SEMATECH Provisional Test Method for Determining the Hydraulic Burst Pressure of UPW Distribution System Components

SEMATECH
Technology Transfer 92010948B-STD

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Abstract: This test method provides a procedure for determining the burst pressure of plastic components used in UPW distribution systems. It is applicable to products in which all parts that are in contact with the fluid media are plastic. This document is in development as an industry standard by Semiconductor Equipment and Materials International (SEMI). When available, adherence to the SEMI standard is recommended.

Keywords: Ultrapure Water Distribution Systems, Testing, Plastic Piping, Pressure Measurement, Failure Testing

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1. Introduction

1.1 *Purpose*—The purpose of this method is to determine the burst pressure of plastic components used in ultrapure water (UPW) distribution systems.

1.2 *Scope*—This method provides a uniform procedure for determining the hydraulic pressure that produces a failure of a plastic UPW system component. This method is applicable to products in which all parts in contact with the fluid media are constructed of plastic materials.

1.3 *Limitations*—This method is intended only for new components to be used in ultrapure water without oxidant.

2. Referenced Documents

2.1 *ASTM Standards*[1]

ASTM D1599 Standard Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings.

ASTM D2122 Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings.

3. Definitions

3.1 *free-end closure*—a component (e.g., cap or plug) used to allow the internal cavity of a specimen to be pressurized. Free-end closures do not contribute to the restraint of the specimen.

3.2 *piping component(s)*—an individual component or combination of components used in a fluid or gas system for transfer of media.

3.3 *pressure-containing envelope*—that part of the component or specimen that contains the pressurized media.

3.4 *pressure rise or rate*—the speed at which the pressure increases (time versus pressure).

4. Summary of Method

This method consists of automatically pressurizing a specimen to failure in a 50- to 80-second time interval by continuously increasing the internal hydraulic pressure while in a controlled temperature environment.

5. Significance and Use

This method is suitable for establishing laboratory testing requirements for quality control purposes for the procurement of test data.

[1] American Society for Testing and Materials. 1916 Race St. Philadelphia, PA 19103.

6. Apparatus

6.1 *Hydraulic System*. Use a hydraulic system capable of automatically applying a continuous increase of the internal hydraulic pressure to the test specimen. The hydraulic system must be capable of controlling the internal fluid temperature at the test specimen to 23 ± 3°C (73 ± 5°).

6.2 *Temperature Monitor*. Provide an instrument for monitoring temperature to within ± 1°C (± 2°F).

6.3 *Pressure Monitor*. Provide an instrument for monitoring pressure within ± 1% of full scale. The pressure sensing device is to be plumbed into the pressure manifold.

6.4 *Recorder*. A strip chart recorder or similar precision equipment is to be used to permanently record the pressure and time-to-failure of each specimen.

6.5 *Specimen Support*. Any support that does not contribute to the restraint of the specimen in either the circumferential or axial direction is acceptable.

6.6 *Specimen End Closures*. Use free-end closures that can withstand the maximum test pressures. Closures shall be designed to not affect the failure of the specimen. When the mode of failure of a piping system is to be determined, no reinforcement shall be used. In large components, loosely fitting pieces may be placed in the pressure-contained envelope to reduce the volume of pressurized fluid.

6.7 *Enclosure*. Use an enclosure that allows observation of the test specimen and is capable of controlling the ambient temperature at 23 ± 3°C (73 ± 5°F).

7. Materials

7.1 *Test Fluid*. The test fluid is water.

8. Precautions

8.1 *Safety Precautions*

8.1.1 This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address the safety considerations associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of regulatory limitations before using this method.

8.1.2 **Warning**: This method involves pressurizing components at high pressure. Adequate precautions must be taken to prevent injury to the person conducting the test.

8.1.3 The data compiled from this testing should be used for comparison purposes only and is not intended to indicate a working pressure rating.

9. Sampling, Test Specimens, and Test Units

9.1 *Specimen Design and Composition*—Specimens shall consist of complete assemblies without modifications.

9.2 *Specimen Fabrication*—Specimens are to be assembled per standard assembly procedures.

9.3 *Sample Size*—Three specimens shall be tested unless the highest or lowest burst pressure value achieved deviates by more than 5% from the average of the three samples tested. This will help to increase the confidence level when there is a large deviation.

Example:

Three samples burst #1 = 285 psi
#2 = 310 psi
#3 = 315 psi
Average = 303 psi

$\frac{303}{315} = 4\%$ $\frac{303}{285} = 6\%$[2]

9.4 *Specimen Surface*—All surfaces of the individual part shall be free of visible flaws, scratches, or other imperfections, unless typically found on a representative sample of that part.

9.5 When evaluating a pipe or tube, the specimen length *between* the end closures shall be a minimum of ten times the outside diameter of the pipe or tube, but in no case less than 30 cm (12 in.).

10. Conditioning

10.1 All specimens must be conditioned for a minimum of one hour in an external air environment of 23 ± 3°C (73 ± 5°F) prior to exposure to the test fluid.

[Note: Unless the specimen undergoes a change of temperature (e.g., fusion or flaring), the conditioning may be satisfied by the length of time the specimen has been stored at room temperature conditions.]

10.2 When conducting the pressure test, maintain the ambient temperature around the specimen to 23 ± 3°C (73 ± 5°F).

11. Test Procedure

11.1 Condition the specimen as specified in Section 10.

11.2 Assemble end closures or port plugs to the specimen, if needed. Completely fill the specimen with test fluid.

11.3 Attach one of the specimens to the pressure supply port on the test stand, making certain no air is entrapped in the fluid system. Bleeding of the system may be required.

11.4 The time-to-failure for all component types shall be between 50 and 80 seconds. Time is started when ramp pressure starts to increase. For a given component, the pressure rise rate (profile) should be the same for each test run.

11.5 Record the pressure trace and time-to-failure using a strip chart recorder or similar instrument.

[2] Because six percent is above the five percent deviation specified, three additional samples would need to be tested.

11.6 If failure time is not between 50 to 80 seconds, adjust the pressure rise rate and repeat the test with an additional sample.

11.7 Repeat testing for remaining samples as noted in 11.2–11.6.

12. Data Analysis

12.1 *Failure Definitions*

12.1.1 Instantaneous or rapid loss of pressure that interrupts the continuous and uniform pressure increase shall constitute a failure.

12.1.2 External leakage of fluid through the specimen, whether a catastrophic or a slow leak, shall constitute a failure.

12.1.3 When testing components, leakage at the end closures shall not be considered a failure. The test item shall be considered invalid.

12.2 *Calculations*

12.2.1 Pipe or tubing burst pressures can be approximated by the following equation:

$$P = 2S\frac{t}{(D - t)}$$

where:

P = Internal pressure, psi (kPa)
S = Hoop stress, psi (kPa)
D = Average outside diameter, cm (in.)
t = Minimum wall thickness, cm (in.)

12.2.2 Intricate geometries of other component types prohibit the use of the above equation.

13. Data Presentation

13.1 The test data report shall include the following information:

13.1.1 *Date Tested*.

13.1.2 *Test Objective*.

13.1.3 *Test Results*.

13.1.4 *Description of Items Tested*, including material type, material manufacturer, lot number, date manufactured, product part number or model number, and component size.

13.1.5 *Test Conclusions*.

13.1.6 *Deviations*, to the test standard or specimens tested, with appropriate detail.

14. Precision and Bias

14.1 The precision of the procedure in SEMASPEC #92010948B–STD for determining the hydraulic burst pressure of UPW distribution system components is being determined.

14.2 Bias of the procedure in SEMASPEC #92010948B–STD for determining the hydraulic burst pressure of UPW distribution system components is being determined.

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