SEMATECH Provisional Test Method for Pressure Cycle Testing Filter Cartridges Used in UPW Distribution Systems

SEMATECH
Technology Transfer 92010941B-STD

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Abstract: This test method provides a standardized method for determining the pressure cycle fatigue characteristics of cartridge filters. It can be used to verify mechanical pressure resistance of filter cartridges, to confirm that a filter cartridge can withstand exceptional conditions of use, and to comparatively qualtify the loss of mechanical strength due to exposure to exceptional conditions. 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, Filters, Fatigue Tests, Pressure Measurement

Authors: Jeff Riddle

Approvals: Jeff Riddle, Project Manager
Venu Menon, Program Manager
Jackie Marsh, Director of Standards Program
Gene Feit, Director, Contamination Free Manufacturing
John Pankratz, Director, Technology Transfer
Debra Elley, Technical Information Transfer Team Leader

SEMASPEC #92010941B–STD

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1. Introduction

1.1 *Purpose*—The purpose of this document is to provide a uniform test method for determining the pressure cycle fatigue characteristics of a cartridge filter.

1.2 *Scope*

1.2.1 This method may be used to verify mechanical pressure resistance of filter cartridges for ultrapure water (UPW) distribution systems.

1.2.2 This test may also be used to confirm that a filter cartridge can withstand exceptional conditions of use, without loss of mechanical strength, by testing a filter after exposure to those conditions.

1.2.3 This test may be used to comparatively quantify the loss of mechanical strength due to exposure to exceptional conditions by comparing the results on test specimens that have and have not been exposed to the exceptional conditions.

2. Referenced Documents

2.1	ASTM D5127	Standard Guide for Electronic Grade Water[1]
2.2	ANSI Standards[2]	
	ANSI B93.24M	Method for Verifying the Flow Fatigue Characteristics of a Hydraulic Fluid Power Filter Element
	ANSI B93.2	Fluid Power Systems and Products—Glossary
2.3	SEMASPEC #92010943B–STD	SEMATECH Provisional Test Method for Pressure Leak Testing Filter Cartridges Used in UPW Distribution Systems[3]
2.4	NFPA Paper	NFPA Proceedings 1992 "Measuring and Surviving Pressure Spikes in Hydraulic Systems," Ref. I92-4.4

3. Terminology

3.1 Filter terms are defined in accordance with ANSI B93.2.

3.2 *AC fine test dust*[4]—a graded, naturally occurring dust frequently used as a polydisperse test aerosol. It is composed of 68% SiO_2, 16% Al_2O_3, and 4.6% Fe_2O_3. Of the total

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

[2] American National Standards Institute. 1430 Broadway. New York, NY 10018.

[3] SEMATECH. 2706 Montopolis Dr. Austin, TX 78741.

mixture, 73% are particles less than 20 µm in size. Additionally, 39% of these particles (size < 20 µm) are composed of particles < 5 µm.

3.3 *ultrapure water (UPW)*—type E-1 electronic grade water as defined in ASTM D5127.

4. Summary of Test Method

Ambient water is recirculated through the test filter (see Figure 1, Test System Schematic). AC fine test dust is used to load the test filters until they reach the desired pressure. A bypass line before the test housing enables cyclical release of the test pressure through an actuated valve. The integrity of each filter is tested before and after loading and cycling according to SEMASPEC #92010943B–STD.

5. Significance and Use

UPW filter cartridges are commonly used in high pressure systems where significant pressure cycling is often encountered. Cyclical pressure loading may fatigue the polymeric components of the filter and cause rupture of the separative layer. Such failure may release the particles the filter was intended to capture.

6. Apparatus

6.1 *Test Stand*. Assemble the test stand per the schematic in Figure 1. Use piping or tubing with sufficient internal diameter so that test system pressure loss does not exceed 1% of the maximum rated pressure of the tested filters. For this test system, stainless steel plumbing and components that resist the long term effects of particulate abrasion and severe cyclical stress should be considered. The pump and system must be sized to provide at least 1.5 times the maximum rated flow and pressure for the filter being tested.

6.2 *Pump Output Controller*, capable of regulating pressure and flow independently.

6.3 *Precision Electronic Pressure Transducer*.

6.4 *Test Accuracy Pressure Gauge*, with snubber.

6.5 *Fast Actuated Cycling Valve*. The valve bore should match the system piping. The cycling valve and related downstream plumbing should be positioned to minimize flow resistance back to the fluid reservoir.

6.6 *Cycle Controller and Counter*.

6.7 *Mixer*.

6.8 *Circulation Pump*, of non-pulsating rotary type.

6.9 *Filter Test Housing*. In-line configuration is recommended.

6.10 *Thermometer*.

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[4] Distributed by AC Rochester Division, General Motors Corporation, Flint, MI.

7. Materials

7.1 *AC Fine Test Dust*. Other test particulate may be used, but it must not add to the filter's ability to absorb or survive the stress of the test.

7.2 *Test Fluid,* filtered (0.2 µm) 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 determine the applicability of regulatory limitations before using this method.

8.1.2 **Warning**: This method may subject test specimens to the maximum performance rating of the products under evaluation. Adequate precautions must be taken to prevent injury to the person conducting the test.

8.2 *Technical Precautions*

8.2.1 Gas entrapped in the test system will moderate the impact of the pressure wave. It is important to provide vents at points in the system where gas is consistently collected. Gas pockets may be evident in pressure traces as small "echoes" of the major pressure curve.

8.2.2 Different filter types have widely varying loading curves; therefore, it is not possible to specify the loading rate. However, it is important to load the filter at a moderate rate to ensure that the particle loading is consistent and continuous over the entire surface of the tested filter. High concentration local loading may cause atypical stress concentration.

8.3 *Interferences*

8.3.1 Failure of the polymeric components is often due to flexing in response to the pressure fluctuation. The number of cycles to failure is dependent on both the amplitude of the pressure cycle and the frequency. Amplitude can be controlled with regulators or pump speed. Frequency is affected primarily by the speed of valve actuation and also by the flow resistance and stress absorption characteristics of the test system. This pressure frequency may not be sensed adequately by mechanical pressure gauges. Therefore, pressure monitoring should be based on quick response pressure transducers. To accurately document the pressure curve, it may be necessary to use an oscilloscope or electronic data collection device. Without reliable documentation of the actual pressure stress wave, it may not be possible to determine the presence or cause of test system bias.

8.3.2 The tensile, creep, and flex resistance of the polymeric materials used in UPW filters may be greatly affected by the system temperature. Test system temperature must be monitored and, if necessary, controlled.

8.3.3 Different pump types may affect the test results. Positive displacement pumps may produce transient pressure waves not detectable by mechanical gauges or pressure transducers with extensive signal conditioning.

9. Sampling and Test Specimens

9.1 *Sample Conditioning*—Test results may vary with component condition or temperature. Allow all components to reach equilibrium at the specified test temperature before testing (see Section 11).

10. Preparation of Apparatus

10.1 See Figure 1 for a schematic of the Ambient Pressure Cycle Test Setup.

10.2 Fill the test system with filtered (0.2 µm) water.

10.3 Activate the controller, timer, and program with the appropriate on/off cycle.

10.4 Verify the integrity of the test filter according to SEMASPEC #92010943B–STD.

11. Conditioning

Ambient test temperature is 23 ± 3°C (74 ± 5°F).

12. Procedure

12.1 Install the test filter in the test housing and start the flow by turning on the pump.

12.2 Measure the water temperature with a thermometer and record the value.

12.3 Adjust the clean flow through the tested filter so the differential pressure across the filter is equal to 20% of the filter's maximum rated pressure.

12.4 Turn on the mixer and slowly add AC fine test dust to the reservoir. Start the stop watch and monitor the filter differential pressure. Continue to add AC fine dust until the filter differential pressure equals the maximum rated pressure of the tested filter. Time taken to load should exceed five minutes.

12.4.1 The filter may be cycle tested at a pressure lower than the maximum rated pressure as specified by the filter manufacturer.

12.4.2 The flow rate through the filter should remain as constant as the test system allows. Positive displacement pumps or electronic pump motor controllers will maintain relatively constant flow even as the flow resistance of the filter increases due to loading.

12.5 Record the time required to load each device.

12.6 Turn off the mixer. Drain and rinse the reservoir and refill with filtered (0.2 µm) water.

12.7 Remove the filter from the housing and integrity test the loaded filter according to SEMASPEC #92010943B–STD. Record the results.

12.8 Reinstall the loaded filter in the test housing and start the pump. Activate the cycle controller and counter to start the pressure cycling.

12.9 Measure the water temperature with a thermometer and record the value.

12.10 Adjust the pump speed to achieve a pressure cycle from zero to the filter's maximum rated pressure (accuracy of the adjustment should equal ± 2% of the maximum pressure.)

12.10.1 Begin counting and timing the cycles when the desired pressure cycle is reached. The duration of the on/off cycles programmed or set with the cycle controller should produce a minimum of three seconds at stable high and low pressures.

12.10.2 Differences in the pressure response of different filters and test systems makes further specification of the pressure change intervals impractical. Pressure rise times are dependent on the degree to which the filter is loaded and the compressibility of the loaded filter. It is more feasible to produce a pressure cycle with an abrupt drop in pressure. This portion of the pressure cycle curve should be as steep as possible.

12.10.3 Obtain a typical pressure/time response curve for at least six cycles. It is recommended that the pressure sensing system operate and record pressures with a speed of response in milliseconds to detect and record pressure transients.

12.11 Stop the cycle testing at regular cycle count intervals and test the device for integrity using SEMASPEC #92010943B–STD.

12.12 When filter failure, which is indicated by bubble streams, is found during the integrity test, carefully note any observations about the nature and location of the bubbling. Specify the leak location precisely. Provide a sketch of the filter if necessary.

13. Data Analysis

13.1 Record the integrity test results before and after loading and cycle testing.

13.2 Record the water temperature and time required to load each device to the desired pressure.

13.3 Record the water temperature and the high pressure of the cycle for each device.

13.4 Record the number of cycles for each device. The filters should retain assembly integrity for a number of cycles consistent with the filter manufacturer's claims.

14. Data Presentation

Prepare a final report that contains the following:

14.1 *Date of Test*.

14.2 *Test Objective*.

14.3 *Test Parameters*, such as required number of cycles, test duration, temperature, and pressure.

14.4 *Test Results*, such as an example of the pressure profile.

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

14.6 *Test Conclusions*.

15. Precision and Bias

15.1 The precision of the procedure in SEMASPEC #92010941B–STD for measuring mechanical pressure resistance of filter cartridges for UPW distribution systems is being determined.

15.2 Bias of the procedure in SEMASPEC #92010941B–STD for measuring mechanical pressure resistance of filter cartridges for UPW distribution systems is being determined.

16. Illustrations

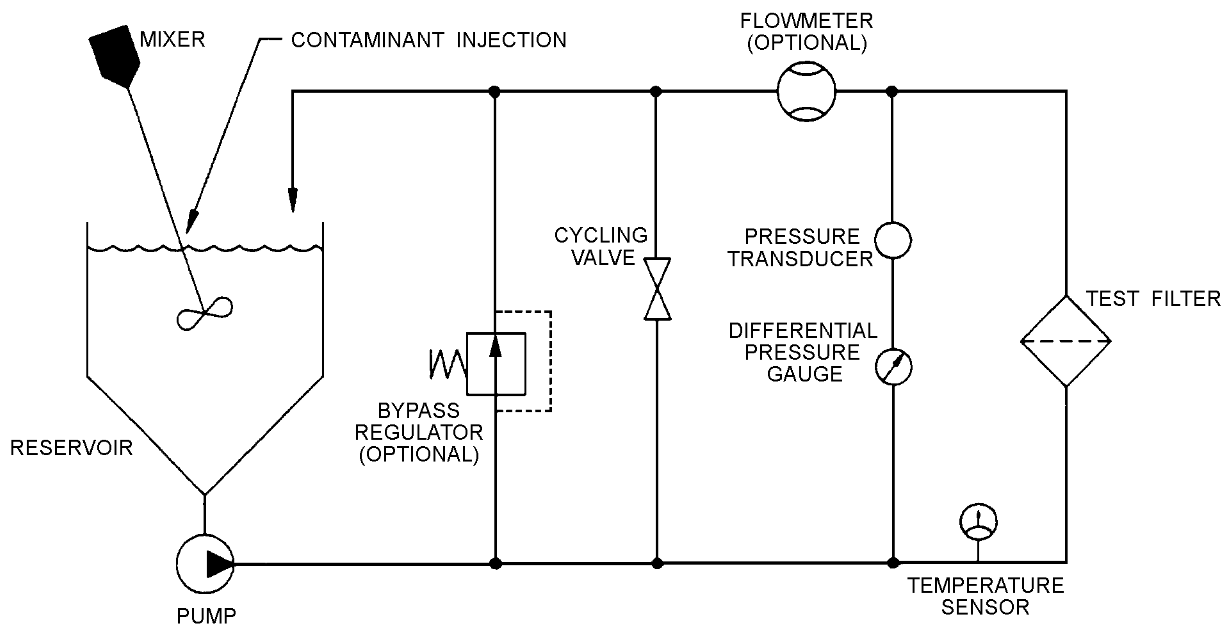

Figure 1 Ambient Pressure Cycle Test Schematic

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SEMATECH Technology Transfer
2706 Montopolis Drive
Austin, TX 78741

http://www.sematech.org