Designation: C1323 – 22

Standard Test Method for Ultimate Strength of Advanced Ceramics with Diametrally Compressed C-Ring Specimens at Ambient Temperature[1]

This standard is issued under the fixed designation C1323; 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 ultimate strength under monotonic loading of advanced ceramics in tubular form at ambient temperatures. The ultimate strength as used in this test method refers to the strength obtained under monotonic compressive loading of C-ring specimens such as shown in Fig. 1, where monotonic refers to a continuous nonstop test rate with no reversals from test initiation to final fracture. This method permits a range of sizes and shapes since test specimens may be prepared from a variety of tubular structures. The method may be used with microminiature test specimens.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.2.1 Values expressed in this test method are in accordance with the International System of Units (SI) and IEEE/ASTM SI 10.

1.3 *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.*

1.4 *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]

C1145 Terminology of Advanced Ceramics

C1161 Test Method for Flexural Strength of Advanced Ceramics at Ambient Temperature

C1239 Practice for Reporting Uniaxial Strength Data and Estimating Weibull Distribution Parameters for Advanced Ceramics

C1322 Practice for Fractography and Characterization of Fracture Origins in Advanced Ceramics

C1368 Test Method for Determination of Slow Crack Growth Parameters of Advanced Ceramics by Constant Stress Rate Strength Testing at Ambient Temperature

C1683 Practice for Size Scaling of Tensile Strengths Using Weibull Statistics for Advanced Ceramics

E4 Practices for Force Calibration and Verification of Testing Machines

E6 Terminology Relating to Methods of Mechanical Testing

E337 Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures)

IEEE/ASTM SI 10 American National Standard for Metric Practice

3. Terminology

3.1 *Definitions:*

3.1.1 *advanced ceramic*—a highly engineered, high performance, predominately non-metallic, inorganic, ceramic material having specific functional attributes. **(C1145)**

3.1.2 *breaking force*—the force at which fracture occurs. **(E6)**

3.1.3 *C-ring*—circular test specimen geometry with the mid-section (slot) removed to allow bending displacement (compression or tension). **(E6)**

3.1.4 *flexural strength*—a measure of the ultimate strength of a specified beam in bending.

3.1.5 *modulus of elasticity*—the ratio of stress to corresponding strain below the proportional limit. **(E6)**

3.1.6 *slow crack growth*—subcritical crack growth (extension) which may result from, but is not restricted to, such mechanisms as environmentally assisted stress corrosion or diffusive crack growth.

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[1] This test method is under the jurisdiction of ASTM Committee C28 on Advanced Ceramics and is the direct responsibility of Subcommittee C28.04 on Applications.

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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.

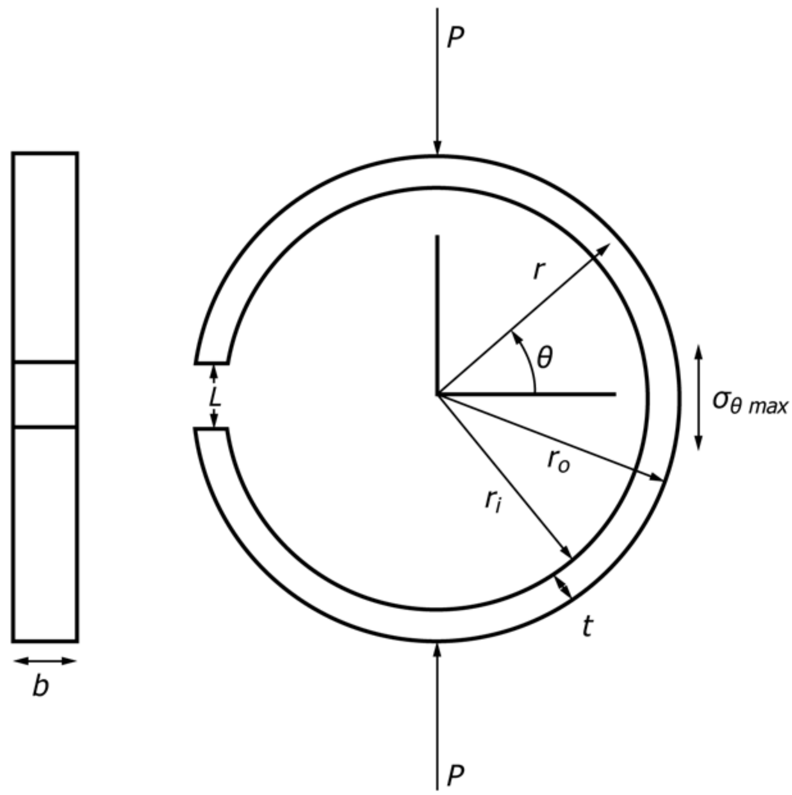

FIG. 1 C-Ring Test Geometry with Defining Geometry and Reference Angle (θ) for the Point of Fracture Initiation on the Circumference

4. Significance and Use

4.1 This test method may be used for material development, material comparison, quality assurance, and characterization. Extreme care should be exercised when generating design data.

4.2 For a C-ring under diametral compression, the maximum tensile stress occurs at the outer surface. Hence, the C-ring specimen loaded in compression will predominately evaluate the strength distribution and flaw population(s) on the external surface of a tubular component in the hoop direction. Accordingly, the condition of the inner surface may be of lesser consequence in specimen preparation and testing.

NOTE 1—A C-ring in tension or an O-ring in compression may be used to evaluate the internal surface.

4.2.1 The flexure stress is computed based on simple curved beam theory (**1-5**).[3] It is assumed that the material is isotropic and homogeneous, the moduli of elasticity are identical in compression or tension, and the material is linearly elastic. These homogeneity and isotropy assumptions preclude the use of this standard for continuous fiber reinforced composites. Average grain size(s) should be no greater than one fiftieth (1⁄50) of the C-ring thickness. The curved beam stress solution from engineering mechanics is in good agreement (within 2 %) with an elasticity solution as discussed in (**6**) for the test specimen geometries recommended for this standard. The curved beam stress equations are simple and straightforward, and therefore it is relatively easy to integrate the equations for calculations for effective area or effective volume for Weibull analyses as discussed in Appendix X1.

4.2.2 The simple curved beam and theory of elasticity stress solutions both are two-dimensional plane stress solutions. They do not account for stresses in the axial (parallel to *b*) direction, or variations in the circumferential (hoop, σ_θ) stresses through the width (*b*) of the test piece. The variations in the circumferential stresses increase with increases in width (*b*) and ring thickness (*t*). The variations can be substantial (>10 %) for test specimens with large *b*. The circumferential stresses peak at the outer edges. Therefore, the width (*b*) and thickness (*t*) of the specimens permitted in this test method are limited so that axial stresses are negligible (see Ref. (**5**)) and the variations of the circumferential stresses from the nominal simple curved beam theory stress calculations are typically less than 4 %. See Refs. (**4**) and (**6**) for more information on the variation of the circumferential stresses as a function of ring thickness (*t*) and ring width (*b*).

4.2.3 The test piece outer rim corners are vulnerable to edge damage, another reason to minimize the differences in the circumferential stresses across the ring outer surface.

4.2.4 Other geometry C-ring test specimens may be tested, but comprehensive finite element analyses shall be performed to obtain accurate stress distributions. If strengths are to be scaled (converted) to strengths of other sizes or geometries, then Weibull effective volumes or areas shall be computed using the results of the finite element analyses.

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