Designation: C1468 – 19

Standard Test Method for
Transthickness Tensile Strength of Continuous Fiber-Reinforced Advanced Ceramics at Ambient Temperature[1]

This standard is issued under the fixed designation C1468; 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 transthickness tensile strength (S_U^T) under monotonic uniaxial tensile loading of continuous fiber-reinforced ceramics (CFCC) at ambient temperature. This test method addresses, but is not restricted to, various suggested test specimen geometries, test fixtures, data collection, and reporting procedures. In general, round or square test specimens are tensile tested in the direction normal to the thickness by bonding appropriate hardware to the samples and performing the test. For a Cartesian coordinate system, the x-axis and the y-axis are in the plane of the test specimen. The transthickness direction is normal to the plane and is labeled the z-axis for this test method. For CFCCs, the plane of the test specimen normally contains the larger of the three dimensions and is parallel to the fiber layers for unidirectional, bidirectional, and woven composites. Note that transthickness tensile strength as used in this test method refers to the tensile strength obtained under monotonic uniaxial tensile loading, where "monotonic" refers to a continuous nonstop test rate with no reversals from test initiation to final fracture.

1.2 This test method is intended primarily for use with all advanced ceramic matrix composites with continuous fiber reinforcement: unidirectional (1D), bidirectional (2D), woven, and tridirectional (3D). In addition, this test method also may be used with glass (amorphous) matrix composites with 1D, 2D, and 3D continuous fiber reinforcement. This test method does not address directly discontinuous fiber-reinforced, whisker-reinforced, or particulate-reinforced ceramics, although the test methods detailed here may be equally applicable to these composites. It should be noted that 3D architectures with a high volume fraction of fibers in the "z" direction may be difficult to test successfully.

1.3 Values are in accordance with the International System of Units (SI) and 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.* Additional recommendations are provided in 6.7 and Section 7.

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:*[2]
C1145 Terminology of Advanced Ceramics
C1239 Practice for Reporting Uniaxial Strength Data and Estimating Weibull Distribution Parameters for Advanced Ceramics
C1275 Test Method for Monotonic Tensile Behavior of Continuous Fiber-Reinforced Advanced Ceramics with Solid Rectangular Cross-Section Test Specimens at Ambient Temperature
C1468 Test Method for Transthickness Tensile Strength of Continuous Fiber-Reinforced Advanced Ceramics at Ambient Temperature
D3878 Terminology for Composite Materials
E4 Practices for Force Verification of Testing Machines
E6 Terminology Relating to Methods of Mechanical Testing
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

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***A Summary of Changes section appears at the end of this standard**

E1012 Practice for Verification of Testing Frame and Specimen Alignment Under Tensile and Compressive Axial Force Application

IEEE/ASTM SI 10 American National Standard for Metric Practice

3. Terminology

3.1 *Definitions:*

3.1.1 The definitions of terms relating to tensile 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 apply to the terms used in this test method. Pertinent definitions as listed in Practice E1012 and Terminologies C1145, D3878, and E6 are shown in the following with the appropriate source given in brackets. Terms used in conjunction with this test method are defined as follows:

3.1.2 *advanced ceramic, n*—a highly engineered, high-performance, predominately nonmetallic, inorganic, ceramic material having specific functional attributes. **[C1145]**

3.1.3 *bending strain [LL^{-1}], n*—the difference between the strain at the surface and the axial strain. **[E1012]**

3.1.4 *breaking force [F], n*—the force at which fracture occurs, P_{max}, is the breaking force in units of N. **[E6]**

3.1.5 *ceramic matrix composite (CMC), n*—a material consisting of two or more materials (insoluble in one another), in which the major, continuous component (matrix component) is a ceramic, while the secondary component(s) (reinforcing component) may be ceramic, glass-ceramic, glass, metal, or organic in nature. These components are combined on a macroscale to form a useful engineering material possessing certain properties or behavior not possessed by the individual constituents. **[C1145]**

3.1.6 *continuous fiber-reinforced ceramic matrix composite (CFCC), n*—a ceramic matrix composite in which the reinforcing phase consists of continuous filaments, fibers, yarn, or knitted or woven fabrics. **[C1145]**

3.1.7 *gage length [L], n*—the original length [L$_{GL}$] of that portion of the test specimen over which strain or change of length is determined. **[E6]**

3.1.8 *modulus of elasticity [FL^{-2}], n*—the ratio of stress to corresponding strain below the proportional limit. **[E6]**

3.1.9 *percent bending, n*—the bending strain times 100 divided by the axial strain. **[E1012]**

3.1.10 *tensile strength [FL^{-2}], n*—the maximum tensile stress which a material is capable of sustaining. Tensile strength is calculated from the maximum force during a tension test carried to rupture and the original cross-sectional area of the test specimen. **[E6]**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *fixturing, n*—fixturing is referred to as the device(s) bonded to the test specimen. It is this device(s) that is actually gripped or pinned to the load train. The fixturing transmits the applied force to the test specimen.

3.2.2 *transthickness, n*—the direction parallel to the thickness, that is, out-of-plane dimension, as identified in 1.1, and also typically normal to the plies for 1D, 2D laminate, and woven cloth. For 3D laminates, this direction is typically taken to be normal to the thickness and associated with the "*z*" direction.

4. Significance and Use

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

4.2 Continuous fiber-reinforced ceramic matrix composites generally are characterized by glass or fine grain-sized (<50 μm) ceramic matrices and ceramic fiber reinforcements. CFCCs are candidate materials for high-temperature structural applications requiring high degrees of corrosion and oxidation resistance, wear and erosion resistance, and inherent damage tolerance, that is, toughness. In addition, continuous fiber-reinforced glass (amorphous) matrix composites are candidate materials for similar but possibly less demanding applications. Although shear test methods are used to evaluate shear interlaminar strength (τ_{ZX}, τ_{ZY}) in advanced ceramics, there is significant difficulty in test specimen machining and testing. Improperly prepared notches can produce nonuniform stress distribution in the shear test specimens and can lead to ambiguity of interpretation of strength results. In addition, these shear test specimens also rarely produce a gage section that is in a state of pure shear. Uniaxially forced transthickness tensile strength tests measure the tensile interlaminar strength (S_U^T), avoid the complications listed above, and provide information on mechanical behavior and strength for a uniformly stressed material. The ultimate strength value measured is not a direct measure of the matrix strength, but a combination of the strength of the matrix and the level of bonding between the fiber, fiber/matrix interphase, and the matrix.

4.3 CFCCs tested in a transthickness tensile test (TTT) may fail from a single dominant flaw or from a cumulative damage process; therefore, the volume of material subjected to a uniform tensile stress for a single uniaxially forced TTT may be a significant factor in determining the ultimate strength of CFCCs. The probabilistic nature of the strength distributions of the brittle matrices of CFCCs requires a sufficient number of test specimens at each testing condition for statistical analysis and design, with guidelines for test specimen size and sufficient numbers provided in this test method. Studies to determine the exact influence of test specimen volume on strength distributions for CFCCs have not been completed. It should be noted that strengths obtained using other recommended test specimens with different volumes and areas may vary due to these volume differences.

4.4 The results of TTTs of test specimens fabricated to standardized dimensions from a particular material, or selected portions of a part, or both, may not totally represent the strength and deformation properties of the entire, full-size end product or its in-service behavior in different environments.

4.5 For quality control purposes, results derived from standardized TTT specimens may be considered indicative of the

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response of the material from which they were taken for given primary processing conditions and post-processing heat treatments.

4.6 The strength of CFCCs is dependent on their inherent resistance to fracture, the presence of flaws, or damage accumulation processes, or a combination thereof. Analysis of fracture surfaces and fractography, though beyond the scope of this test method, is highly recommended.

5. Interferences

5.1 Test environment (vacuum, inert gas, ambient air, etc.) including moisture content, for example, relative humidity, may have an influence on the measured 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 should 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 use 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.

5.2 Surface and edge preparation of test specimens can introduce fabrication flaws which may have pronounced effects on the measured transthickness strength (1).[3] Machining damage introduced during test specimen preparation can be either a random interfering factor in the determination of strength of pristine material, that is, increased frequency of surface-initiated fractures compared to volume-initiated fractures, or an inherent part of the strength characteristics. Universal or standardized test methods of surface and edge preparation do not exist. It should be understood that final machining steps may, or may not, negate machining damage introduced during the initial machining; thus, test specimen fabrication history may play an important role in the measured strength distributions and should be reported. In addition, the nature of fabrication used for certain composites, for example, chemical vapor infiltration or hot pressing, may require the testing of test specimens in the as-processed condition.

5.3 Bending in uniaxial TTTs can cause or promote nonuniform stress distributions with maximum stresses occurring at the test specimen edge, leading to nonrepresentative fractures. Similarly, fracture from edge flaws may be accentuated or suppressed by the presence of the nonuniform stresses caused by bending.

Note 1—Finite element calculations were performed for the square cross section test specimen for the forcing conditions and test specimen thickness investigated in Reference (1). Stress levels along the four corner edges were found to be lower than the interior, except for the corners at the bond lines where the stress was slightly higher than the interior. Stress

levels along the sides and interior of the test specimen were found to be uniform.

6. Apparatus

6.1 *Testing Machines*—Machines used for TTT shall conform to the requirements of Practices E4. The forces used in determining tensile strength shall be accurate within ±1 % at any force within the selected force range of the testing machine as defined in Practices E4. A schematic showing pertinent features of the TTT apparatus for two possible forcing configurations is shown in Figs. 1 and 2.

6.1.1 Values for transthickness tensile strength can range a great deal for different types of CFCC. Therefore, it is helpful to know an expected strength value in order to properly select a force range. Approximate transthickness tensile strength values (1) for several CFCCs are as follows: porous oxide/oxide composites range from 2 to 10 MPa; hot-pressed, fully dense SiC/MAS-5 glass-ceramic composites range from 14 to 27 MPa; Polymer Infiltrated and Pyrolyzed (PIP) SiC/SiNC range from 15 to 32 MPa; and hot-pressed SCS-6/Si_3N_4 ranges from 30 to 43 MPa.

6.1.2 For any testing apparatus, the load train will need to be aligned for angularity and concentricity. Alignment of the testing system will need to be measured and is detailed in A1.1 of Test Method C1275.

6.2 *Gripping Devices:*

6.2.1 *General*—Various types of gripping devices may be used to transmit the force applied by the testing machine to the test fixtures and into the test specimens. The brittle nature of the matrices of CFCCs requires accurate alignment. Bending moments can produce stresses leading to premature crack initiation and fracture of the test specimen. Gripping devices can be classified generally as those employing active and those employing passive grip interfaces as discussed in the following
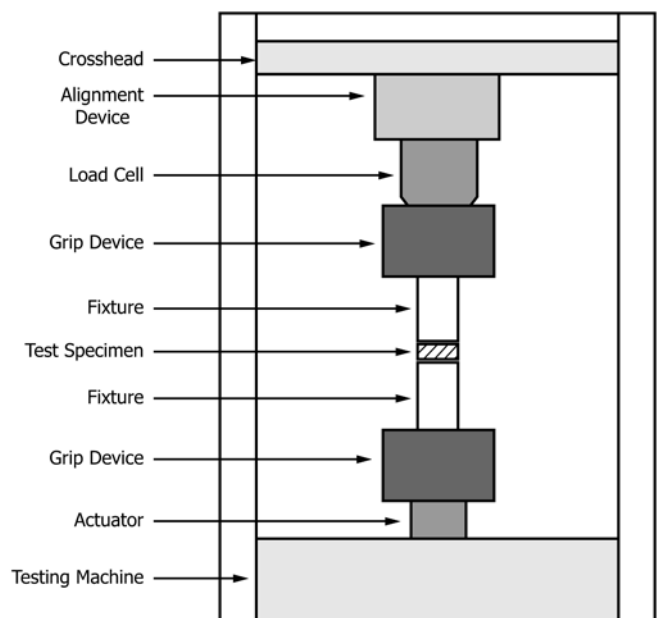

FIG. 1 Schematic Diagram of One Possible Apparatus for Conducting a Uniaxial Transthickness Tensile Test

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[3] The boldface numbers in parentheses refers to the list of references at the end of this standard.
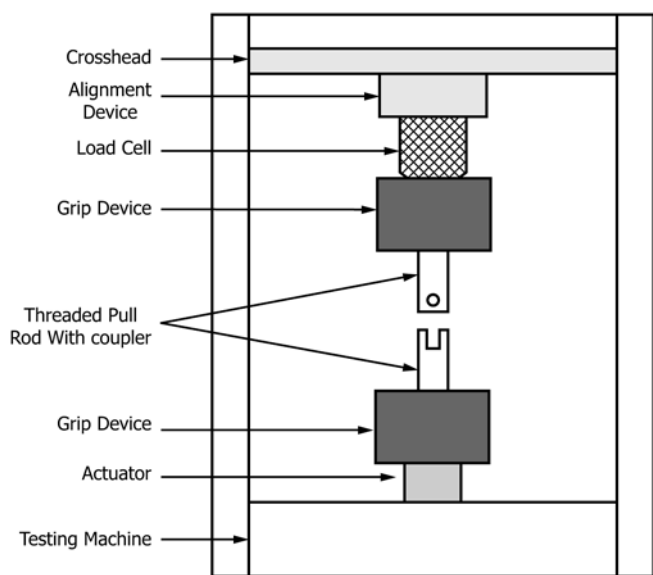
FIG. 2 Schematic Diagram of a Second Possible Apparatus for Conducting a Uniaxial Transthickness Tensile Test

sections. Several additional gripping techniques are discussed in Test Method C1275.

6.2.1.1 *Active Grip Interfaces*—Active grip interfaces require a continuous application of a mechanical, hydraulic, or pneumatic force to transmit the force applied by the test machine to the test fixtures. Generally, these types of grip interfaces cause a force to be applied normal to the surface of the gripped section of the test fixturing. Transmission of the uniaxial force applied by the test machine then is accomplished by friction between the test fixturing and the grip faces; thus, important aspects of active grip interfaces are uniform contact between the gripped section of the test fixturing and the grip faces and constant coefficient of friction over the grip/fixture interface. In addition, for active grips, uniform application of gripping force and motion of the grips upon actuation are important factors to consider in assuring proper gripping.

(1) Face-forced grips, either by direct lateral pressure grip faces (**2**) or by indirect wedge-type grip faces, act as the grip interface (**3**). Generally, close tolerances are required for the flatness and parallelism as well as for the wedge angle of the wedge grip faces. In addition, the thickness, flatness, and parallelism of the gripped section of the fixturing shall be within similarly close tolerances to promote uniform contact at the fixture/grip interface. Tolerances will vary depending on the exact configuration.

(2) Sufficient lateral pressure should be applied to prevent slippage between the grip face and the fixturing. Grip surfaces that are scored or serrated with a pattern similar to that of a single-cut file have been found satisfactory. A fine serration appears to be the most satisfactory. The serrations should be kept clean and well defined but not overly sharp. The length [*L*] and width [*W*] of the grip faces should be equal to or greater than the respective length and width of the fixturing to be gripped.

(3) Grip inserts, called wedges, can be machined to accept flat or round fixturing. This allows for a wide range of fixturing to be utilized.

6.2.1.2 *Passive Grip Interfaces*—Passive grip interfaces transmit the force applied by the test machine through a direct mechanical link (**4**). Generally, these mechanical links transmit the test forces to the test specimen via geometrical features of the test fixturing. Passive grips may act through pin forcing via pins at holes in the fixturing. Generally, close tolerances of linear dimensions are required to promote uniform contact as well as to provide for noneccentric forcing. In addition, moderately close tolerances are required for center-line coincidence and diameter [*D*] of the pins and holes.

6.3 *Load Train Couplers:*

6.3.1 *General*—Various types of devices (load train couplers) may be used to attach the active or passive grip interface assemblies to the testing machine (**1, 5-7**). The load train couplers, in conjunction with the type of gripping device, play major roles in the alignment of the load train, and thus, subsequent bending imposed in the test specimen. Load train couplers can be classified generally as fixed and non-fixed as discussed in the following sections. Note that use of well-aligned fixed or self-aligning non-fixed couplers does not automatically guarantee low bending in the test specimen. The type and operation of grip interfaces, as well as the as-fabricated dimensions of the test specimen, can add significantly to the final bending imposed in the test specimen. Additional information pertaining to couplers can be found in Test Method C1275.

6.3.1.1 Verify alignment of the testing system as a minimum at the beginning and end of a test series as detailed in A1.1 of Test Method C1275, unless the conditions for verifying alignment additional times are met. A test series is a discrete group of tests on individual test specimens conducted within a discrete period of time on a particular material configuration, test specimen geometry, test condition, or other uniquely definable qualifier. For example, a test series composed of Material A comprising ten test specimens of Geometry B tested at a fixed rate in force control to final fracture in ambient air. An additional verification of alignment is recommended, although not required, at the middle of the test series. Measure alignment with a dummy test specimen and the alignment verification procedures detailed in Test Method C1275. Allowable bending values are discussed in 6.4. Alignment test specimens used for verification should be equipped with a recommended eight separate longitudinal strain gages to determine bending contributions from both concentric and angular misalignment of the grip heads. The length of the alignment test specimen should be approximately the same length as the test specimen and fixturing. Use a material (isotropic, homogeneous, continuous) with similar elastic modulus and elastic strain capability to the CFCC being tested.

6.3.2 *Fixed Load Train Couplers*—Fixed couplers may incorporate devices which require either a one-time, pre-test alignment adjustment of the load train which remains constant for all subsequent tests, or an *in-situ*, pre-test alignment of the load train which is conducted separately for each test specimen and each test. Such devices (**8**) usually employ angularity and concentricity adjusters to accommodate inherent load train misalignments. Fixed load trains have two translational degrees of freedom and three degrees of rotational freedom fixed.

Regardless of which method is used, verify the alignment as discussed in 6.3.1.1. A schematic diagram of one possible arrangement for a fixed load train is shown in Fig. 3, and this arrangement corresponds to the load train identified in Fig. 1.

6.3.2.1 Fixed load train couplers often are preferred for monotonic testing CFCCs. During the fracture process, the fixed coupler tends to hold the test specimen in an aligned position, and thus, provides a continuous uniform stress across the remaining ligament of the gage section. For TTT, however, this is not an issue, allowing for use of both methods.

6.3.2.2 The use of fixed load train couplers typically will require that the test specimens be bonded to the fixturing after the fixturing has been mounted in the test frame or grips. CFCCs in general have low transthickness tensile strength, as stated in 6.1.1, and this requirement will minimize the possibility of inducing bending when the fixturing is gripped. One drawback to mounting the test specimen in the force frame is that it will reduce productivity. There will be a waiting period as the adhesive cures. Care must be taken to ensure that the test specimen does not move on the fixturing during the cure cycle of the adhesive.

6.3.3 *Non-Fixed Load Train Couplers*—Non-fixed couplers may incorporate devices which promote self-alignment of the load train during the movement of the crosshead or actuator. Generally, such devices rely upon freely moving linkages to eliminate applied moments as the load train components are forced. Knife edges, universal joints, hydraulic couplers, or air bearings are examples (**5, 9, 10**) of such devices. Although non-fixed load train couplers are intended to be self-aligning, the operation of the couplers must be verified as discussed in 6.3.1.1. A schematic diagram of one possible arrangement for

a non-fixed load train is shown in Fig. 4, and this arrangement corresponds to the load train identified in Fig. 2.

NOTE 2—The use of non-fixed load train couplers allows for many test specimens to be prepared ahead of time using an alignment device. Once the test specimens are bonded to the fixturing, they can all be tested in a very short period of time. This greatly increases throughput and minimizes machine time.

6.3.3.1 The forcing configuration shown in Fig. 4 uses universal rod ends (sometimes called ball joint rod ends) at both ends of the fixtured test specimen. The universal rods allow for a full range of angular motion and will allow for some concentricity and angularity misalignment of the grips. A photograph showing assembly of the fixturing, test specimen, and universal rod ends is shown in Fig. 5.

6.4 *Allowable Bending*—Analytical and empirical studies (**11**) have concluded that for negligible effects on the estimates of the strength distribution parameters (for example, Weibull modulus, $\hat{m}$, and characteristic strength, σ_θ) of monolithic advanced ceramics, allowable percent bending as defined in Practice E1012 should not exceed five. Conclusions arrived at in Ref (**11**) for the uniaxial tension strength along one of the directions of reinforcement are also supposed to be valid for the transthickness case. Applying these conclusions for this test method (**11**) assumes that transthickness tensile strength fractures are due to single fracture origins in the volume of the material, all test specimens experience the same level of bending, and that Weibull modulus, $\hat{m}$, was constant.

6.4.1 Studies of the effect of bending on the transthickness tensile strength distributions of CFCCs do not exist. Until such information is forthcoming for CFCCs, this test method adopts
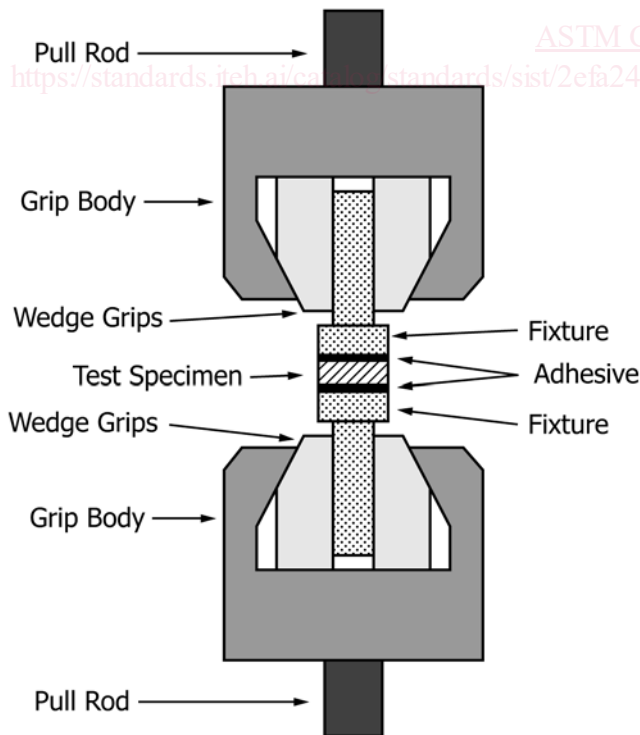

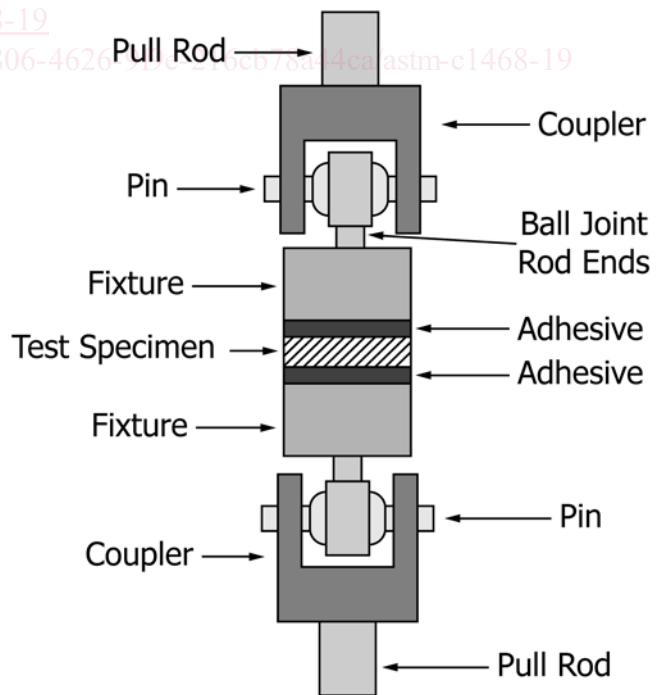**FIG. 3 Schematic Diagram of One Possible Arrangement for a Fixed Load Train**

FIG. 4 Schematic Diagram of One Possible Arrangement for a Non-Fixed Load Train That Uses Couplers and Ball Joint Rod End Adapters
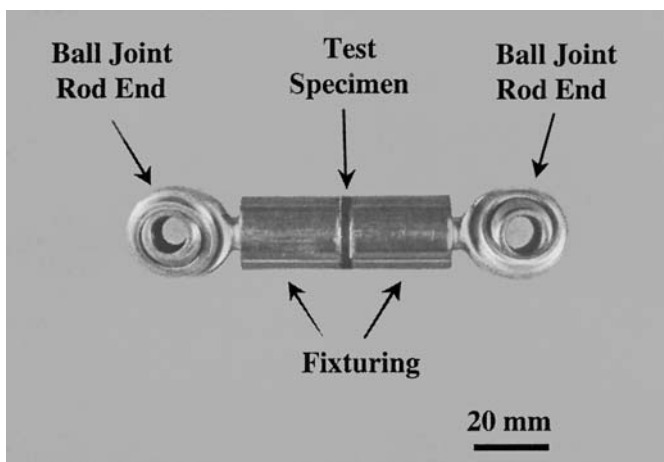
FIG. 5 Photograph of a Transthickness Tensile Test Specimen Bonded to Fixturing, With Fixturing Assembled with Universal Rod Ends (Ball Joint Rod Ends) for Improved Alignment

the recommendations for tensile testing of monolithic advanced ceramics and uniaxial tensile testing of CFCCs. The recommended maximum allowable percent bending at the onset of the cumulative fracture process, for example, matrix cracking stress, for test specimens tested under this standard is five at the anticipated fracture force.

6.5 *Data Acquisition*—At minimum, make an autographic record of maximum force; however, it is desirable to also make a record, where applicable, of applied force, crosshead displacement, strain, and time. Use either digital data acquisition systems or analog chart recorders for this purpose, although a digital record is recommended for ease of later data analysis. Recording devices shall be accurate to 1.0 % of full scale. Data acquisition rates will depend on the forcing rates used to conduct the test. A data acquisition rate of at least 20 Hz should be used, and the acquisition rate should be fast enough to capture the maximum force within 1 %.

6.6 *Dimension-Measuring Devices*—Micrometers and other devices used for measuring linear dimensions shall be accurate and precise to at least one half the smallest unit to which the individual dimension is required to be measured. For the purposes of this test method, measure cross-sectional dimensions to within 0.02 mm, requiring measuring devices with accuracy of 0.01 mm.

6.7 *Adhesives*—In conducting a TTT, an adhesive is required to bond the test specimen to the fixturing, as it is not normally possible to directly grip the test specimen. There are many types of adhesives available, and care should be taken to select an adhesive strong enough to conduct the test.

NOTE 3—Many adhesives contain hazardous chemicals. Manufacturers of adhesives routinely provide listings of the possible hazards associated with particular adhesives, and commonly provide Material Safety Data Sheets (MSDS) on their products. Read all safety handling requirements and follow the manufacturer's recommended handling procedures. In general, always utilize protective face, eye, hand, and body gear. If the adhesive produces gases, use only in vented hoods certified for those specific gases.

6.7.1 The strength of the adhesive can be evaluated by bonding the fixturing together without the test specimen and performing the TTT on just the adhesive. The tensile strength of the adhesive then can be determined as described in 10.3.

6.7.2 Single-part adhesives that air cure at room temperature are the easiest to use, but generally exhibit low strength.

6.7.3 Two-part adhesives require a bulk resin, along with a catalyst to activate curing. These adhesives demonstrate moderate strength, and often require glass beads of a specific size to produce a bond line of specific thickness for optimum bonding. Often, there is excess adhesive present when trying to ensure a complete bond line, and this can pose a problem, as adhesive should not flow up or down the edges of the test specimen; therefore, care should be taken in the amount of adhesive used.

6.7.4 Single-part adhesives that cure at an elevated temperature are very easy to handle and generally produce very high-strength bonds. Several of these elevated temperature curing adhesives are produced in sheets that easily are cut to the desired shape using scissors or cutting blades. A tack agent is often used to keep the film in place on the fixturing. Excess film extending beyond the test specimen can easily be trimmed off before the fixturing is placed in a furnace for cure. Use of these types of adhesives results in the same amount of adhesive being used during each test, thus minimizing the influence of adhesives on transthickness strength.

6.7.4.1 Adhesives that cure at an elevated temperature are usually sensitive to the maximum temperature; therefore, thermocouples should be attached to the fixturing [1] to ensure that the cure temperature is reached and maintained, and the overall cure cycle is followed.

NOTE 4—Adhesives that cure at elevated temperature must reach the cure temperature in order to be activated. Extra care should be used in documenting that the temperature of the adhesive bond has been reached. It is not acceptable to simply record the temperature of the furnace and assume that the fixturing and adhesive have reached the same temperature. Improper curing of the adhesive [1] has been found to be the number one cause of bond line failures.

6.7.5 Porous CFCCs may allow the adhesive to penetrate into the interior of the CMC. Care must be taken to determine if the viscosity of the adhesive will allow it to penetrate into the test specimen. For porous CFCC systems, extra material or a spare test specimen should be bonded to blocks that are of the same material as the fixture, and then sectioned metallographically to determine the depth of penetration of the adhesive into the test specimen. The adhesive should not penetrate more than one fiber ply or more than 10 % of the specimen thickness [6] from each face.

6.8 Measurement of displacement on thicker samples can be made using a very small gage length [L_{GL}] extensometer, strain gages, video extensometers, or noncontacting laser extensometry. No data exists to determine what effect the contacting measurement devices have on measured transthickness tensile strength. Displacement measurements can be used to calculate a transthickness elastic modulus [E_{ZZ}] value. All displacement measurements are to be made directly on the test specimen.

7. Precautionary Statements

7.1 During the conduct of this test method, the possibility of flying fragments of broken test material may be high. The