humidity and temperature must be monitored and reported. Testing at humidity levels >65 % RH is not recommended and any deviations from this recommendation must be reported.

6.2 Preparation of test specimens, although normally not considered a major concern with CFCCs, can introduce fabrication flaws which may have pronounced effects on the mechanical properties and behavior (for example, shape and level of the resulting force-displacement curve and shear strength). Machining damage introduced during test specimen preparation can be either a random interfering factor in the

³ Whitney, J., M., "Stress Analysis of the Double Notch Shear Specimen," Proceedings of the American Society for Composites, 4th Technical Conference, Blacksburg Virginia, Oct. 3–5, 1989, Technomic Publishing Co., p. 325.

⁴ Iosipescu, N., "New Accurate Procedure for Shear Testing of Metals," *Journal of Materials*, Vol 2, No. 3, 1967, pp. 537–566.



FIG. 2 Schematic of Double-Notched Compression Test Specimen

6.3 Bending in uniaxially loaded shear tests can cause or promote nonuniform stress distributions that may alter the desired uniform state of stress during the test.

6.4 Fractures that initiate outside the uniformly stressed gauge section of a test specimen may be due to factors such as localized stress concentrations, extraneous stresses introduced by improper loading configurations, or strength-limiting features in the microstructure of the specimen. Such non-gauge section fractures will normally constitute invalid tests.

6.5 For the conduction of the Iosipescu test, thin test specimens (width to thickness ratio of more than ten) may suffer from splitting and instabilities rendering in turn invalid test results.



FIG. 3 Idealized Force, Shear, and Moment Diagrams for Asymmetric Four-Point Loading



6.6 For the evaluation of the interlaminar shear strength by the compression of a double-notched test specimen, the distance between the notches in the specimen has an effect on the