SEMATECH Provisional Test Method for Determining the Flow Coefficient of Filter Cartridges Used in UPW Distribution Systems

SEMATECH
Technology Transfer 92010942B-STD

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Abstract: This test method can be used to verify that a filter cartridge will produce the rated forward flow at the specified applied pressure or the rated pressure loss at a specified flow rate. It applies to filter cartridges used in UPW distribution systems. 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, Flow Rates, Filters, Pressure Measurement

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1. Introduction

1.1 *Purpose*—The purpose of this document is to provide a uniform test method for the verification of forward flow ratings for cartridge filters used in ultrapure water (UPW) distribution systems.

1.2 *Scope*—This procedure applies to filter cartridges used in ultrapure water distribution systems.

2. Referenced Documents

2.1 ASTM D5127 Standard Guide for Electronic Grade Water[1]

2.2 ANSI Standards[2]

ANSI B93.80M Hydraulic Fluid Power–Filters–Evaluation of Pressure Drop Versus Flow Characteristics (technically identical to ISO 3968[3])

ANSI B93.2 Fluid Power Systems and Products–Glossary

3. Terminology

3.1 *Acronyms and Abbreviations*

3.1.1 *lpm*—liters per minute

3.1.2 *psid*—pounds per square inch differential

3.2 *Definitions*

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

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

4. Summary of Method

Differential pressure is recorded for a minimum of five flow rates.

5. Significance and Use

The accurate characterization of filter pressure drops are necessary for successful filtration system design because the pump and plumbing system sizing may be affected. The performance of single 10-in. or smaller filter units may be reliably scaled-up to characterize multiunit systems.

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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] International Organization for Standardization. Geneva, Switzerland.

6. Apparatus

6.1 *Recirculating Test Stand*. The stand should have a flow meter of appropriate range for the test device. The test set-up must have the ability to vary flow rate.

6.2 *Pressure Gauge*. A differential gauge appropriate for expected pressure range of the device is recommended.

6.3 *Pressure Measurement Ports*. The ports are to be positioned at a distance equal to five pipe diameters upstream and ten diameters downstream of the tested filter to minimize turbulence and venturi effects.

7. Materials

7.1 *Test Fluid*, ultrapure water, type E-1 electronic grade, as defined in ASTM D5127.

7.2 *Filtered Test Liquid*. The test liquid must be filtered to a rating at least equivalent to the tested filter.

8. Precautions

8.1 *Safety Precautions*—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.

8.2 *Technical Precautions*

8.2.1 The cleanliness of the liquid is essential or the filter cartridge being tested could "plug."

8.2.2 The test filter must be thoroughly wetted with the test fluid using manufacturer's recommended methods.

8.2.3 The pressure drop across the empty test housing should be negligible; otherwise, it must be subtracted from the pressure drop recorded during the test.

8.2.4 The test system may be designed to recirculate; however, temperature buildup may be seen in recirculating systems unless a heat exchanger is used to maintain constant test temperature.

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 12).

10. Calibration

[Note: Test assembly system pressure drops must be determined with no test filter in place before filter testing.]

10.1 Assemble empty test housing.

10.2 Start the flow and bleed trapped air from the housing.

10.3 Stop the flow for a few seconds, then restart. If bubbles are observed in the flowmeter, repeat step 10.2.

10.4 When using a differential gauge, bleed both lines to the gauge.

10.5 Record the pressure drop at a minimum of five different flow rates. Start with the highest rate, drop to the lowest flow rate, and then sequentially increase the flow rates back to the highest flow rate.

10.6 Record the test liquid temperature.

11. Preparation of Apparatus

See Figure 1 for a schematic of a typical test setup.

12. Conditioning

Ambient temperature is 23 ± 3°C (73 ± 5°F).

13. Procedure [Note: A control filter may be tested first.]

13.1 Install the test filter.

13.2 Start the flow and bleed the trapped air from the housing. Stop the flow for a few seconds and then restart. If bubbles are observed in the flowmeter, stop the flow and start again.

Caution: Do not start gathering test data until the filter is fully wet.

13.3 Record the filter differential pressure (delta P) at a minimum of five flow rates. Start with the highest test flow rate, drop to the lowest flow rate, then sequentially increase to the highest flow rate. The highest flow should produce a differential pressure 20–30% of the filter's maximum rated pressure.

13.4 Record the test liquid temperature.

14. Data Analysis

14.1 *Calculations*

14.1.1 Record test data in the form provided (see Section 15.2). The form provides information for the calculations involved.

14.1.2 Subtract the system pressure drop from the test pressure drop at each flow rate.

14.1.3 Solve for the flow rate per unit of pressure drop at the test temperature for each flow rate setting:

Q per psid at test temperature = lpm/pressure drop

where:

Q = flow rate
psid = pounds per square inch differential
lpm = liters per minute

14.1.4 Normalize Q to a viscosity of 1 cp (centipoise), the viscosity of water at 20°C, as follows:

Q per psid at 1 cp = (lpm/psid @ test temp.) · (water viscosity @ test temp./1.002 cp)

For example, if the measured flow at 10 psid was 30 lpm, and the measured test liquid temperature was 26°C, then the viscosity of water (per Table 1) would be 0.8705, and

Q per psid @ 1 cp = 30 lpm/10psid (.8705/1.002) = 2.606 lpm/psid.

If the viscosity of water at test temperature is lower than one, the normalized flow rate (Q at 1 cp) will be smaller than the measured Q. If the viscosity of water is higher than one, the normalized flow rate will be larger than the measured Q.

14.1.5 Average the normalized Qs resulting from the various flow rates for each filter.

15. Data Presentation

15.1 Plot test data as follows:

X axis: lpm
Y axis: psid at 1 cp

Y = X/(Q per psid at 1 cp)

15.2 Sample Data Sheet

Test: Liquid Flow Rates, Flow Meter Method

Project _____ Page _____ of _____

Date _____ Log Book _____ Technician _____

Test Equipment _____

Test Liquid _____

P1 = Upstream pressure P2 = Downstream pressure psid = P1 - P2 - Blank

Q/psid = lpm/psid (@ test temp) psid @ 1 cp = lpm/(Q per psid @ 1 cp)

Q/psid @ 1 cp, 20°C = (lpm/psid)·(test liquid visc @ test/water visc @ 20°C)

To plot: X: lpm Y: psid @ 1 cp

Device	lpm	Blank psid	P1	P2	psid	Q/psid	Q/psid @1 cp	psid @ 1 cp
Fluid temp:_____ Viscosity: _____								

Average Q @ 1 cp, 20°C = ___ lpm/psid

Fluid temp:_____ Viscosity: _____								

Average Q @ 1 cp, 20°C = ___ lpm/psid

Fluid temp _____ Viscosity: _____								

Average Q @ 1 cp, 20°C = ___ lpm/psid

16. Precision and Bias

16.1 The precision of the procedure in SEMASPEC #92010942B–STD for measuring forward flow ratings for cartridge filters for UPW distribution systems is being determined.

16.2 Bias of the procedure in SEMASPEC #92010942B–STD for measuring forward flow ratings for cartridge filters for UPW distribution systems is being determined.

17. Illustrations

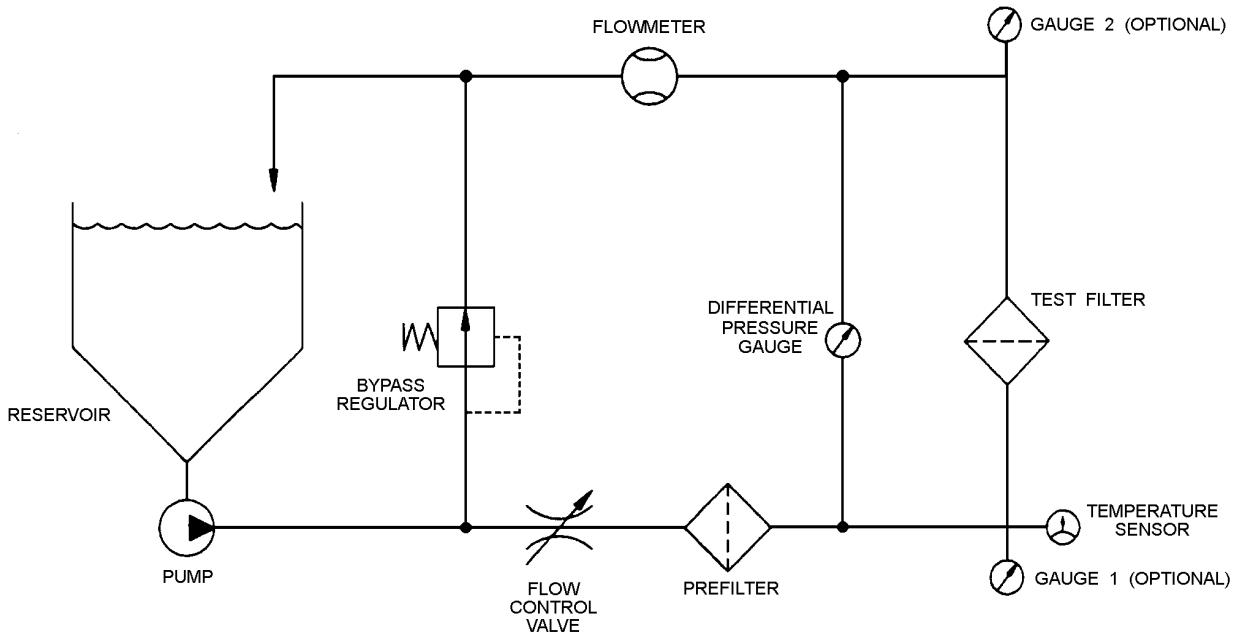

Figure 1 Typical Test Setup Schematic

Table 1 Water Viscosity at Various Temperatures

°C	cp	°C	cp
15	1.139	22	.9548
16	1.109	23	.9325
17	1.081	24	.9111
18	1.053	25	.8904
19	1.027	26	.8705
20	1.002	27	.8513
21	.9779	28	.8327

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