Designation: D4680 − 98 (Reapproved 2023)

Standard Test Method for Creep and Time to Failure of Adhesives in Static Shear by Compression Loading (Wood-to-Wood)[1]

This standard is issued under the fixed designation D4680; 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 time-dependent properties of structural adhesives in wood-to-wood bonds when specimens are subjected to shearing stresses at various levels of static load, constant temperature, and relative humidity. Apparatus and procedures are provided for direct measurement of time-dependent shear deformation (creep) and time to failure of adhesive bonds under static load. Guidelines for selecting test conditions, methods for calculating creep rate, creep strain, creep modulus, and extrapolation of time to failure, are given along with methods of presenting these data.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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]

D143 Test Methods for Small Clear Specimens of Timber

D905 Test Method for Strength Properties of Adhesive Bonds in Shear by Compression Loading

D907 Terminology of Adhesives

D2016 Methods of Test for Moisture Content of Wood (Withdrawn 1987)[3]

2.2 *ASTM Adjuncts:*

Compression-Shear Creep Test Apparatus[4]

3. Terminology

3.1 *Definitions:*

3.1.1 Many terms in these test methods are defined in Terminology D907.

3.1.2 *creep, n*—the dimensional change with time of a material under load, following the initial instantaneous elastic or rapid deformation. Creep at room temperature is sometimes called cold flow.

3.1.3 *creep modulus, n*—the ratio of initial applied stress to creep strain.

3.1.4 *creep strain, n*—the total strain, at any given time, produced by the applied stress during a creep test.

3.1.4.1 *Discussion*—In this test method, creep strain is calculated by dividing displacement at any given time by the estimated apparent thickness of the adhesive bondline.

3.1.5 *rate of creep, n*—the slope of the creep-time curve at a given time.

3.1.6 *shear stress, n*—the stress component tangential to the plane on which the forces act, that is, in the plane of the bond line.

3.1.7 *strain, n*—the unit change, due to stress, in the size or shape of a body referred to its original size or shape.

3.1.8 *stress, n*—the force exerted per unit area at a point within the plane.

4. Significance and Use

4.1 Creep data that are obtained over a relatively short period of time in this test method can provide a measure of an adhesive bond's ability to withstand static loading in shear over a relatively long period of time. Creep measurements are made

[1] This test method is under the jurisdiction of ASTM Committee D14 on Adhesives and is the direct responsibility of Subcommittee D14.30 on Wood Adhesives.

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

[4] Available from ASTM International Headquarters. Order Adjunct No. ADJD4680. Original adjunct produced in 1987.

over a range of expected service conditions, including level of stress, temperature, relative humidity, and duration of load. Creep rate, creep strain, and creep modulus are calculated at the various service conditions.

4.2 Creep data can be used to (*1*) predict performance of an adhesive under long-term loading, (*2*) characterize an adhesive, (*3*) compare adhesives with each other and against specifications, and (*4*) design structural members fabricated with an adhesive.

4.3 Time-to-failure data provide a measure of the ultimate load-carrying ability of an adhesive bond as a function of time at various levels of stress, temperature, and relative humidity.

4.4 With proper caution, time-to-failure data derived from relatively short loading periods can be extrapolated to estimate the useful service life of an adhesive at working levels of static stress. This property may also be used with creep data to accomplish purposes listed in 4.2.

4.5 This test method is a research tool intended for development or evaluation of new adhesives and new product designs. The researcher may select from suggested tests those that are appropriate. However, creep and time-to-failure tests are nonroutine and can be time-consuming and expensive, so tests must be selected with care.

4.6 The apparatus and procedures may be suitable for measuring creep properties of adhesives on substrates other than wood, such as metal, plastic, and glass, but such considerations are not within the scope of this test method.

5. Apparatus

5.1 *Testing Machine*—A testing machine, or other suitable loading machine, capable of applying compression loads from 0 lbf to 5000 lbf (22 kN) and cross-head speeds from 0.01 in./min to 0.40 in./min (0.3 mm/min to 10.2 mm/min) is sufficient for this test method. A minimum vertical space of 20 in. (508 mm) is required to compress the loading spring in the creep-test apparatus.

5.2 *Compression Shearing Tool*—The testing machine is equipped with a shearing tool capable of applying a uniformly distributed compression load to the loading ledges of the block-shear specimen. A shearing tool equipped with a self-aligning seat in the shearing blade ensures uniform loading.

5.3 *Creep-Test Apparatus*—Static loads shall be applied and maintained on block-shear specimens by means of the compression-loaded creep-test cylinder shown in Fig. 1.[5,4] The apparatus is spring-loaded and can sustain any load up to the design capacity of the spring. This particular spring has a design load of 2300 lbf (10 kN); however, others of greater or less capacity may be substituted. Varying spring capacities with outside diameters no greater than the cylinder inside diameter are available.

5.3.1 For creep tests above room temperature, it is not necessary to adjust the spring or load to compensate for the effects of changing temperature. It is only necessary that the apparatus, with included specimen, be preconditioned to the test temperature before the test load is applied to the spring. The preheated apparatus must be wrapped with a piece of flexible thermal insulation material while the test load is applied to the specimen. After loading and measurements, return the loaded apparatus to the test environment. Since there are no significant changes in temperature before or after loading, no adjustments are needed in the spring.

5.3.2 The creep-test apparatus is made of corrosion-resistant components so that it can be used in high-temperature and humid environments for prolonged periods without concern for damaging the apparatus or interfering with the effectiveness of the test.

5.3.3 The creep-test apparatus has been compactly designed with its load-applying mechanism built-in. Thus, several of the units may be stacked on racks in a small environmental chamber such as an oven, incubator, or humidity cabinet. The apparatus may be transferred from one exposure chamber to another, or may be removed from an exposure chamber for measurements without disturbing the specimen under static load.

5.3.4 The creep-test apparatus shown in Fig. 1 has a microswitch mounted at its base which is activated when the creep specimen fails. A small pin is located in the lower specimen seat which is driven against the microswitch when the failed specimen strikes it. The microswitch must be connected to an automatic timer-recorder.

5.4 *Automatic Timer-Recorder*—If creep or time-to-failure measurements are to be made, an automatic and multi-channel timer-recorder is connected to the microswitch on each creep-test apparatus. The timer-recorder is capable of automatically scanning the several connected circuits at selected intervals of time. When the creep specimen fails and activates the microswitch, the timer-recorder automatically records the time at which the circuit is broken.

5.5 *Microscope*—A microscope is required to measure displacement of scribe marks across the two adherends of a specimen as creep occurs. Accurate measurements are also required for bondline thicknesses. Make measurements to the nearest 0.001 mm (0.0004 in.). A linear traveling binocular microscope is ideally suited to creep measurements; however, a microscope fitted with an appropriately graduated scale is satisfactory. An objective lens of at least 7× magnification is required.

5.6 *Environmental Chambers*—Control of temperature and relative humidity is required in creep tests of adhesive bonds on wood substrates. Temperature has a profound effect on creep properties of adhesives. Humidity also affects creep of certain adhesives, but it can also affect dimensional change in wood adherends. Conditioning equipment should be capable of maintaining a constant temperature within ±3.0 °F (±1.7 °C) of the set-point and constant relative humidity within ±5 % of the set-point at a given temperature.

6. Materials

6.1 *Adherends*—Select sugar maple (*Acer saccharum*) as the standard adherend material with the grain of the wood straight

[5] This creep-test apparatus may be purchased from Hull Machine Shop, P.O. 373, Hull, GA 30646, or other suitable suppliers.

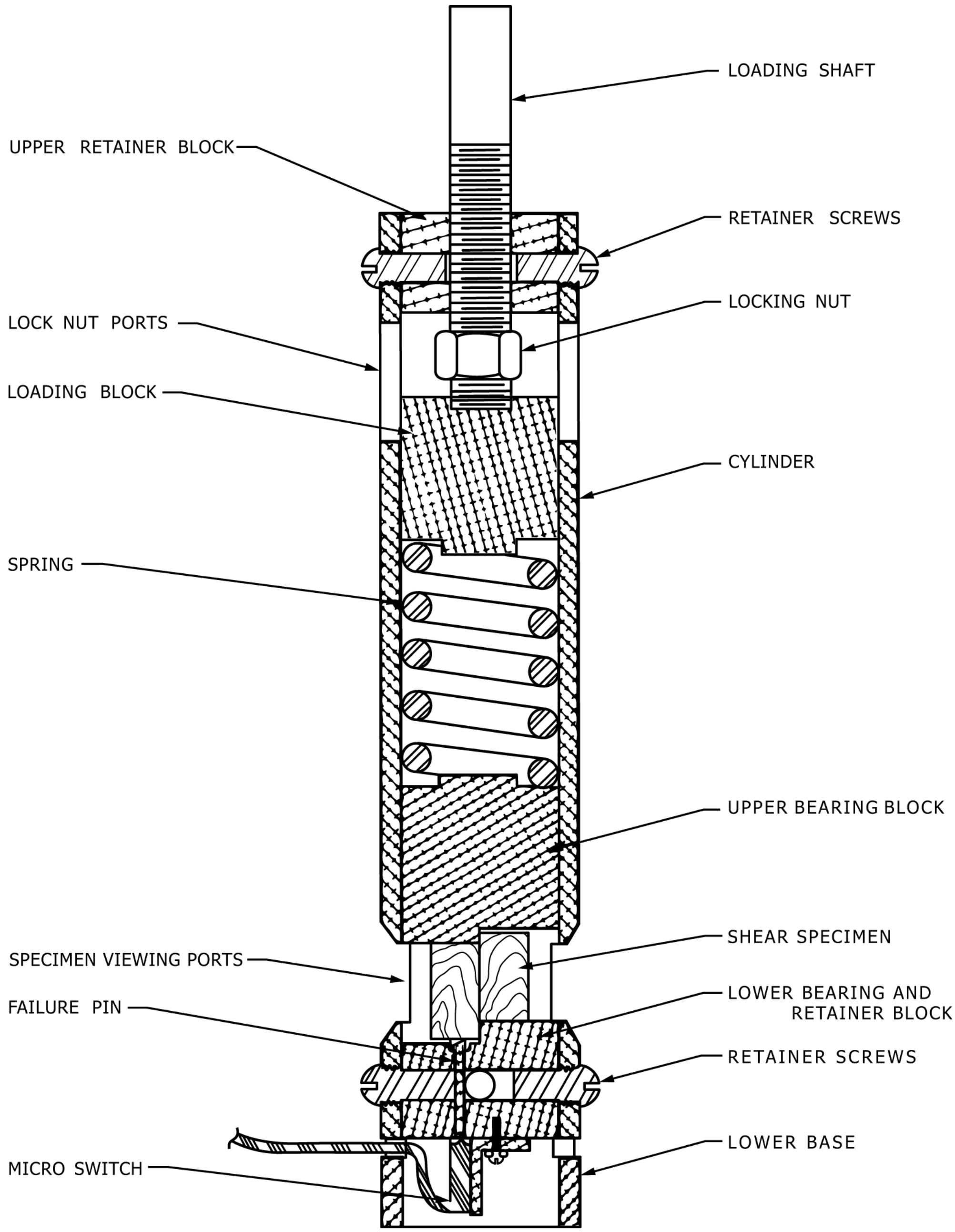

FIG. 1 Creep Test Apparatus

and parallel to the direction of shear and free of all defects such as knots, splits, and discolorations. Sugar maple is a uniformly textured and high-density wood preferred in creep tests because it is less likely to deform near the bondline or fail in the wood before the test is completed.

6.1.1 Sugar maple adherend material has a minimum specific gravity of 0.65 (based on oven-dry weight and volume). A method for selecting maple blocks at this specific gravity, including appropriate adjustments in specific gravity for various moisture contents, is described in the Appendix of Test Method D905. If more complete procedures are required for refereed tests, specific gravity may be determined in accordance with Section 116 of Test Methods D143.

6.1.2 Any other species of wood may be used as adherend material, particularly in those cases where it is necessary to know the creep behavior of an adhesive in contact with a specific wood species. However, it should be recognized that woods that are less uniform in texture and lower in density than sugar maple, are more likely to deform and fail prematurely.

6.1.3 When conducting creep and time-to-failure tests, it is important not to overload the adherend and cause deformation at the bondline or failure in the wood before the test is completed. As a guide to selecting maximum levels of stress, it is recommended that the load not exceed the average shear strength parallel-to-grain for the species of wood when adjusted for any change in moisture content from 12 %. Average