



Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe¹

This standard is issued under the fixed designation D2290; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method covers the determination of the comparative apparent tensile strength of most plastic products utilizing a split disk or ring segment test fixture, when tested under defined conditions of pretreatment, temperature, humidity, and test machine speed. This test method is applicable to reinforced-thermosetting resin pipe regardless of fabrication method. This test method also is applicable to extruded and molded thermoplastic pipe.

Procedure A is used for reinforced-thermosetting resin pipe; Procedure B is used for thermoplastic pipe of any size; Procedure C is used for thermoplastic pipe with nominal diameter of 4½ in. (110 mm) and greater. Procedure D is used for polyethylene pipe with a nominal diameter of 14 in. (350 mm) and greater and preferably having wall thickness 1 in. (25 mm) and greater. Procedure E is used for polyvinyl chloride (PVC) pipe with a nominal diameter of 14 in. (350 mm) and greater and having wall thickness 1 in. (25 mm) and greater.

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

2. Referenced Documents

2.1 *ASTM Standards:*²

[D618 Practice for Conditioning Plastics for Testing](#)

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.

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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.

[D1599 Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings](#)
[E4 Practices for Force Verification of Testing Machines](#)

3. Summary of Test Method

3.1 For Procedures A, B, and C, the test specimen is loaded through the suggested self-aligning split disk test fixture ([Fig. 1](#)) which applies tensile stress to the test ring. An apparent tensile strength rather than a true tensile strength is obtained in this test because of a bending moment imposed during test at the split between the split disk test fixture. This moment is induced by the change in contour of the ring between the two disk sections as they separate. The test fixture is designed to minimize the effect of this bending moment.

3.2 For Procedure D, ring segment test specimen pairs are loaded into the suggested self-aligning test fixtures ([Fig. 2](#)) that are designed to apply direct tensile stress to the reduced areas of the ring segment test specimens ([Fig. 3](#)) with minimal bending moment.

3.3 For Procedure E, a single ring segment test specimen is loaded into the suggested self-aligning test fixture ([Fig. 4](#)) that is designed to apply direct tensile stress to the reduced areas of the ring segment test specimen ([Fig. 5](#)) with minimal bending moment.

4. Significance and Use

4.1 Split disk and ring segment tensile tests, properly interpreted, provide reasonably accurate information with regard to the apparent tensile strength of plastic pipe when employed under conditions approximating those under which the tests are made.

4.2 Ring tensile tests may provide data for research and development, engineering design, quality control, acceptance or rejection under specifications, and for special purposes. The test cannot be considered significant for applications differing widely from the load-time scale of the standard test.

NOTE 1—Procedure C has been used on polyethylene and polybutylene pipe to produce results equivalent to Quick Burst results (Test Method [D1599](#)) for 4 in. to 8 in. pipes.

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

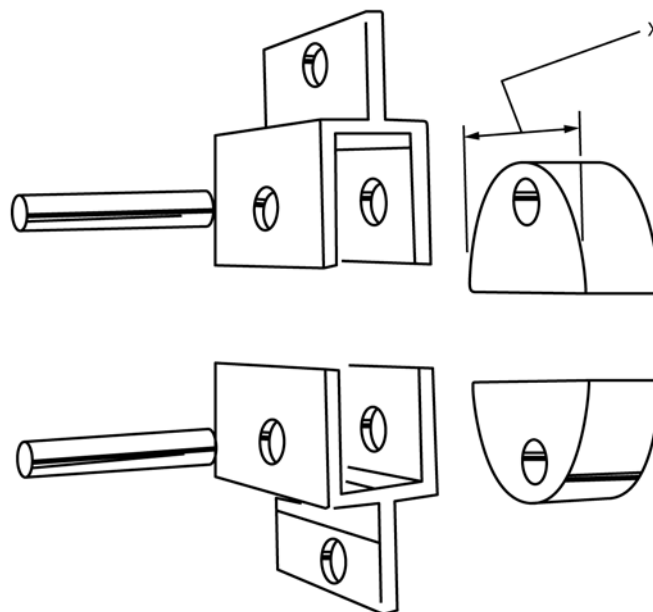


FIG. 1 Test Fixture: Typical

5. Apparatus

5.1 *Micrometers*—Suitable ball anvil-type micrometers, reading to at least 0.001 in., for measuring the width and thickness of the test specimens.

5.2 *Testing Machine*—A universal testing machine of the constant-rate-of-cross-head-movement type and comprising essentially the following:

5.2.1 *Drive Mechanism*—A drive mechanism for imparting to the crosshead a uniform controlled velocity with respect to the base, this velocity to be regulated as specified in Section 9.

5.2.2 *Load Indicator*—A load-indicating mechanism capable of showing the total tensile load carried by the test specimen. This mechanism shall be essentially free from inertia lag at the specified rate of testing and shall indicate the load with an accuracy of $\pm 1\%$ of the indicated value. The accuracy of the testing machine shall be verified in accordance with Method E4.

5.3 *Procedure A, B, and C Test Fixture*—The recommended test fixture Procedures A, B, and C is shown in Fig. 1. The width of the split disk for Procedure A and Procedure B shall be at least 0.1 in. greater than the width of the specimen. The width of the split disk for Procedure C shall be 2.0 in. \pm 0.1 in. The supports for holding the tension test fixture shall be self-aligning, that is, they shall be attached to the fixed and movable member of the test machine, respectively, in such a manner that they move freely into alignment as soon as any load is applied, so that the direction of the applied pull is directly perpendicular to the split axis of the test fixture.

5.4 *Procedure D Test Fixture*—A tension test fixture for Procedure D is illustrated in Fig. 2. The supports for holding the tension test fixture shall be self-aligning, that is, they shall be attached to the fixed and movable member of the test machine, respectively, in such a manner that they move freely into alignment as soon as any load is applied, so that the

direction of the applied pull is directly perpendicular to the split axis of the test fixture.

NOTE 2—In Fig. 2, the 2.00-in (50.8 mm) wide by 5.00-in (127 mm) long openings are suitable for ring segment specimens that are 1.6 to 1.8 in (40.6 to 45.7 mm) wide and from 1.0 to 4.5 in (25.4 to 114.3 mm) wall thickness. For ring segment specimen wall thickness greater than 4.5 in (114.3 mm), opening size may be adjusted appropriately. Opening size should allow 0.10 in (2.5 mm) minimum width clearance on each side, and at least 0.50 in (12.7 mm) wall thickness clearance. Ring segment test specimen securing pins 0.50-in (12.7 mm) diameter have been found suitable. Tapering or rounding the ends of the securing cross pins facilitates installation into the ring segments specimens. See Fig. 2 and Fig. 3.

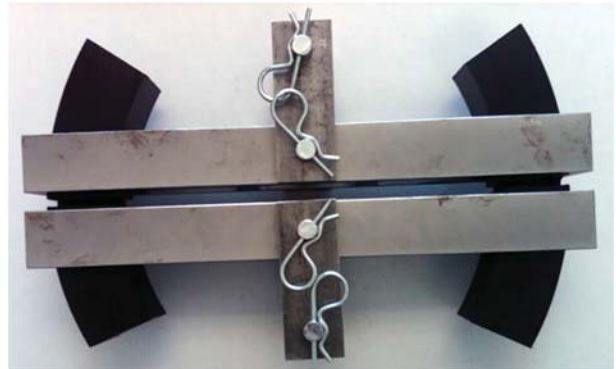
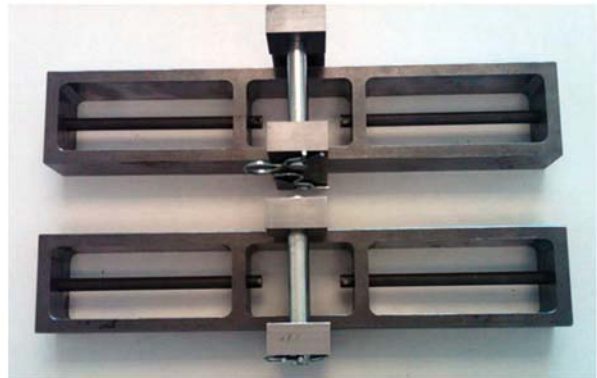
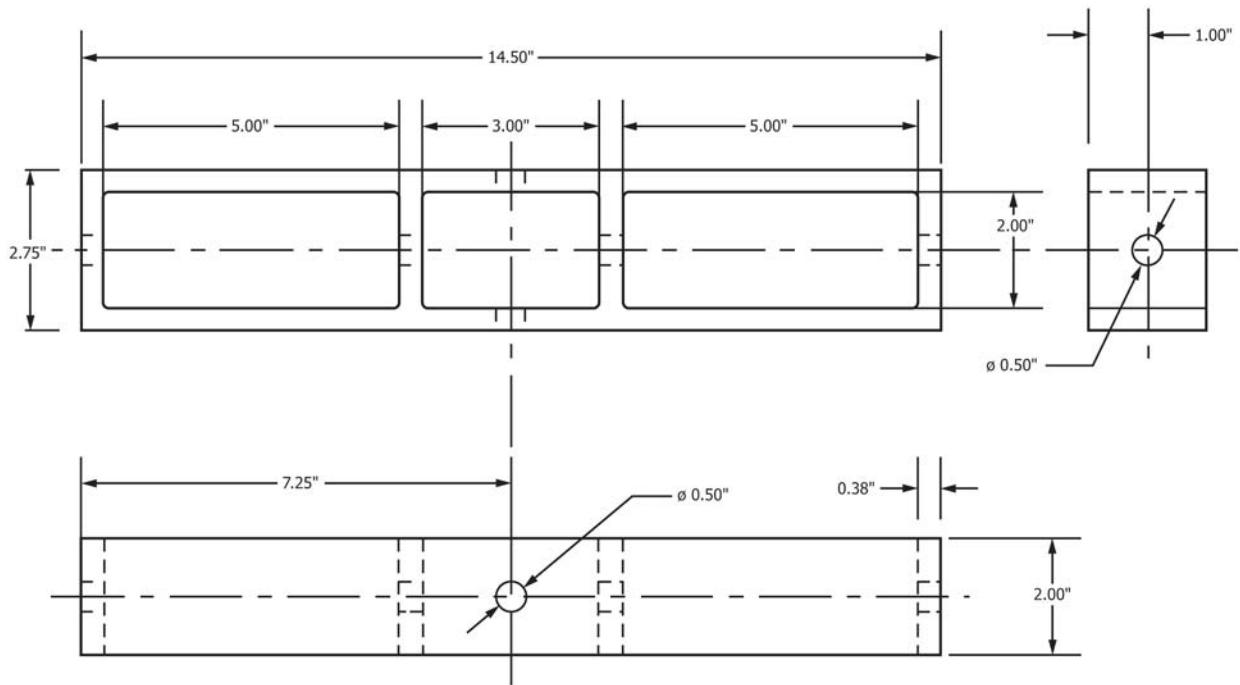
5.5 *Procedure E Test Fixture*—A test fixture for Procedure E is illustrated in Fig. 4. The Test fixture shall be self-aligning, that is, it shall be attached to the fixed and movable member of the test machine, respectively, in such a manner that it moves freely into alignment as soon as any load is applied, so that the direction of the applied pull is directly perpendicular to the split axis of the test fixture.

5.6 *Conditioning Apparatus*—Apparatus for maintaining temperature and relative humidity for conditioning prior to test, in accordance with Section 7.

6. Test Specimen

6.1 Test specimen for Procedure A shall be full-diameter, full-wall thickness rings cut from reinforced thermosetting resin pipe by any suitable means. Specimens shall conform to Fig. 6. Specimens shall have a minimum overall width of 0.90 in., and a minimum width in the reduced section(s) of 0.55 in. The number of reduced areas shall be one or two. If two, they must be located 180° apart. Reduced areas must be centered relative to the specimen width to within 0.05 in.

6.2 Test specimens for Procedure B shall be full-diameter, full-thickness rings cut from thermoplastic pipe, by any suitable means, as shown in Fig. 7. The minimum width of the



Fixture dimensions are for illustration only. See Note 2.

FIG. 2 Procedure D Test Fixture

ring, W , per Fig. 7 shall be 0.50-in. The maximum width of the ring shall be 2.00-in. Reduced areas shall be machined as shown in Fig. 7 and shall be located at the point of minimum

wall thickness and at 180° thereto except when the test is used

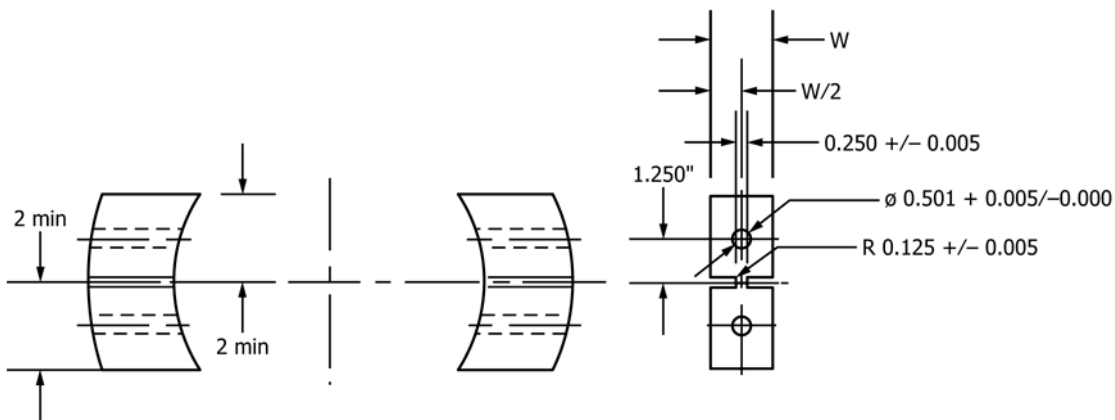


FIG. 3 Ring Segment Specimens 1 and 2 for procedure D (See 6.4.2 and 6.4.3.)

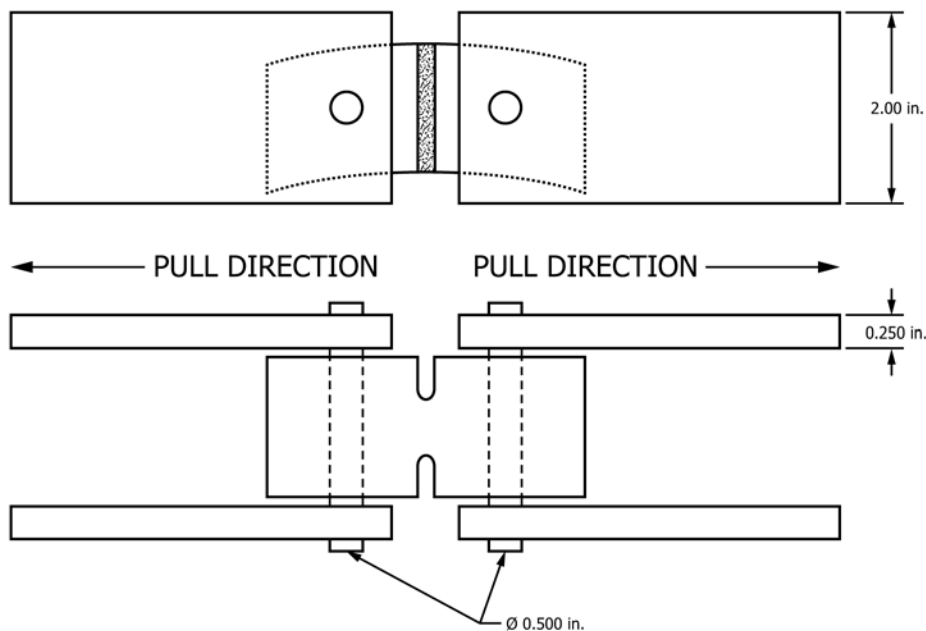


FIG. 4 Self Aligning Test Fixture for Procedure E

for specialized purposes (see Note 3). The reduced areas of the specimen must be free of machining marks and uniform in cross section.

NOTE 3—The reduced sections for the extruded or molded specimens can be located at any points on the periphery of the specimen provided they are 180° apart, that is, even at the weld or “knot” line of the specimen if the strength of these areas is being investigated.

NOTE 4—Specimen ring width, *W*, per Fig. 7 may be varied between 0.50 in. and 2.00 in. For larger diameter pipes with greater wall thickness, specimen stability during testing is improved when ring width is greater.

6.3 Test specimens for Procedure C shall be cut normal to the pipe axis with parallel sides. The width of the specimen shall be nominally 1.75 in. to 2.00 in. Two areas, one of which includes the minimum pipe wall thickness and the other 180 deg opposite, shall be wet sanded to remove cutting marks; care must be exercised to retain the rectangular cross-section of the prepared areas.

6.4 Test samples for Procedure D shall be full rings cut normal to the pipe axis with parallel sides. The width of ring

samples shall be nominally 2.00 ± 0.2 in. (50.8 ± 5.1 mm). One ring sample is used to produce ring segment Specimens 1 and 2.

6.4.1 Ring sample wall thickness shall be measured, and the minimum wall thickness and the point 180 degrees opposite shall be located and marked.

6.4.2 Ring segment Specimens 1 and 2 shall be cut from the ring sample. Ring segment specimen cuts shall be made not less than 2.0 in (50 mm) above and below the minimum wall thickness point (Specimen 1) and the point 180 degrees opposite (Specimen 2). Ring segment Specimens 1 and 2 shall be machined smooth on both sides to width *W* (1.70 ± 0.10 in (43.2 ± 2.5 mm)) per Fig. 3. Care shall be taken to retain a rectangular cross section. After machining, Specimens 1 and 2 shall be conditioned per Practice D618 Procedure A at $73.4 \pm 3.6^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) and 50 ± 50 percent without regard to relative humidity for not less than 24 h.

6.4.3 After conditioning per 6.4.2, reduced cross section areas shall be machined into ring segment Specimens 1 and 2,

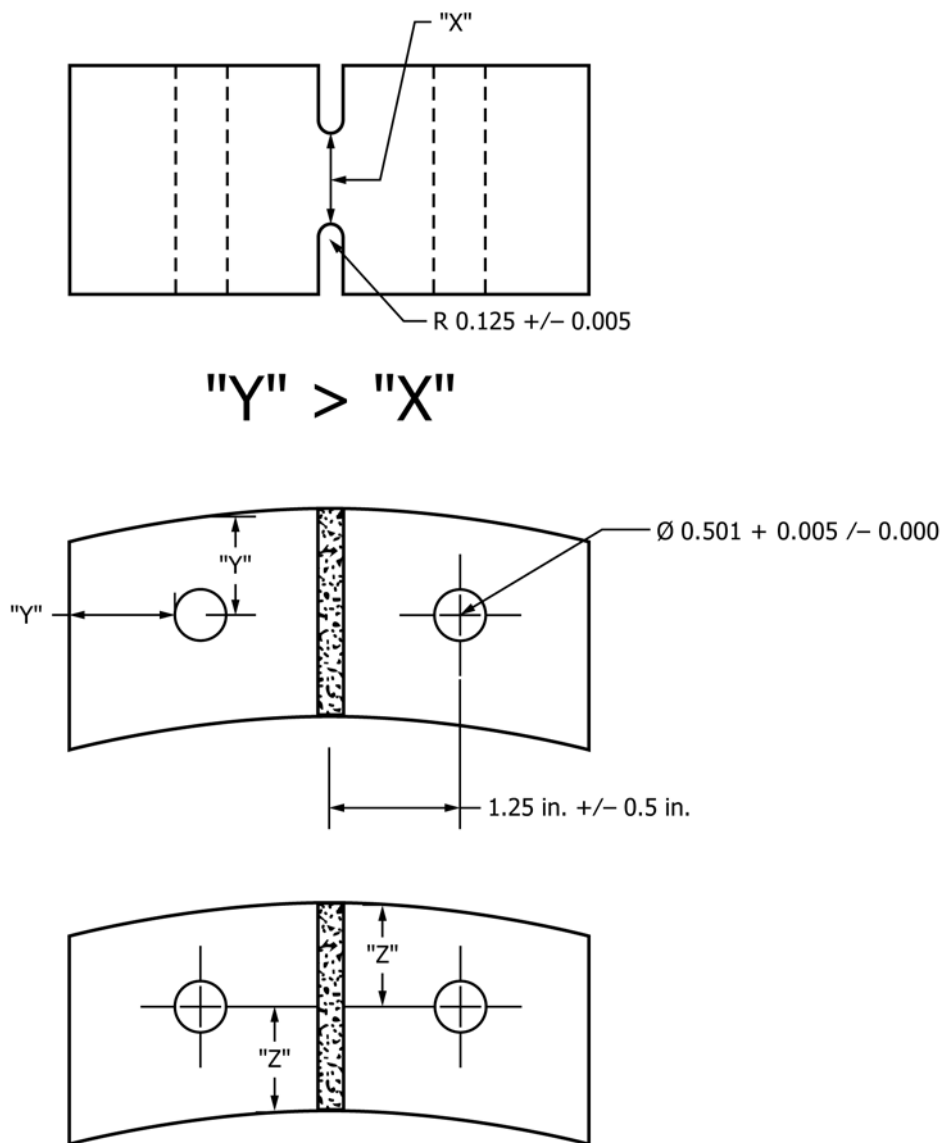


FIG. 5 Ring Segment Test Specimen for Procedure E (See 6.5.1 and 6.5.2)

and two holes for cross pins shall be drilled parallel to and centered equidistant above and below the Specimen 1 and 2 reduced cross section areas. See Fig. 3.

6.5 Test samples for Procedure E shall be full rings cut normal to the pipe axis with parallel sides. The width of ring samples shall be nominally 1.00 ± 0.2 in. (25.4 ± 5.1 mm). One ring sample shall be used to produce each specimen.

6.5.1 Ring segment test specimen shall be cut from the ring sample. Ring segment test specimen shall be machined smooth on both sides, with care taken to retain a rectangular cross section.

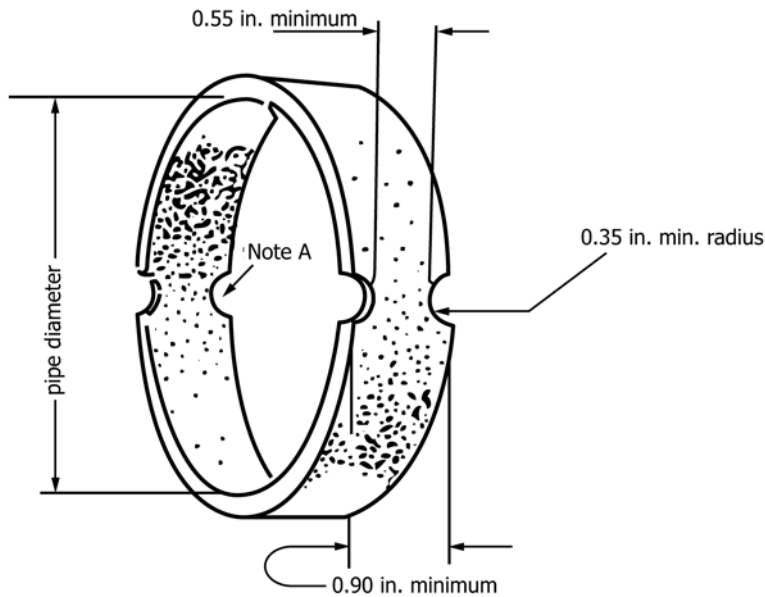
6.5.2 Reduced cross sections shall be machined into ring segment test specimen and two holes for cross pins shall be drilled parallel to and centered equidistant, above and below, the reduced cross section areas as detailed in Fig. 5. Reduced cross section areas shall be machined to 0.25 in to 0.75 in (6.35 mm to 19.05 mm) thick thick with variance through reduced cross section areas no greater than ± 0.005 in (0.127 mm).

6.6 Number of Test Specimens—The number of ring test samples is optional; however, a minimum of five samples are needed to obtain a reliable average test value. For quality control purposes, the sample quantity shall be one, and in cases of disagreement, five ring samples shall be tested and the average test value shall be recorded.

7. Conditioning

7.1 Conditioning—Condition the Procedure A, B, and C test specimens at $73.4 \pm 3.6^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) and $50 \pm 10\%$ relative humidity for not less than 24 h prior to test in accordance with Procedure A of Practice D618. After preparation per 6.4 through 6.4.3, condition Procedure D and E test specimens at $73.4 \pm 3.6^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) without regard to relative humidity for not less than 24 h in accordance with Procedure A of Practice D618 prior to test specimen.

7.2 Test Conditions—Conduct Procedure A, B, and C tests in the standard laboratory atmosphere of $73.4 \pm 3.6^\circ\text{F}$ ($23 \pm$



a) Second reduced area is optional.

FIG. 6 Reduced-Section Specimens for Procedure A

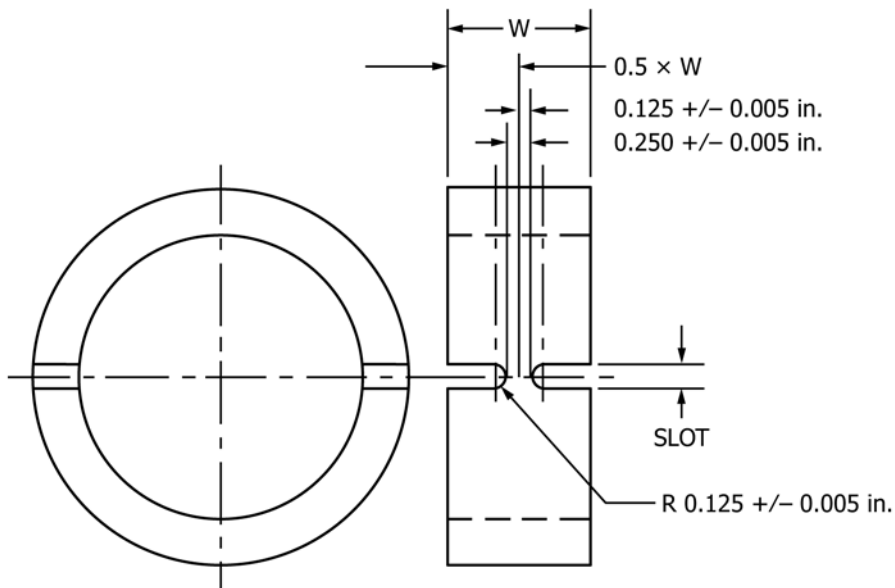


FIG. 7 Reduced Section Specimen for Procedure B

2°C) and 50 ± 10 % relative humidity, unless otherwise specified in the test methods or in this specification. Conduct Procedure B, C, D, and E tests in a laboratory atmosphere of 73.4 ± 3.6°F (23 ± 2°C) without regard to relative humidity, unless otherwise specified in the test methods or in this specification.

7.3 In case of disagreement, special conditioning procedures may be used by agreement between cooperating laboratories.

8. Speed of Testing

8.1 Speed of testing is velocity of separation of the two members of the testing machine when running idle (under no

load). Speed of testing shall be 0.1 in./min (2.5 mm/min) minimum and 0.5 in./min (12.7mm) maximum for Procedure A. It shall be 0.5 in./min for Procedures B, C, D, and E.

9. Procedure

9.1 Procedure A:

9.1.1 Measure the minimum width and thickness of the reduced area(s) to the nearest 0.001 in., using a suitable micrometer.

9.1.2 Mount the specimen on the lubricated periphery of the test fixture, with the reduced area(s) centered 2.0 ± 0.2 in. away from the split in the disk.

9.1.3 Run the test at a constant speed between 0.1 and 0.5 in./min (2.5 and 12.7 mm).

9.1.4 Record the maximum load carried by the specimen during the test.

9.2 Procedure B:

9.2.1 Measure the width and thickness of the reduced sections to the nearest 0.001 in. using a ball-type micrometer or a dial indicator. Record the width and thickness of both cross-sectional areas.

9.2.2 Mount the test specimen on the split disk test fixture with the reduced sections at the split in the fixture. Align the test specimen on the split disk specimen holder so that it is centered on the line joining the points of attachment of the fixture to the test machine.

9.2.3 Set the speed control at 0.50 in./min and start the test machine.

9.2.4 Record the yield and ultimate loads carried by the specimen during the test.

9.3 Procedure C:

9.3.1 Measure the width and thickness of the prepared areas to the nearest 0.001 in. using a ball anvil type micrometer. Record the width and thickness of both prepared cross-sectional areas.

9.3.2 Mount the test specimen on the outside of the split disk fixture with the prepared and measured areas located at the split in the fixture. Align the test specimen on the test fixture so that it is centered on the line joining the points of attachment to the test machine.

9.3.3 Set the speed control at 0.50 in./min and start the machine.

9.3.4 Record the yield point and maximum load carried by the specimen during the test.

9.3.5 Record the crosshead separation required to rupture the test specimen.

9.4 Procedure D:

9.4.1 To the nearest 0.001 in. (0.025 mm), measure the width and thickness of the reduced cross section areas using a ball anvil type micrometer. Record the width and thickness of Specimen 1 and Specimen 2 reduced cross section areas.

9.4.2 Install Specimens 1 and 2 into the Procedure D test fixture. See Fig. 2. Specimens shall be located equidistant to the test fixture pull centerline.

9.4.3 Set the speed control at 0.50 in./min and start the machine.

9.4.4 Record the yield point and maximum load carried by the specimens during the test.

9.4.5 Record the crosshead separation required to rupture the test specimen.

9.5 Procedure E:

9.5.1 To the nearest 0.001 in. (0.025 mm), measure the width and thickness of the reduced cross section area using a ball anvil type micrometer. Record the width and the maximum and minimum thickness of the reduced cross section area.

9.5.2 Install specimen into the Procedure E test fixture, see Fig. 4.

9.5.3 Set/verify the speed control is at 0.50 in./min. and start the machine.

9.5.4 Record the yield point and maximum load carried by the specimen during the test.

9.5.5 Record the crosshead separation required to rupture the test specimen.

10. Calculation

10.1 Calculate the apparent tensile strength (at yield or rupture, or both) of the specimen using the appropriate equation and report to three significant figures.

$$\sigma_a = P_b / 2A_m \text{ (Procedure A)} \quad (1)$$

$$\text{or: } \sigma_a = \frac{P_b}{(d_1 \cdot b_1 + d_2 \cdot b_2)} \text{ (Procedure B, C, or D)} \quad (2)$$

$$\text{or: } \sigma_a = \frac{P_b}{(d_1 \cdot b_1)} \text{ (Procedure E)} \quad (3)$$

where:

σ_a = apparent yield or ultimate tensile stress of the specimen, psi (or MPa),

P_b = maximum or breaking load, or both, lbf (or N),

A_m = minimum cross-sectional area of the two measurements, $d \times b$, in.²,

d = thickness at minimum area, in.,

d_1, d_2 = thickness at reduced or test sections, in.,

b = width at minimum area, in., and

b_1, b_2 = width of reduced or test sections, in.

10.2 For each series of tests, calculate the arithmetic mean of all values obtained to three significant figures and report as the “average value” for the particular property in question.

10.3 Calculate the standard deviation as follows and report to two significant figures:

$$s = \sqrt{\frac{\sum X - n\bar{X}^2}{n - 1}} \quad (4)$$

where:

s = estimated standard deviation,

X = value of single observation,

n = number of observations, and

\bar{X} = arithmetic mean of the set of observations.

11. Report

11.1 The report shall include the following:

11.1.1 Complete identification of the material tested, including type, source, manufacturer’s code number, form, principal dimensions, and previous history.

11.1.2 Fabrication procedure,

11.1.3 Type specimen used,

11.1.4 Thickness and width of test cross-sectional area,

11.1.5 Conditioning procedure used,

11.1.6 Atmospheric conditions in test room,

11.1.7 Number of specimens tested,

11.1.8 Rate of crosshead motion,

11.1.9 Apparent composite tensile strength of each specimen, and average calculated and reported to three significant figures,

11.1.10 Standard deviation (estimated) of the sample calculated and reported to two significant figures,

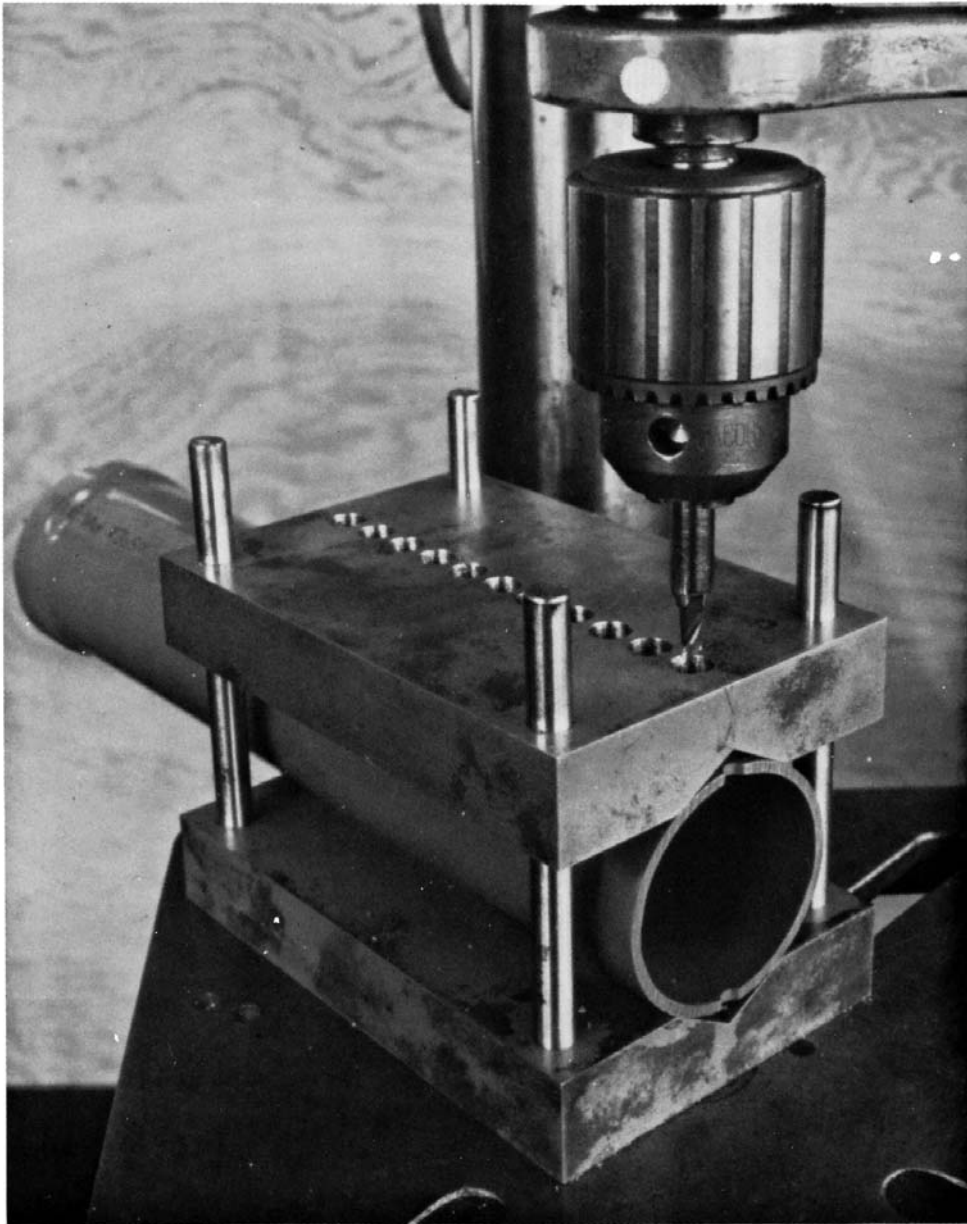


FIG. 8 Fixture for Preparation of Reduced-Section Ring Tensile Specimens

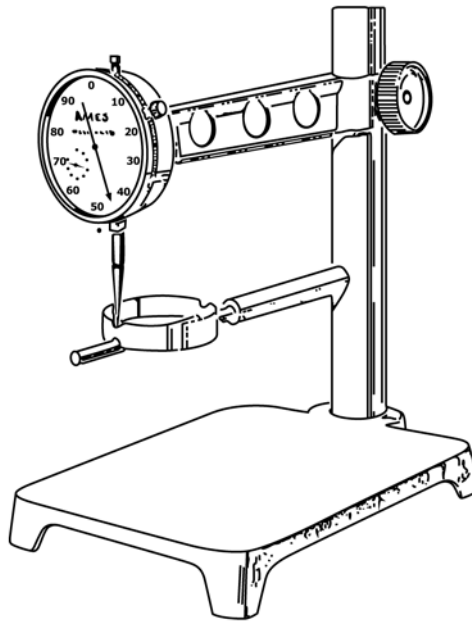


FIG. 9 Instrument for Measuring Ring Tensile Specimens

- 11.1.11 Average resin content weight percent of specimens when applicable, and
- 11.1.12 Date of test.

12. Precision and Bias

12.1 *Procedures A, B, and C*—Because of the nature of the materials and a lack of a wide data base on a variety of applicable composites, no definitive statement can be made at this time concerning precision and bias of this test method.

12.2 *Precision Procedure D*³—Based on a laboratory round-robin conducted of 30-in and 20-in high density poly-

³ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:F17-1052. Contact ASTM Customer Service at service@astm.org.

ethylene pipe, the precision (one standard deviation) of the Procedure D method for high density polyethylene pipe is as follows:

- 12.2.1 Within-laboratory, $\pm 2\%$ (repeatability).
- 12.2.2 Between-laboratory, $\pm 9\%$ (reproducibility).

12.3 *Precision Procedure E*—Based on a laboratory round-robin testing in process.

12.4 *Bias Procedure D and E*—Data obtained using the Procedure D method are believed to be reliable, since accepted techniques of analysis are used. However, because no referee method is available, no bias statement can be made.

13. Keywords

13.1 apparent tensile strength; hoop tensile strength; plastic pipe; ring segment method; split-disk method

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (D2290–12) that may impact the use of this standard.

(1) Added Procedure E and renumbered figures and sections after additions.

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