Designation: C1144 – 89 (Reapproved 2004)

Standard Test Method for Splitting Tensile Strength for Brittle Nuclear Waste Forms[1]

This standard is issued under the fixed designation C1144; 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 is used to measure the static splitting tensile strength of cylindrical specimens of brittle nuclear waste forms. It provides splitting tensile-strength data that can be used to compare the strength of waste forms when tests are done on one size of specimen.

1.2 The test method is applicable to glass, ceramic, and concrete waste forms that are sufficiently homogeneous (Note 1) but not to coated-particle, metal-matrix, bituminous, or plastic waste forms, or concretes with large-scale heterogeneities. Cementitious waste forms with heterogeneities >1 to 2 mm and <5 mm can be tested using this procedure provided the specimen size is increased from the reference size of 12.7 mm diameter by 6 mm length, to 51 mm diameter by 100 mm length, as recommended in Test Method C496/C496M and Practice C192/C192M.

NOTE 1—Generally, the specimen structural or microstructural heterogeneities must be less than about one-tenth the diameter of the specimen.

1.3 This test method can be used as a quality control check on brittle waste forms and may be useful for optimizing waste form processing. Meaningful comparison of waste forms, however, requires data obtained on specimens of one size.

1.4 The values stated in SI units are to be regarded as the standard.

1.5 *This standard may involve hazardous materials, operations, and equipment. 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 and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements, see Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory
C496/C496M Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
C773 Test Method for Compressive (Crushing) Strength of Fired Whiteware Materials
D2938 Test Method for Unconfined Compressive Strength of Intact Rock Core Specimens[3]
E4 Practices for Force Verification of Testing Machines

2.2 *Society of Manufacturing Engineers:*

Geometrical Tolerance Interpretations, SME Tool and Manufacturing Engineers Handbook [4]

3. Summary of Test Method

3.1 A right-circular cylinder of the waste solid is loaded diametrally between two hardened, parallel bearing blocks positioned between the specimen and the two test machine platens, one of which is moving at a constant speed relative to the other (Fig. 1).

3.2 As the load increases, the resultant stress eventually reaches the fracture strength of the material, and the specimen splits along the vertical diameter, usually with some subsidiary fracture at other locations. The splitting tensile strength, T (MPa), is calculated from the measured fracture load as follows:

$$T = 2P/\pi LD \quad (1)$$

where:

P = applied force, or fracture load, at initiation of fracture, N,
L = specimen length, mm, and
D = specimen diameter, mm.

3.3 The splitting tensile-strength test uses a compressive loading to effect a tensile stress. The stress state in the specimen during the test is well documented by both theoretical and experimental stress analysis. The stress state is intended to be biaxial with a uniform tensile stress normal to the loading axis across the anticipated fracture plane (the vertical diameter

[1] This test method is under the jurisdiction of ASTM Committee C26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.07 on Waste Materials.

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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] Withdrawn. The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from Society of Manufacturing Engineers, P.O. Box 930, One SME Dr., Dearborn, MI 48121.

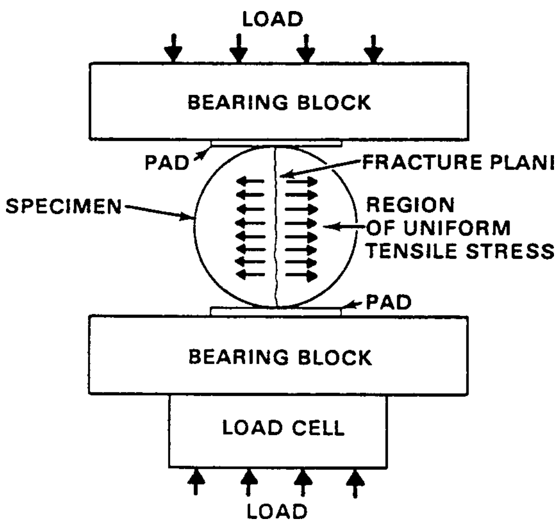


FIG. 1 Diametral Test Specimen and Apparatus

between loading points). The loading pads tend to prevent compressive-stress failure near the loading points. In a valid test, failure is initiated near the axis of the cylinder and propagates on the plane defined by the lines of contact of the bearing blocks with the specimen (see Fig. 2(*a*) and Section 5).

4. Significance and Use

4.1 The splitting tensile-strength test can be used only on brittle waste materials such as ceramics, glass, concrete, or other materials that also have tensile fracture strengths that are less than one third of the compression strengths.

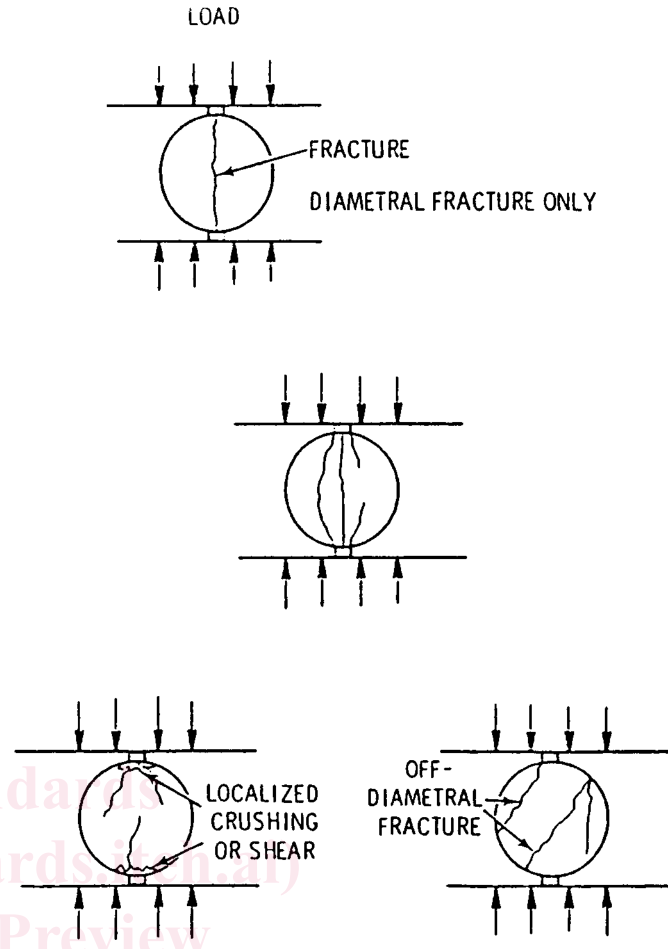
4.2 The test cannot be used for metal-matrix, bituminous, plastic, or coated-particle waste forms.

4.3 The strength values derived from this test cannot be applied to compressive-stress impact failure. The results apply only to tensile-stress failure. A separate compression-strength test, in which a cylindrical specimen is loaded on the flat surfaces, is required to determine compression strength along the lines of Test Methods C39/C39M, D2938, and C773. Failures caused by impact must be determined in a separate test.

4.4 This test method is applicable only to brittle solids because these are the only materials that fail under a definable stress state for the test specimen geometry and loading. For instance, extensive local shearing at or near the loading points that will also occur for plastically deformable solids, such as ductile metals or viscous polymers, will change the stress distribution sufficiently to invalidate the elastic-stress calculation used to obtain the tensile stress across the vertical fracture plane. Ductile materials will not, in many cases, fracture in the test.

4.5 The effect of specimen size on the measured strength of brittle materials is not determined by this test method. In some materials, such as concretes, heterogeneities may be so large that tests on larger specimens are more representative. Testing along the lines of Test Method C496/C496M may then be appropriate to measure splitting tensile strength.

4.6 This test method does not determine the effects of time and environment on strength, nor does it address failure under long-duration static loading.



(*a*) Normal Tensile Failure (Valid Test)
(*b*) Triple-Cleft Failure (Valid Test)
(*c*) Compression and Shear Failures (Invalid Test)

FIG. 2 Failure Modes

4.7 This test method can be used as a quality-control check and for optimizing waste form processing.

5. Interferences

5.1 Visually inspect the specimen after fracture. Disqualification is based on the occurrence of compression and shear failure or failure at an observable surface flaw. See 5.3, 5.4, and 5.5 for guidance in identification of the failure mode. Report identification of the failure mode in terms relatable to these sections.

5.2 There are two fracture modes that indicate a valid test, normal tensile failure and triple-cleft failure, both of which can be followed by additional severe fragmentation of the center vertical region of the specimen. A third type of failure, or fracture, called compression and shear failure, invalidates the test results. Because of the possible varied fractures and because there is no satisfactory way to predict which will occur, the specimen must be examined after the test to qualify the results.

5.3 *Normal Tensile Failure*—In normal tensile failure, the specimen splits along the loaded diameter (see Fig. 2(*a*)). This is the ideal failure and can be used to compute splitting tensile