Designation: D1598 – 23

Standard Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure[1]

This standard is issued under the fixed designation D1598; 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 the time-to-failure of both thermoplastic and reinforced thermosetting/resin pipe under constant internal pressure.

1.2 This test method provides a method of characterizing plastics in the form of pipe under the conditions prescribed.

1.3 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.

1.4 *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.*

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]

D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings

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

D2992 Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings

D2517 Specification for Reinforced Epoxy Resin Gas Pressure Pipe and Fittings

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *failure, n*—occurrence of ballooning, rupture, seepage or weeping.

3.1.1.1 *ballooning, n*—any localized expansion of a pipe while under internal pressure. This is sometimes referred to as ductile failure.

3.1.1.1.1 *Discussion*—Overall distention caused by applied stress is not considered to be a failure.

3.1.1.2 *rupture, n*—a break in the pipe wall with immediate loss of test fluid and continued loss at essentially no pressure. If rupture is not preceded by some yielding, this may be termed a non-ductile failure.

3.1.1.3 *seepage or weeping, n*—test fluid passing through cracks in the pipe wall to an extent detectable visually or electronically. A reduction in pressure will frequently enable the pipe to carry fluid without apparent evidence of loss of fluid.

3.1.2 *free (unrestrained) end closure, n*—a pipe specimen end closure(cap) that seals the end of the pipe against loss of internal fluid and is fastened to the pipe specimen.

3.1.3 *restrained end closure, n*—a pipe specimen end closure (cap) that seals the end of the specimen against loss of internal fluid and pressure, but is not fastened to the pipe specimen. Retained end closures rely on tie-rod(s) through the pipe specimen or on an external structure to resist internal pressure end thrust.

4. Summary of Test Method

4.1 This test method consists of exposing specimens of pipe to a constant internal pressure while in a controlled environment. Such a controlled environment may be accomplished by, but is not limited to, immersing the specimens in a controlled temperature water or air bath. The time-to-failure is measured.

NOTE 1—Dimensional changes should be measured on specimens

[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 July 1, 2023. Published July 2023. Originally approved 1958. Last previous edition approved in 2021 as D1598 – 21. DOI: 10.1520/D1598-23

[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.

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

undergoing long-term strength tests. Measurements using circumferential tapes, strain gages, or mechanical extensometers provide useful information.

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 from which the hydrostatic design basis for plastic pipe materials can be computed. (Refer to Test Method D2837 and Practice D2992.)

5.2 In order to determine how plastics will perform as pipe, it is necessary to establish the stress-failure time relationships for pipe over 2 or more logarithmic 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.

5.3 The factors that affect creep and long-term strength behavior of plastic pipe are not completely known at this time. This procedure takes into account those factors that are known to have important influences and provides a tool for investigating others.

5.4 Creep, or nonrecoverable deformation for pipe made of some plastics, is as important as actual leakage in deciding whether or not a pipe has failed. Specimens that exhibit localized ballooning, however, may lead to erroneous interpretation of the creep results unless a method of determining creep is established that precludes such a possibility. Circumferential measurements at two or three selected positions on a specimen may not be adequate.

5.5 Great care must be used to ensure that specimens are representative of the pipe under evaluation. Departure from this assumption may introduce discrepancies as great as, if not greater than, those due to departure from details of procedure outlined in this test method.

6. Apparatus

6.1 *Constant-Temperature System*—A water bath or other fluid bath equipped so that uniform temperature is maintained throughout the bath. This may require agitation. If an air or other gaseous environment is used, provision shall be made for adequate circulation. The test may be conducted at 73 °F (23 °C) or other selected temperatures as required and the temperature tolerance requirements shall be ±3.6 °F (±2.0 °C).

6.2 *Pressurizing System*—Any device that is capable of continuously applying constant internal pressure on the specimen may be used. The device shall be capable of reaching the test pressure without exceeding it and of holding the pressure within the tolerance shown in 6.6 for the duration of the test.

6.3 *Pressure Gage*—A pressure gage or pressure transducer having an accuracy sufficient to meet the pressure tolerance requirements of 6.6 is required.

6.4 *Timing Device*—A time meter connected to the pressurized fluid side of the system through a pressure or flow switch, or both. The timing device and pressure or flow switch, or both, together shall be capable of measuring the time when the specimen is at 98 % or more of test pressure with sufficient accuracy to meet the tolerance requirements of 6.6.

6.5 *Specimen End Closures*—Either free-end or restrained-end closures that will withstand the maximum test pressures may be used. Closures shall be designed so that they do not cause failure of the specimen. Free-end closures shall be used for referee tests for thermoplastic pipe.

NOTE 3—Free-end closures fasten to the specimen so that internal pressure produces longitudinal tensile stress in addition to hoop. Compared to free end closure specimens, stresses in the wall of restrained-end closure specimens act in the hoop and radial directions only. Because of this difference in loading, the equivalent hoop stress in free-end closure specimens of solid wall thermoplastic pipe are approximately 11 % lower than in restrained-end closure specimens tested at the same pressure. The test results for each specimen and the LTHS will reflect this difference in test method.

6.6 *Time and Pressure Tolerance*—When added together, the tolerance for the timing device and the tolerance for the pressure gage shall not exceed ±2 %.

7. Test Specimens

7.1 *Pipe Specimen Length*—For pipe sizes of 6 in. (150 mm) or less, the specimen length between end closures shall be not less than five times the nominal outside diameter of the pipe, but in no case less than 12 in. (300 mm). The 12 in. (300 mm) minimum specimen length requirement shall not apply to molded specimens. For larger sizes of pipe, the minimum length between end closures shall be not less than three times the nominal outside diameter but in no case less than 30 in. (760 mm).

7.2 *Measurements*—Dimensions shall be determined in accordance with Test Method D2122 or Practice D3567.

7.2.1 The average outside diameter and the minimum wall thickness shall be measured for each pipe specimen tested. The measured values shall be used to calculate the hoop stress and the pressure as defined in Section 10.

8. Conditioning

8.1 Specimens to be tested at 73 °F (23 °C) shall be conditioned at test temperatures in a liquid bath for a minimum of 1 h or in a gaseous medium for a minimum of 16 h before pressurizing.

8.2 When specimens are to be tested at higher temperatures, condition them in the elevated temperature environment until they have reached test temperature.

NOTE 4—Conditioning time is a function of pipe size wall thickness, temperature differential, the film heat transfer coefficient and whether the elevated temperature environment is applied to one or both sides of the specimen. One-hour conditioning of 1 in. (25.4 mm) and smaller pipe at 180 °F (82 °C) in a water environment has been found to be sufficient.