Designation: F 948 – 94

An American National Standard

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
Reprinted from the Annual Book of ASTM Standards. Copyright ASTM

Standard Test Method for Time-to-Failure of Plastic Piping Systems and Components Under Constant Internal Pressure With Flow[1]

This standard is issued under the fixed designation F 948 ; 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 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 Reagents[2]

D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings[3]

D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials[3]

D 2992 Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass'' (Glass–Fiber–Reinforced Thermosetting Resin) Pipe and Fittings[3]

D 3567 Practice for Determining Dimensions of "Fiberglass'' (Glass–Fiber–Reinforced Thermosetting-Resin) Pipe and Fittings[3]

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods[4]

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 Flow[5]

TR-3 Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials[5]

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 (MPag), and
t = mimimum wall thickness in. (mm).

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

[1] This test method is under the jurisdiction of ASTM Committee F-17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.40 on Test Methods.

Current edition approved April 15, 1994. Published June 1994. Originally published as F 948 – 85. Last previous edition F 948 – 85.

[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.04.

[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.

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 ± 3.6°F (±2°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 ±3.6°F (±2°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 ±3.6°F (±2°C). In the special case of hot water inside/ambient air outside, provision shall be made to ensure maximum internal surface temperature of the specimen within ±3.6°F (±2°C).

7. Test Specimens

7.1 *Material*—Material evaluation shall be done on cylindrical test specimens molded or formed by the same process as the actual product. Unless otherwise specified the part shall meet the specimen requirements as follows:

7.1.1 *Injection Molded*—The test specimens shall be injection molded tubes with as uniform a wall as technically

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

possible. The mold shall be side-gated so that a bond line is created lengthwise along the tubular test specimens (see Note 5). The working exposed length of the specimen in the test shall have a minimum length to actual outside diameter ratio of 5 to 1.

NOTE 5—The PPI Hydrostatic Stress Board is currently evaluating the question of side versus end gating as part of a broad study of the forecasting of the long-term strength of fittings.

7.1.2 *Extrusion*—The specimen length between end closures shall be not less than 5 times the nominal outside diameter of the pipe, but in no case less than 12 in. (300 mm).

7.1.3 *Others*—For manufacturing processes other than those specified, straight hollow cylindrical shapes produced by the process should be used as specimens for evaluating the material. Restriction of 7.1.2 should apply.

7.2 *End-Use Products*—Actual commercial designs simulating end-use products shall be representative of the final product design and manufacturing process (see Appendix X2).

7.3 *Systems and Assemblies*—System or subsystem designs that include joints or other assembly techniques which represent field installations, or both, may be tested.

7.4 *Measurements*—Dimensions shall be determined in accordance with Test Method D 2122 or Practice D 3567, where applicable.

8. Conditioning

8.1 If the external environment is gaseous, test specimens shall be conditioned in the external air or gaseous environment for a minimum of 16 h before pressurizing the internal test fluid. If the external environment is a liquid, test specimens shall be conditioned for a minimum of 1 h. This conditioning period may be concurrent with internal conditioning using flowing internal test fluid. Refer to Table 2.

8.2 The internal test fluid shall be circulated through the test specimens for a minimum of 1 h if liquid, or 16 h if gaseous, before applying test pressure. Refer to Table 2.

9. Procedure

9.1 Attach the specimens or assemblies to the system supported in a manner that will minimize externally induced stresses and minimize entrapment of gas in the specimen when the internal fluid is a liquid.

9.2 After conditioning the specimens as specified in Section 8, adjust the pressure to produce the desired loading. Apply the pressure to the specimens and make sure the timing devices have started after reaching the assigned pressure. Pressures should be preset prior to loading test specimens in order to avoid overstressing the specimens during pressure setting procedure.

TABLE 2 Minimum Conditioning Period

External Fluid	Internal Fluid	Minimum External Environment Exposure, h	Minimum Internal Flowing, h
Gas	Gas	16	16
Gas	Liquid	16	1
Liquid	Gas	1	16
Liquid	Liquid	1	1

9.3 Periodically, measure the surface temperature of each test specimen (see X2.7) and the air temperature near the test specimen's surface.

9.3.1 Any failure occurring within one pipe diameter of the joining system of the test assembly to test apparatus should be examined carefully. If there is any reason to believe that the failure was attributable to the joining system, this data point should not be used in the regression equation computations.

9.3.2 All data must be reported, whether employed in the regression analysis or not. Widely scattered failures may be indicative of performance to be expected in the field. If circumstances can be determined for inconsistent test performance, the reason should be so noted with the failure time.

10. Report

10.1 Report the following information:

10.1.1 Complete identification of the sample, including material type, source, manufacturer's name and code number, and previous significant history, if any.

10.1.2 Specimen dimensions, including nominal size and, when applicable, average and minimum wall thickness, average outside diameter and length to diameter ratio.

10.1.3 A sketch of the test specimen shall be included in the report.

10.1.4 Fluid temperatures inside and outside the specimen.

10.1.4.1 *For Water Inside/Ambient Air Outside*—Report fluid temperatures entering and leaving the specimen, air temperature around the specimens, minimum external surface temperature of the specimens, and method used to measure surface temperature of the specimens.

10.1.5 Test environments inside and outside the specimen.

10.1.6 A table of pressures or stresses, or both, and the respective time-to-failure in hours for all the specimens tested.

10.1.6.1 In those cases where pressure variations could affect the life performance, pressure variations should be reported (see X2.6).

10.1.7 The nature of the failures in accordance with 3.1.1. In the case of test assemblies, the failure type and location (such as, fitting, joint, seal, etc.) must be included.

10.1.8 Any unusual behavior observed in the tests. Any change in color, surface texture, or other change in appearance that may be the result of a physical, chemical, or environmental effect must be reported, whether or not such change played a role in the failure of the part.

10.1.9 Dates of test.

10.1.10 Name of laboratory and signature of the supervisor of the tests.

11. Precision and Bias

11.1 *Precision*—This test method has produced replicate failure times over a wide stress level for acetal (POM) resins using an injection molded tubular specimen. The two sigma percent precision was 49 %, using the analytical procedure in Practice E 177. This precision is based on one laboratory, several test assemblies, and three different acetal resins.

11.1.1 The two sigma precision of the extrapolated 100 000 and 50 year stress values for a single acetal resin, triplicated by a single laboratory was 15 %.