



Designation: F 948 – 94 (Reapproved 2001)^{ε1}

An American National Standard

Standard Test Method for Time-to-Failure of Plastic Piping Systems and Components Under Constant Internal Pressure With Flow¹

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ε¹ NOTE—Keywords added editorially in November 2003.

1. Scope

1.1 This test method covers the determination of the time-to-failure of plastic piping products under constant internal pressure and flow.

1.2 This test method provides a method of characterizing plastics in the form of pipe, components, and systems under any reasonable combination of internal and external temperatures and environments, under the procedures described.

1.3 This test method can be used to characterize the tested plastic materials or products, or both, on the basis of pressure-, or stress-rupture data developed under the conditions prescribed.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *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:

D 543 Test Method for Resistance of Plastics to Chemical Reagents²

D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings³

D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials³

D 2992 Practice for Obtaining Hydrostatic or Pressure Design Basis for “Fiberglass” (Glass–Fiber–Reinforced Thermosetting Resin) Pipe and Fittings³

D 3567 Practice for Determining Dimensions of “Fiberglass” (Glass–Fiber–Reinforced Thermosetting-Resin) Pipe and Fittings³

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 Annual Book of ASTM Standards, Vol 08.01.

³ Annual Book of ASTM Standards, Vol 08.04.

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods⁴

2.2 PPI Documents:

TR-2 Policies and Procedures for the Listing of Thermoplastic Pipe, Fittings, and Fixture Materials When Evaluated Under Constant Internal Pressure With Flow⁵

TR-3 Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials⁵

3. Terminology

3.1 Definitions:

3.1.1 *failure*—bursting, cracking, splitting, or weeping (seepage of test fluid through the wall of the product) during the test, which results in the inability of the specimen to maintain pressure or contain the internal test fluid, shall constitute failure of the test specimen. Failure may sometimes occur by ballooning, an excessive extension leading to structural failure. When failure occurs by ballooning the degree of distension should be recorded. Assemblies may also fail to joint leakage or separation.

NOTE 1—Overall distension, which results from creep caused by long-term stress, is not considered to be a ballooning failure.

3.1.2 *hoop stress*—the tensile stress in the wall of the piping product in the circumferential direction due to internal pressure. Units will be reported as pounds per square inch (psi) or mega pascals (MPa). Hoop stress will be calculated by the following ISO equation:

$$S = P(D - t)/2t$$

where:

S = hoop stress, psi (MPa),

D = average outside diameter, in. (mm),

P = internal pressure, psig (MPa), and

t = minimum wall thickness in. (mm).

NOTE 2—Hoop stress should only be determined on straight hollow

⁴ Annual Book of ASTM Standards, Vol 14.02.

⁵ Available from Plastics Pipe Institute, Division of The Society of the Plastics Industry, 250 Park Avenue, New York, NY 10017.

cylindrical specimens. Products of more complex shape may be evaluated by Option 2 of Appendix X1 based on pressure.

3.1.3 *make-up fluid*—an exchange of internal fluid with fresh fluid at a minimum rate of 10 % of the total system volume per week.

3.1.4 *maximum internal surface temperature*—that temperature attained when increased fluid velocity results in no further increase in the outside surface temperature of the specimen (see X2.7).

3.1.5 *pressure*—the force per unit area exerted by the test fluid in the piping product. Units will be reported as pounds per square inch gage (psig) or mega pascals gage (MPag).

3.1.6 *test assembly*—components (such as, pipe, fittings, valves, etc.) tested separately or together in an array that may simulate an actual field system that might include joints, fusions, plastic-to-metal transitions, etc.

4. Summary of Test Method

4.1 This test method consists of exposing specimens of extruded, molded, or otherwise manufactured pipe or components (such as fittings, valves, assemblies, etc.) to a constant internal pressure by a flowing test fluid of controlled temperature and composition, while in a controlled external environment. Time-to-failure and specimen surface temperature should be measured during exposure under the test conditions. Unless otherwise specified the internal fluid shall be water and the external environment will be air.

5. Significance and Use

5.1 The data obtained by this test method are useful for establishing pressure, or hoop stress where applicable, versus failure-time relationships, under independently controlled internal and external environments that simulate actual anticipated product end-use conditions, from which the design basis (DB) for piping products or materials, or both, can be determined. (Refer to Test Method D 2837 and Practice D 2992, and Appendix X1 of this test method.)

NOTE 3—Reference to design basis (DB) in this test method refers to the hydrostatic design basis (HDB) for material in straight hollow cylindrical shapes where hoop stress can be easily calculated, or is based on applied pressure design basis (PDB) for complex-shaped products or systems where complex stress fields seriously prohibit the use of hoop stress.

5.2 In order to characterize plastics as piping products, it is necessary to establish the stress-to-rupture-time, or pressure-to-rupture-time relationships over two or more logarithmic decades of time (hours) within controlled environmental parameters. Because of the nature of the test and specimens employed, no single line can adequately represent the data. Therefore, the confidence limits should be established.

5.3 Results obtained at one set of environmental conditions should not be used for other conditions, except that higher temperature data can be used for a design basis assignment for lower application temperatures, provided that it can be demonstrated that the application conditions present a less stringent environment. The design basis should be determined for each specific plastic material and each different set of environmental constraints. Design and processing can significantly affect the

long-term performance of piping products, and therefore should be taken into consideration during any evaluation (see Appendix X2).

5.4 Specimens used must be representative of the piping product or material under evaluation (see Appendix X2).

6. Apparatus

6.1 *Constant-Temperature System:*

6.1.1 *Controlling the Internal Environment of Test Specimens*—Any system that will ensure that the test fluid entering and exiting the test specimen is maintained at a constant temperature within $\pm 3.6^\circ\text{F}$ ($\pm 2^\circ\text{C}$) throughout the duration of the test.

6.1.2 *Controlling the External Environment of Test Specimens*—Any system that will ensure constant external environment temperature within $\pm 3.6^\circ\text{F}$ ($\pm 2^\circ\text{C}$) throughout the duration of the test.

6.2 *Dynamic Flowing Pressure System*—Any device that is capable of continuously applying a constant internal pressure within the tolerance limits defined in Table 1, while allowing a continuous flow through the test specimens. The flow rate should be substantial enough to control the internal temperature of each test specimen. The device shall be capable of reaching the test pressures without exceeding it, and holding the pressures within the tolerances listed in Table 1 for the duration of the test.

NOTE 4—Pressure variations from pumps may exceed the tolerance limits. (See X2.6.)

6.3 *Pressure Gage*—A pressure measuring instrument capable of determining the internal pressure of the test specimen(s) within the limits as required in Table 1.

6.4 *Timing Device*—Any timing device or system capable of determining the time-to-failure for each test specimen, within the tolerances listed in Table 1.

6.5 *Specimen Holder*—Any device that will support the specimens, but will minimize externally induced stresses. Provisions shall be made to allow for normal bidirectional thermal expansion of the test specimen.

6.6 *Feed-and-Bleed System*—Provisions shall be made to introduce fresh make-up fluid to the system while bleeding off an equivalent amount necessary to maintain a constant volume and ensure constant composition of the test fluid. This system should be designed to maintain composition of the internal fluid within prescribed limits.

6.7 *Other Provisions*—Additional provisions may be necessary to maintain constant composition.

6.8 *Flow Control*—Provisions shall be made to ensure that the internal fluid velocity shall be adequate to ensure constant internal temperature in the specimen within $\pm 3.6^\circ\text{F}$ ($\pm 2^\circ\text{C}$). In the special case of hot water inside/ambient air outside,

TABLE 1 Tolerances for Testing Thermoplastic Piping Products

Test Periods, h	Pressure, %	Time, %
0 to 10	± 0.5	± 0.5
10 to 100	± 0.5	± 1.0
100+	± 1.0	± 2.0

