Designation: F2018 – 00 (Reapproved 2010)

Standard Test Method for Time-to-Failure of Plastics Using Plane Strain Tensile Specimens[1]

This standard is issued under the fixed designation F2018; 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 requirements to determine the time-to-failure of thermoplastic resins for piping applications by uniaxial loading of a grooved tensile test specimen. This grooved tensile specimen achieves a multi-axial stress condition, which mimics the stress condition found in pressurized solid-wall plastic pipe. The ratio of the stress in the axial direction to the transverse direction approximates that for a pressurized solid-wall pipe specimen.

1.2 It is intended that the data generated on these specimens be analyzed according to the methodology set forth in Test Method D2837 to generate a long-term strength design value for the material.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure

D1600 Terminology for Abbreviated Terms Relating to Plastics

D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

D2990 Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics

D1928 Practice for Preparation of Compression-Molded Polyethylene Test Sheets and Test Specimens (Withdrawn 2001)[3]

D4703 Practice for Compression Molding Thermoplastic Materials into Test Specimens, Plaques, or Sheets

F412 Terminology Relating to Plastic Piping Systems

2.2 *Other Document:*

PPI TR-4 HDB Listed Materials[4]

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600.

3.1.2 *long-term strength (LTS)*—the estimated tensile stress in the test specimen that when applied continuously will cause failure of the specimen at 100 000 h. This is the intercept of the stress regression line with the 100 000-h coordinate.

4. Summary of Test Method

4.1 This test method consists of a description of the grooved tensile test specimen and its use in various environments to obtain the long-term strength capacity for piping materials. Such a controlled environment may be accomplished by, but is not limited to, immersing the specimens in a controlled-temperature water bath or circulating-air oven.

5. Significance and Use

5.1 The data obtained by this test method are useful for establishing stress versus failure-time relationships in a controlled environment. The long-term strength (LTS) is determined primarily for materials used in molding applications. The LTS categorized in accordance with Table 1 of ASTM D2837 is known as the SDB (strength design basis).

NOTE 1—These SDB values will be published in PPI TR-4 for materials used in molding applications only.

[1] This test method is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.40 on Test Methods.

Current edition approved Aug. 1, 2010. Published November 2010. Originally approved in 2000. Last previous edition approved in 2006 as F2018–00(2006). DOI: 10.1520/F2018-00R10.

[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 Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.

5.2 The test method can also be used on an experimental basis for pipe-grade materials as an indicator of stress-rupture performance. The long-term strength or SDB values obtained by this test method are not intended to replace the HDB determined for pressure pipe tested in accordance with Test Method D1598.

5.3 In order to determine how plastics will perform in pipe fitting applications, it is necessary to establish the stress-failure time relationships over four or more decades of time (hours) in a controlled environment. Because of the nature of the test and specimens employed, no single line can adequately represent the data, and therefore the confidence limits should be established.

NOTE 2—Some materials may exhibit a nonlinear relationship between log-stress and log-failure time, usually at short failure-times. In such cases, the 10^5 - hour stress value computed on the basis of short-term test data may be significantly different than the value obtained when a distribution of data points in accordance with Test Method D2837 is evaluated. However, these data may still be useful for quality control or other applications, provided correlation with long-term data has been established.

6. Apparatus

6.1 *Constant-Temperature System*—A reservoir capable of maintaining a fluid bath at a uniform temperature shall be used. If water or other liquid medium is used, agitation is permitted to stabilize the temperature throughout the fluid bath. If an air or other gaseous environment is used, provision shall be made for adequate circulation. The test may be conducted at 23°C (73°F) or other selected temperatures as required and the temperature tolerance requirements shall be ± 2°C (± 3.6°F). A typical test setup is shown in Fig. 1.

6.2 *Loading System*—Any device that is capable of continuously applying constant load on the specimen may be used. The device shall be capable of reaching the test load without exceeding it and of holding it within the tolerances shown in 6.5 for the duration of the test. A typical loading system is shown in Fig. 2, which utilizes a pressurized cylinder to apply load to the specimen. Other creep load frames can be used, such as those described in Test Methods D2990 for tensile creep. The loading system shall be checked with a load cell that has a calibration certificate traceable to National Institute for Standards and Technology (NIST).

6.3 *Load or Pressure Gage*—A load gage or, for use with an air cylinder, a pressure gage that meets the tolerance requirements in 6.5 is required.

6.4 *Timing Device*—The timing device shall be capable of measuring the time-to-failure with sufficient accuracy to meet the requirements listed in 6.5.

6.5 *Time and Force Tolerance*—When added together, the tolerance for the timing device and the tolerance for the force measuring device shall not exceed ±2 %.

7. Test Specimen

7.1 *Test Specimen Dimensions*—The shape of the test specimen is shown in Fig. 3. A round groove is produced along the full width of the specimen on both sides. The opposing grooves should be parallel and centered in the specimen to within± 0.127 mm (0.005 in.). A specimen that has been used successfully for polyethylene is shown in Fig. 3. The critical dimensions of this specimen are shown below in Table 1.

7.1.1 The reduced thickness in the groove shall be measured at three locations, the center of the groove, and at the edges of the specimen. All three measurements must conform to the dimensions specified in Table 1.

7.2 *Measurements*—Dimensions shall be determined in accordance with Test Method D4703.

7.3 *Specimen Fabrication*—Plane-strain specimens may be fabricated from plaques of materials which are injection-molded, extruded, or compression-molded (for example, in

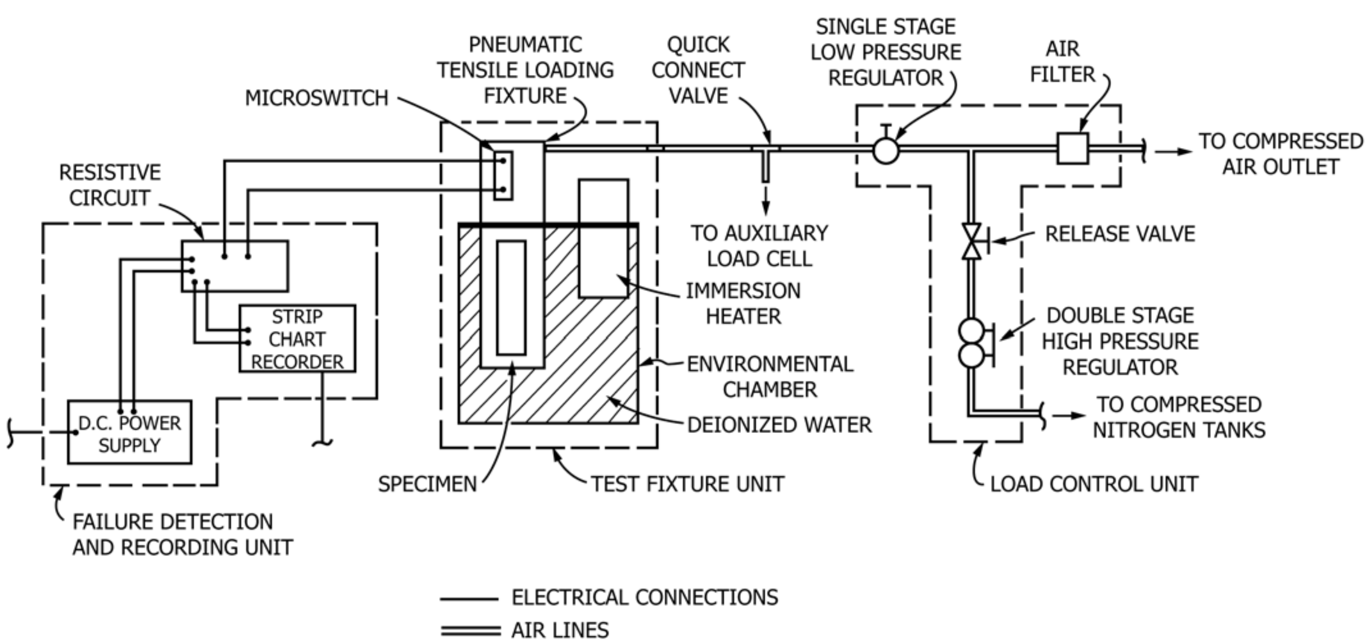

FIG. 1 Schematic Diagram of Typical Experimental Setup

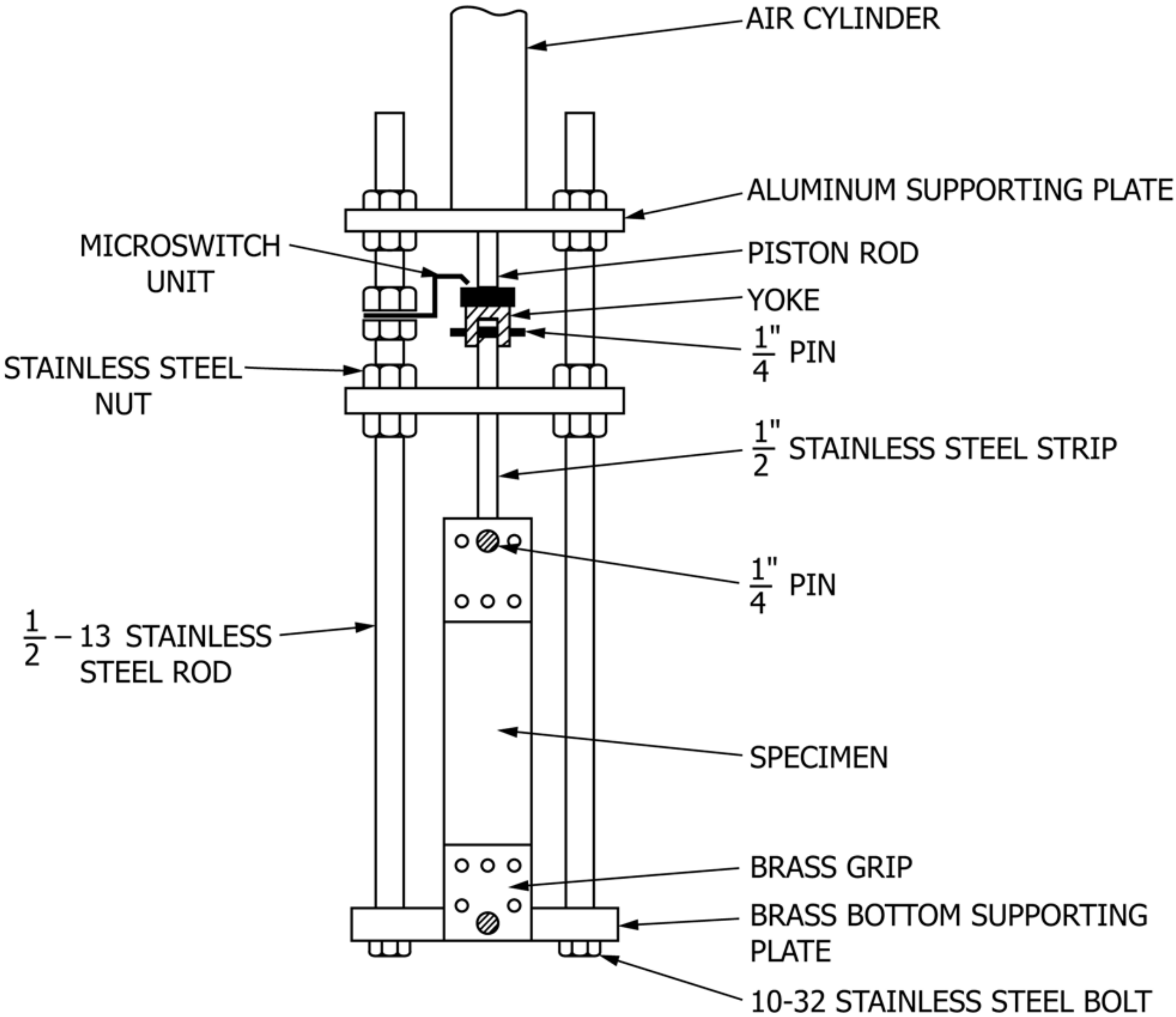

FIG. 2 Schematic Diagram of Pneumatic Tensile Loading Fixture Assembly

accordance with Practice D4703 for compression molding of polyethylene). The specimens machined from these plaques shall be free of voids. Test plaques may also be formed by flattening thick-wall pipe sections. All specimens used for a particular data set must be prepared in the same manner, that is, all compression-molded or all injection-molded using the same gate configuration.

7.3.1 *Machining*—The compression-molded or injection-molded sample can be machined to size by milling, and the edges should be smooth and free from burrs. The groove shall be machined in such a way that the groove surface will be smooth, minimizing any machining marks on the groove surface. A 3.175 mm (0.125 in.) radius, 4-flute ball end mill has been used successfully for machining the grooves. Appropriate fixturing is necessary to ensure that the grooves on both sides of the specimen coincide with one another. In all machining operations, care shall be taken to minimize any heating of the sample.

7.3.2 *Injection-Molding*—Samples may be injection-molded to the appropriate dimensions. In this case the grooves would be molded-in, as opposed to above, where the sample is machined from an injection-molded plaque. All specimens in a test lot must be prepared the same way, whether with molded-in grooves or machined grooves. The location of the gate can affect the material orientation in the sample and thus significantly affect the results of the testing.

TABLE 1 Dimensions of Plane-Strain Specimen

	Dimension mm (in.)	Tolerance ± mm (± in.)
Width (W)	38.0 (1.5)	0.5 (0.02)
Groove Radius	3.18 (0.125)	1.0 (0.04)
Groove Height	6.35 (0.25)	0.5 (0.02)
Unreduced Thickness	> 7.62 (> 0.3)	NA
Reduced Thickness	2.54 (0.1)	0.25 (0.01)
Overall Length (L)[A]		
Minimum	76 (3.0)	6.4 (0.25)
Maximum	152.4 (6.0)	6.4 (0.25)

[A] The overall length of the specimen can vary from approximately 76 mm (3 in.) To 152 mm (6 in.), as long as the ends of the grips do not extend closer than 10 mm (0.39 in.) to the edge of the grooves.

NOTE 3—Use of an injection-molded sample may allow study of knit

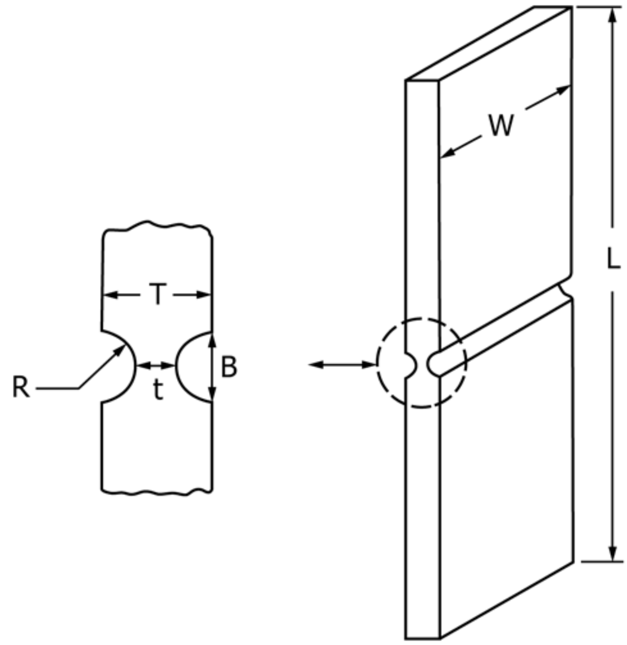

FIG. 3 Dimensions of Plane-Strain Specimen

lines and other variables important for pipe fitting applications.

8. Conditioning

8.1 Specimens shall be conditioned at the test temperature before loading. Specimens in a liquid bath shall be conditioned for a minimum of 1 h before loading. Specimens in a gaseous medium shall be conditioned for a minimum of 16 h before loading. All specimens in a test lot must be tested in the same medium. Newly molded specimens shall be preconditioned for a minimum of 40 h at 23 ± 2°C (73.4 ± 3.6°F) prior to test.

9. Procedure

9.1 Attach grips to the test specimen and load into the test fixture for conditioning at the selected test-temperature. The ends of the grips shall be at least 10 mm (0.39 in.) from the grooved area.

9.2 Apply the load to the specimen gradually within a period of about 5 to 10 s without any impact of the specimen.

9.3 Record the time-to-failure of each specimen. The time-to-failure shall not include periods of time during which the specimen was under no load. Failure occurs when the two halves of the specimen separate completely or extension of the groove section causes the timer to be shut off (approximately 12.5 mm (0.5 in.) deflection).

10. Calculation

10.1 Calculate the stress in the grooved tensile test specimen as follows:

$$S = P/(Wt) \qquad (1)$$

where:

S = stress, MPa (psi),
P = tensile load, N (lbs),
W = width of specimen, mm (in), and
t = minimum thickness at grooved notch of specimen, mm (in).

11. Report

11.1 Report the following information:

11.1.1 Complete identification of the specimens, including material type, manufacturer's name and code number, specimen preparation, and previous history,

11.1.2 Test temperature,

11.1.3 Test environment, including conditioning time,

11.1.4 Test load, calculated stress, and time-to-failure for each specimen,

11.1.5 Failure mode, any unusual effects of prolonged exposure, and the type of failure,

11.1.6 Date test was started and report date,

11.1.7 Any deviations in dimensions from 7.1, and

11.1.8 Name of test laboratory and supervisor of this test.

12. Precision and Bias

12.1 The repeatability standard deviation has been determined to be ±36 %, based on limited data. The reproducibility of this test method is being determined and will be available on or before January 1, 2005.