

**SEMATECH Guide to Test Methods  
for UPW Distribution System  
Components**

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# SEMATECH Guide to Test Methods for UPW Distribution System Components

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**Abstract:** Because of the great variety of components used in ultrapure water (UPW) distribution systems and their different designs, a variety of test procedures is necessary. This guide provides a brief overview of the applicable procedures for evaluating the performance characteristics of UPW distribution system components. The purpose for using these test methods is to enable improvements in manufacturing of UPW components, and to empower the user or purchaser of components to make better decisions regarding cost versus quality. Four categories of test method matrices are given (one for particles, two for chemical, one for mechanical, and two for surface tests). The type of components covered by the test procedures described include: tubing and piping; fittings; regulators; valves; filter housing and cartridges; o-rings, gaskets; and ion exchange resins. The matrices show the identification number of the test method suitable for use with a given component. Each applicable test method is then briefly summarized, describing the method's intended use. 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, Surface Tests, Mechanical Tests, Materials Testing

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## SEMASPEC #92010933B–STD

### SEMATECH Guide to Test Methods for UPW Distribution System Components

#### 1. Introduction

1.1 *Purpose*—This guide provides information about methods available for testing ultrapure water (UPW) distribution system components. Because of the great variety of components and their different designs, a variety of test procedures for UPW distribution system components is necessary.

The purpose for using these test methods is to enable improvements in manufacturing of UPW components and empower the user or purchaser of components to make better decisions regarding cost versus quality.

#### 1.2 *Scope*

1.2.1 This guide provides a brief overview of applicable methods for evaluating the performance characteristics of ultrapure water distribution system components. The methods listed are recommended for components intended for use in UPW distribution systems.

1.2.2 Four test method matrices are provided (one each) for particle, chemical, mechanical, and surface tests (see Sections 3.1, 4.1, 5.1, and 6.1). Types of components covered by the test procedures described include:

- Tubing and piping
- Fittings
- Regulators
- Valves
- Filter housings and cartridges
- O-rings and gaskets
- Ion exchange resins

1.2.3 In each matrix, the column heading lists individual test methods by name. The left-hand column lists the components that can be tested. The identification number of a test method in the matrix indicates that a particular test method is suitable for use with a given component.

#### 1.3 *Significance and Use*

The user should consider the result of testing samples when determining the sequence in which tests are performed. For example, if a test of four samples for resistivity results in one sample being unacceptable, then that sample should be rejected. These considerations will help to reduce unnecessary testing. Several samples may be required to run a full set of these tests. For the full set of tests, the following sequence is recommended:

- Chemical Extraction Tests (Section 4)
- Mechanical Tests (Section 5)
- Particles Tests (Section 3)
- Surface Tests (Section 6)
- Bulk Chemicals Tests (Section 4)

The sequence (left-to-right) presented in each matrix may be used as a guide for determining the order in which tests in these groups are performed. For further information, consult the test method under consideration.

#### 1.4 *Limitations*

1.4.1 This guide does not provide detailed information sufficient for conducting the procedures. It is the responsibility of the user to procure a copy of the detailed test procedure from the issuing organization.

1.4.2 Test methods referenced from standards organizations (e.g., ASTM, ISA, or ANSI) are under revision control by those organizations. SEMATECH does not warrant or endorse these documents. SEMATECH is not responsible for the application and use of the methods listed in this guide or for any liabilities incurred therein.

1.4.3 These tests can be used sequentially or individually. However, initial tests can invalidate the specimen and data resulting from following tests. Therefore, the sequence of tests should be carefully planned with the understanding that several specimens are required to complete the battery of all applicable component tests without invalidating later tests. This requirement of several specimens is in addition to the replicates normally required under good statistical practices.

[Note: Because some methods are destructive, contaminate, or decontaminate, a single component cannot provide valid results. For example, to perform a selected series of 26 test methods on a particular manufacturer's fitting and obtain valid data, several representative fittings are required. Eight fittings may give one data reading for each test. If the user wishes to have three readings per test, 24 fittings are required.]

## 2. **Acronyms**

2.1 *AFM*—atomic force microscope (microscopy)

2.2 *DSC*—differential scanning calorimeter (calorimetry)

2.3 *ESCA*—electron spectroscopy for chemical analysis

2.4 *FTIR*—Fourier transform infrared

2.5 *GFAAS*—graphite furnace atomic absorption spectrometer (spectrometry)

2.6 *IC*—ion chromatograph (chromatography)

2.7 *ICP–AES*—inductively coupled plasma atomic emission spectrometer (spectrometry)

2.8 *ICP–MS*—inductively coupled plasma–mass spectrometer (spectrometry)

2.9 *OPC*—optical particle counter

2.10 *SEM*—scanning electron microscope (microscopy)

2.11 *STM*—scanning tunneling microscope (microscopy)

2.12 *TGA*—thermal gravimetric analysis

2.13 *TOC*—total oxidizable carbon

2.14 *UPW*—ultrapure water

2.15 XPS—X-ray photoelectron spectroscopy

### 3. Particle Test Methods

The matrix of particle tests in Section 3.1 is a reference to available test methods used for evaluating components of and analyzing particles found in UPW systems. A description of the application of these methods is provided in Section 3.3.

#### 3.1 Particle Test Methods Matrix

<i>Components</i>	<b>Contribution and Retention</b>	<b>OPC Qualification</b>	<b>Particle Characterization (SEM)</b>
<b>Tubing and Piping Fittings</b>	SEMASPEC 92010949B	SEMASPEC 92010949B, Appendix X2	SEMASPEC 92010949B, Appendix X3
<b>Pressure Regulators</b>	SEMASPEC 92010949B	SEMASPEC 92010949B, Appendix X2	SEMASPEC 92010949B, Appendix X3
<b>Valves</b>	SEMASPEC 92010949B	SEMASPEC 92010949B, Appendix X2	SEMASPEC 92010949B, Appendix X3
<b>Filters</b>	SEMASPEC 92010949B	SEMASPEC 92010949B, Appendix X2	SEMASPEC 92010949B, Appendix X3
<b>Filter Housings</b>	SEMASPEC 92010949B	SEMASPEC 92010949B, Appendix X2	SEMASPEC 92010949B, Appendix X3

#### 3.2 Referenced Documents (Particle)

3.2.1 JIS K 0554 Testing Methods for Concentration of Fine Particles in Highly Purified Water<sup>1</sup>

3.2.2 SEMATECH<sup>2</sup>

92010949B–STD SEMATECH Provisional Test Method for Determination of Particle Contribution and Retention by UPW Distribution System Components

#### 3.3 Applicability of Particle Test Methods

3.3.1 JIS K 0554 Testing Methods for Concentration of Fine Particles in Highly Purified Water

<sup>1</sup> Available from the Japanese Standards Association, 4-1-24, Akasaka, Minato-Ku, Tokyo 107.

<sup>2</sup> Available from SEMATECH, 2706 Montopolis Dr., Austin, TX 78741

This document contains methods intended to determine the concentration of fine particles in highly purified water. Classifications of methods contained within the document include optical microscopy, scanning electron microscopy, and use of a fine particle measuring instrument.

3.3.2 SEMASPEC #92010949B-STD, SEMATECH Provisional Test Method for Determination of Particle Contribution and Retention by UPW Distribution System Components

This document contains test methods intended to draw statistically significant particle retention and shedding comparisons between UPW components tested under representative conditions. It applies to piping and fittings, valves, pressure regulators, filters, and filter housings.

The document contains two appendices that describe methods for characterizing and qualifying components in ultrapure water systems, a laser-based real time particle counting method and an SEM method for characterizing particles shed from a component.

**4. Chemical Test Methods**

The matrix for chemical tests in Section 4.1 is divided into two sections: Component Extraction Testing and Component Bulk Materials Testing. The different components used in UPW systems and the relevant test methods used to analyze the components are provided in this matrix. A description of the applicability of these methods is provided in Section 4.3.

The test methods for component extraction are used to analyze UPW for contaminants contributed by the components.

The test methods for component bulk materials are used to analyze the polymers used in the components to determine polymer type and purity.

4.1 *Chemical Test Methods Matrix*

## 4.1.1 Chemical Extraction Test Methods Matrix

<i>Components</i>	<b>Resistivity</b>	<b>Leachable Inorganics</b>	<b>TOC (Organic/ Inorganic)</b>	<b>Leachable Anions</b>	<b>Silica in Water<sup>3</sup></b>	<b>Non-Volatile Residue</b>
<b>Tubing and Piping Fittings</b>	SEMASPEC 92010935B	SEMASPEC 92010936B	ASTM D4779	ASTM D4327	ASTM D859	ASTM D1353
<b>Regulators</b>	SEMASPEC 92010935B	SEMASPEC 92010936B	ASTM D4779	ASTM D4327	ASTM D859	ASTM D1353
<b>Valves</b>	SEMASPEC 92010935B	SEMASPEC 92010936B	ASTM D4779	ASTM D4327	ASTM D859	ASTM D1353
<b>Filter Housings</b>	SEMASPEC 92010935B	SEMASPEC 92010936B	ASTM D4779	ASTM D4327	ASTM D859	ASTM D1353
<b>Filter Cartridges</b>	SEMASPEC 92010935B	SEMASPEC 92010936B	ASTM D4779	ASTM D4327	ASTM D859	ASTM D1353
<b>O-Rings</b>	SEMASPEC 92010935B	SEMASPEC 92010936B	ASTM D4779	ASTM D4327	ASTM D859	ASTM D1353
<b>Gaskets</b>	SEMASPEC 92010935B	SEMASPEC 92010936B	ASTM D4779	ASTM D4327	ASTM D859	ASTM D1353
<b>Ion Exchange Resins</b>		SEMASPEC 92010936B	ASTM D4779	ASTM D4327	ASTM D859	ASTM D1353

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<sup>3</sup> ASTM D859 is for reactive silica. Also see ASTM D4517 for total silica determination.

## 4.1.2 Chemical Bulk Material Test Methods Matrix

<i>Components</i>	<b>Bulk Inorganics</b>	<b>DSC and TGA</b>	<b>FTIR</b>	<b>Water Retention of Ion Exchange Resins</b>	<b>Permeability</b>
<b>Tubing and Piping Fittings</b>	SEMASPEC 92010938B	SEMASPEC 92010939B	SEMASPEC 92010937B		ASTM F1249
<b>Regulators</b>	SEMASPEC 92010938B	SEMASPEC 92010939B	SEMASPEC 92010937B		ASTM F1249
<b>Valves</b>	SEMASPEC 92010938B	SEMASPEC 92010939B	SEMASPEC 92010937B		ASTM F1249
<b>Filter Housings</b>	SEMASPEC 92010938B	SEMASPEC 92010939B	SEMASPEC 92010937B		ASTM F1249
<b>Filter Cartridges</b>	SEMASPEC 92010938B	SEMASPEC 92010939B	SEMASPEC 92010937B		ASTM F1249
<b>O-Rings</b>	SEMASPEC 92010938B	SEMASPEC 92010939B	SEMASPEC 92010937B		ASTM F1249
<b>Gaskets</b>	SEMASPEC 92010938B	SEMASPEC 92010939B	SEMASPEC 92010937B		ASTM F1249
<b>Ion Exchange Resins</b>	SEMASPEC 92010938B			SEMASPEC 92010940B	

4.2 *Referenced Documents (Chemical)*4.2.1 ASTM<sup>4</sup>

D859	Standard Test Method for Silica in Water
D1353	Standard Test Method for Nonvolatile Matter in Volatile Solvents for Use in Paint, Varnish, Lacquer, and Related Products
D2187	Standard Test Methods for Physical and Chemical Properties of Particulate Ion-Exchange Resins
D4327	Standard Test Method for Anions in Water by Ion Chromatography
D4517	Standard Test Method for Low-Level Total Silica in High-Purity Water by Flameless Atomic Absorption Spectroscopy
D4779	Standard Test Method for Organic and Inorganic Carbon in High Purity Water by Ultraviolet (UV), or Persulfate Oxidation, or Both, and Infrared Detection

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<sup>4</sup> Available from ASTM, 1916 Race St., Philadelphia, PA 19103

F1249 Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor

#### 4.2.2 SEMATECH

92010934B–STD SEMATECH Provisional Test Method for Sample Preparation for Chemical Testing of UPW Distribution System Components

92010937B–STD SEMATECH Provisional Test Method for the Evaluation of Bulk Polymer Samples of UPW Distribution System Components (FTIR)

92010938B–STD SEMATECH Provisional Test Method for the Determining Bulk Trace Metals in Polymer Samples for UPW Distribution System Components

92010936B–STD SEMATECH Provisional Test Method for Determining Leachable Trace Organics from UPW Distribution System Components

92010935B–STD SEMATECH Provisional Test Method for Electrical Resistivity of UPW

92010939B–STD SEMATECH Provisional Test Method for Evaluating Bulk Polymer Samples of UPW Distribution System Components (Differential Scanning Calorimetry and Thermal Gravimetric Analysis)

92010940B–STD SEMATECH Provisional Test Method for Determining the Water Retention Capacity of Ion-Exchange Resins Used in UPW Distribution Systems

### 4.3 *Applicability of Chemical Test Methods*

#### 4.3.1 Sample Preparation Method

##### 4.3.1.1 SEMASPEC #92010934B–STD, SEMATECH Provisional Test Method for Sample Preparation for Chemical Testing of UPW Distribution System Components

This document defines and specifies the sample pretreatment and preparation procedures for UPW distribution system components for purposes of chemical analysis. This method should be used with SEMASPECs #92010937B–STD, #92010938B–STD, #9201039B–STD, #92010936B–STD, #92010935B–STD, and #92010940B–STD.

#### 4.3.2 Extraction Tests

##### 4.3.2.1 SEMASPEC #92010935B–STD, SEMATECH Provisional Test Method for Electrical Resistivity of UPW

This method contains a procedure for determining the electrical resistivity of ultrapure water. It can be used to detect ionized impurities dissolved in treated waters prepared for electronics manufacturing facilities.

The method is intended for UPW components, including tubing, piping, fittings, valves, regulators, filter housings and cartridges, O–rings, and gaskets. Sample preparation for this method is provided in SEMASPEC #92010934B–STD.

#### 4.3.2.2 SEMASPEC #92010936B–STD, SEMATECH Provisional Test Method for Determining Leachable Trace Inorganics from UPW Distribution System Components

This method provides a procedure for the determination of trace inorganic impurities that leach from a distribution system into ultrapure water. Samples are analyzed for trace metals by ICP–AES, ICP–MS, and GFAAS; for cations and anions by IC; and for silica by colorimetry and flameless atomic absorption spectroscopy. This method applies to tubing, piping, fittings, valves, regulators, filter housings and cartridges, O-rings, gaskets, and ion-exchange resins. Sample preparation for this method is provided in SEMASPEC #92010934B–STD.

#### 4.3.2.3 ASTM D4779, Standard Test Method for Organic and Inorganic Carbon in High Purity Water by Ultraviolet (UV), or Persulfate Oxidation, or Both, and Infrared Detection

This method covers the determination of total carbon, organic carbon, and inorganic carbon in makeup water and in high purity process water, including demineralizer effluent, condensate, and electronic grade rinse water. The tested concentration range is from 50 to 1000 µg of carbon per liter.

This method is recommended for UPW distribution system components with the following adaptations:

The concentration range to be tested is 10 to 1000 µg of carbon per liter.

In *Reagents and Materials*, the purity of water should be UPW, as defined in the "Standard Test Method for Sample Preparation for Chemical Testing of UPW Distribution System Components," Section 6.1.

#### 4.3.2.4 ASTM D4327, Standard Test Method for Anions in Water by Ion Chromatography

This test method covers the sequential determination of fluoride, chloride, nitrite, phosphate, bromide, nitrate, and sulfate ions in water by ion chromatography. The method applies to drinking, ground, and surface waters, boiling and cooling waters, domestic and industrial wastes, and atmospheric precipitation samples. Typical concentrations determined by this method are from 0.1 mg/l to 0.2 mg/l, depending on the anions of interest.

This method is recommended for UPW distribution systems with the following adaptations:

The scope and application of the method includes ultrapure deionized water (UPDI) and component samples soaked in UPW.

For ppm level work, a filtered aliquot of sample is injected into an ion chromatograph. For ppb work, concentrator columns are used in place of injection loops. These columns use the same ion exchange resins used in IC separator columns. Large volumes of the sample (up to 50 ml) are pumped through the concentrator column, which quantitatively retains the ions of interest. The sample is carried by the eluent through the separator column and analyzed.

Parts per billion (ppb) values for detection limits are as follows:

<u>Anion</u>	<u>mg/l (ppb)</u>
fluoride	0.1
chloride	0.1
nitrite	0.2
phosphate	0.1
bromide	0.2
nitrate	0.2
sulfate	0.2

#### 4.3.2.5 ASTM D859, Standard Test Method for Silica in Water

This is a colorimetric method for photometric determination of molybdate-reactive silica in water and waste water. This method applies to concentrations in the 20 to 1000  $\mu\text{g/l}$  (ppb) range at 815 nm wavelength and in the 0.1 to 5 mg/l (ppm) range at 640 nm.

#### 4.3.2.6 ASTM D4517, Standard Test Method for Low-Level Total Silica in High-Purity Water by Flameless Atomic Absorption Spectroscopy

This method applies to silica concentrations between a range of 25–250  $\mu\text{g/l}$  as  $\text{SiO}_2$ . Concentrating the water sample will yield a lower detection level.

#### 4.3.2.7 ASTM D1353, Standard Test Method for Nonvolatile Matter in Volatile Solvents for Use in Paint, Varnish, Lacquer, and Related Products

This method is intended for the determination of the nonvolatile matter in volatile solvents. This method can also be used to determine nonvolatile residue in ultrapure water.

### 4.3.3 Bulk Material Tests

#### 4.3.3.1 SEMASPEC #92010937B–STD, SEMATECH Provisional Test Method for the Evaluating Bulk Polymer Samples of UPW Distribution System Components (FTIR)

This method uses Fourier transform infrared spectroscopy to examine bulk polymer samples of UPW distribution system components. It is intended to qualitatively verify the chemical structure of a polymer resin by comparing the sample's mid-infrared spectrum with that of a reference standard. Sample preparation for this method is provided in SEMASPEC #92010934B–STD.

#### 4.3.3.2 SEMASPEC #92010938B–STD, SEMATECH Provisional Test Method for Determining Bulk Trace Metals in Polymer Samples of UPW Distribution System Components

This method contains a procedure for determining the nonvolatile trace inorganic impurities in bulk polymeric material used for components of UPW distribution systems. The method applies to tubing, piping, fittings, valves, regulators, filter housing and cartridges, O-rings, gaskets, and ion-exchange resins. This method can be used with ICP-MS (recommended), GFAAS, or ICP–AES. Sample preparation for this method is provided in SEMASPEC #92010934B–STD.

4.3.3.3 SEMASPEC #92010939B–STD, SEMATECH Provisional Test Method for Evaluating Bulk Polymer Samples of UPW Distribution System Components (Differential Scanning Calorimetry and Thermal Gravimetric Analysis)

This method uses thermal analysis techniques to examine polymeric samples used in UPW distribution system components. Comparison of the sample to a reference standard provides indications of performance characteristics of the resin, including chemical inertness, thermal stability, durability, and physical properties of the polymer resin, including crystallinity, molecular weight, morphology, and extent of polymerization.

4.3.3.4 SEMASPEC #92010940B–STD, SEMATECH Provisional Test Method for Determining the Water Retention Capacity of Ion-Exchange Resins Used in UPW Distribution Systems

This is a method for determining the amount of water retained by hydrated ion-exchange resins. Procedures are provided for cation, anion, and mixed-bed resins. For accurate comparisons, this method cites ASTM D2187 for preconditioning of a new resin to known ionic forms.

4.3.3.5 ASTM D2187, Standard Test Methods for Physical and Chemical Properties of Particulate Ion-Exchange Resins

This document provides nine test methods that may be used for the determination of the physical and chemical properties of ion-exchange resins used for the treatment of water. It applies to new or used resins.

4.3.3.6 ASTM F1249, Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor

This method provides a procedure for determining the rate of water vapor transmission through flexible barrier materials. It applies to sheets and films up to three mm thick and consisting of single or multilayer synthetic or natural polymers and foils, including coated materials. It can be used to determine water vapor transmission rate, the permeability of film to water vapor, and, for homogeneous materials, water vapor permeability coefficient.

## 5. Mechanical Methods

The methods described in this section apply to leak rate procedures, flow-pressure coefficient procedures, proof pressure tests, compression set procedures for elastomeric components, and life cycle tests.

5.1 *Mechanical Test Methods Matrix*

<i>Components</i>	<b>Leak Test</b>	<b>Flow Coefficient</b>	<b>Proof Pressure Test</b>	<b>Compression Set Test</b>	<b>Life/ Cycle Test</b>
<b>Tubing and Piping</b>			SEMASPEC 92010948B		ASTM D2837
<b>Tube Fitting Connection</b>	SEMI 1971 SEMI 1974 SEMASPEC 92010947B		SEMI 1972B		
<b>Regulator</b>	ASTM E515	ISA S75-02	SEMASPEC 92010948B		
<b>Valves</b>	SEMASPEC 92010946B ASTM E515	ISA S75-02	SEMASPEC 92010948B		SEMASPEC 92010945B
<b>Filter Housings</b>	ASTM E515	ISA S75-02	SEMASPEC 92010948B		
<b>Filter Cartridges</b>	SEMASPEC 92010943B	SEMASPEC 92010942B	SEMASPEC 92010944B		SEMASPEC 92010941B
<b>O-Rings</b>				ASTM D1414	
<b>Gaskets</b>				ASTM D395	

5.2 *Referenced Documents (Mechanical)*

## 5.2.1 American Society for Testing and Materials (ASTM)

D395 Standard Test Methods for Rubber Property – Compression Set

D1414 Standard Test Methods for Rubber O-Rings

D2837 Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials

E515 Standard Test Method for Leak Testing Using Bubble Emission Techniques

## 5.2.2 SEMATECH

92010941B–STD SEMATECH Provisional Test Method for Pressure Cycle Testing of Filter Cartridges used in UPW Distribution Systems

92010942B–STD SEMATECH Provisional Test Method for Flow Coefficient Testing of Filter Cartridges Used in UPW Distribution Systems

92010943B–STD SEMATECH Provisional Test Method for Pressure Leak Testing Filter Cartridges Used in UPW Distribution Systems

92010944B–STD SEMATECH Provisional Test Method for Pressure Proof Testing Filter Cartridges Used In UPW Systems

- 92010945B–STD SEMATECH Provisional Test Method for Verifying the Pressure Ratings of Plastic Valves Used in UPW Distribution Systems
- 92010946B–STD SEMATECH Provisional Test Method for Determining the Seat Leakage of Control Valves Used in UPW Distribution Systems
- 92010947B–STD SEMATECH Provisional Test Method for Leak Testing Tube Fitting Connections Used in UPW Distribution Systems
- 92010948B–STD SEMATECH Provisional Test Method for Determining the Hydraulic Burst Pressure of Plastic Piping System Components

### 5.2.3 Semiconductor Equipment and Materials International (SEMI)<sup>5</sup>

- F8–92 Test Method for Evaluating the Sealing Capabilities of Tube Fitting Connections Made of Fluorocarbon Materials, When Subjected to Tensile Forces
- F9–92 Test Method to Determine the Leakage Characteristics of Tube Fitting Connections Made of Fluorocarbon Materials When Subjected to a Side Load Condition
- 1972B Test Method to Determine the Maximum Internal Pressure Required to Produce a Failure of a Tube Fitting Connection Made of Fluorocarbon Materials (Proposed)

### 5.2.4 Instrument Society of America (ISA)<sup>6</sup>

- S75-02 Control Valve Capacity Test Procedure

## 5.3 *Applicability of Mechanical Test Methods*

### 5.3.1 Leak Tests

#### 5.3.1.1 SEMI F8–92, Test Method for Evaluating the Sealing Capabilities of Tube Fitting Connections Made of Fluorocarbon Materials, When Subjected to Tensile Forces

This method is specific for leak test integrity while the connection is subjected to tensile load.

#### 5.3.1.2 SEMI F9–92, Test Method to Determine the Leakage Characteristics of Tube Fitting Connections Made of Fluorocarbon Materials When Subjected to a Side Load Condition

This method is specific for leak testing while the connection is subjected to a side load.

#### 5.3.1.3 SEMASPEC #92010947B–STD, SEMATECH Provisional Test Method for Leak Testing Tube Fitting Connections Used in UPW Distribution Systems

This is an immersion leak test method applicable to tube fitting connections with no externally applied load.

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<sup>5</sup> Available from SEMI, 805 East Middlefield Rd., Mountain View, CA 94043.

<sup>6</sup> Available from Instrument Society of America, 67 Alexander Dr., Research Triangle Park, NC 27709

- 5.3.1.4 ASTM E515, Standard Test Method for Leak Testing Using Bubble Emission Techniques  
This method uses the immersion technique and can be applied to regulators, valves (external leak only) and filter housings. The leak testing of filter cartridges and valve seat leakage are covered under separate procedures.
- 5.3.1.5 SEMASPEC #92010946B-STD, Provisional Test Method to Determine the Seat Leakage of Valves Used in UPW Distribution Systems (Bubble Leak Detection Method)  
This method applies only to valves and is a test for leakage across the valve seat. When the valve is pressurized with a gas, any leakage across the valve seat is detected as bubbles in the liquid.
- 5.3.1.6 SEMASPEC #92010943B-STD, SEMATECH Provisional Test Method for Pressure Leak Testing Filter Cartridges Used in UPW Distribution Systems  
This method can be used to verify the assembly integrity of filter cartridges. It is an immersion leak technique used to locate leaks in filter cartridge assemblies. This method is specific to filter cartridges due to air entrainment in the media support layers and to the porous nature of the filter membrane.
- 5.3.2 Flow Coefficient Tests
- 5.3.2.1 ISA S75-02, Control Valve Capacity Test Procedure  
This procedure can be used to determine the flow coefficient characteristics of valves, filter housings, and regulators to be used in UPW distribution systems.
- 5.3.2.2 SEMASPEC #92010942B-STD, SEMATECH Provisional Test Method for Flow Coefficient Testing of Filter Cartridges Used in UPW Distribution Systems  
This 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.
- 5.3.3 Proof Pressure Tests
- 5.3.3.1 SEMI #1972B, Test Method to Determine the Maximum Internal Pressure Required to Produce a Failure of a Tube Fitting Connection Made of Fluorocarbon Materials  
The application of this test method may be expanded to include other plastic materials. This test procedure should be used to determine the maximum internal pressure required to produce a failure in a tube fitting connection made of plastic materials. Only the seal between the tube and tube fitting being evaluated is within the scope of this method.
- 5.3.3.2 SEMASPEC #92010948B-STD, SEMATECH Provisional Test Method for Determining the Hydraulic Burst Pressure of UPW Distribution System Components  
This procedure gives a method for proof pressure testing UPW distribution system components including fittings, tubes, pipes, regulators, valves, and filter housings. It is not applicable to filter cartridges.

### 5.3.3.3 SEMASPEC #92010944B–STD, SEMATECH Provisional Test Method for Pressure Proof Testing Filter Cartridges Used In UPW Distribution Systems

This method is used to determine mechanical pressure resistance of filter cartridges. It is used to verify that filter cartridges will withstand their rated pressurization without integrity failure or permanent mechanical deformation.

### 5.3.4 *Compression Set Tests*

#### 5.3.4.1 ASTM D1414, Standard Test Methods for Rubber O-Rings

This method is intended to be used for compression set testing of O-rings with the following modifications:

For testing O-rings, the temperature of the testing room (ambient) shall be  $23 \pm 3^{\circ}\text{C}$  ( $73 \pm 5^{\circ}\text{F}$ ).

When testing O-rings with a hardness of Shore 90 A<sup>7</sup> or above, a compression ratio of no more than 10% should be used.

When testing O-rings, specific gravity and hardness should be tested and recorded before and after compression set testing.

Perform time and temperature testing as follows: 22 hours at 70°C and 70 hours at ambient temperature. This is in reference to ASTM D395, Method B, compression set under constant deflection in air.

#### 5.3.4.2 ASTM D395, Standard Test Methods for Rubber Property – Compression Set

This test is recommended for compression set testing of gaskets with the following modifications:

When testing gaskets for UPW distribution systems, specific gravity and hardness should be tested and recorded before and after compression set testing.

When performing time and temperature testing, 22 hours should be utilized at 70°C, and 70 hours should be utilized at ambient temperature. This in reference to D395, Method B, Compression Set Under Constant Deflection in Air.

### 5.3.5 Life Cycle Tests

#### 5.2.5.1 ASTM D2837, Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials

This test method describes a procedure for obtaining a hydrostatic design basis for thermoplastic pipe materials by evaluating stress rupture test data derived from testing pipe made from the subject material. This method is applicable to all known types of thermoplastic pipe and for any practical temperature and medium.

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<sup>7</sup> Shore A 90 hardness as measured using a Shore A Durometer.

### 5.3.5.2 SEMASPEC #92010941B–STD, SEMATECH Provisional Test Method for Pressure Cycle Testing of Filter Cartridges Used in UPW Distribution Systems

This method provides a standardized test method for determining the pressure cycle fatigue characteristics of cartridge filters. Due to the porous nature of the filter medium, this method can be used only on filter elements.

### 5.3.5.3 SEMASPEC #92010945B–STD, SEMATECH Provisional Test Method for Verifying the Pressure Ratings of Plastic Valves Used in UPW Distribution Systems

This method applies only to plastic valves and not to fittings, tubing, or piping products unless those products are an integral part of the valve being evaluated.

## 6. Surface Test Methods

The methods described in this section apply to evaluation of plastic components and ion exchange resin beads used in UPW distribution systems. Procedures include determination of surface roughness and condition, analysis of surface composition and chemical bonding, and optical analysis of ion exchange resin beads. A method is also included for determination of surface-associated biofilms on UPW system components.

### 6.1 *Surface Test Methods Matrix*

#### 6.1.1 Surface Roughness Test Methods Matrix

<i>Components</i>	<b>Surface Roughness (Visual)</b>	<b>Surface Roughness (AFM)</b>	<b>Surface Roughness (STM)</b>	<b>Surface Roughness (Noncontact Optical)</b>
<b>Tube/Pipe Fittings</b>	SEMASPEC 92010950B	SEMASPEC 92010952B	SEMASPEC 92010953B	SEMASPEC 92010954B
<b>Regulators Valves</b>	SEMASPEC 92010950B	SEMASPEC 92010952B	SEMASPEC 92010953B	SEMASPEC 92010954B
<b>Filter Housings</b>	SEMASPEC 92010950B	SEMASPEC 92010952B	SEMASPEC 92010953B	SEMASPEC 92010954B
<b>Filter Cage</b>	SEMASPEC 92010950B	SEMASPEC 92010952B	SEMASPEC 92010953B	SEMASPEC 92010954B
<b>O-Rings</b>	SEMASPEC 92010950B	SEMASPEC 92010952B	SEMASPEC 92010953B	SEMASPEC 92010954B
<b>Gaskets</b>	SEMASPEC 92010950B	SEMASPEC 92010952B	SEMASPEC 92010953B	SEMASPEC 92010954B

## 6.1.2 Surface Condition Methods Matrix

<i>Components</i>	<b>Surface Condition (Optical)</b>	<b>Surface Condition (SEM)</b>	<b>Surface Composition/ Chemical Bonding (ESCA)</b>	<b>Ion Exchange Resin Beads (Optical)</b>	<b>Surface-Associated Biofilms</b>
<b>Tube/Pipe Fittings</b>	SEMASPEC 92010951B	SEMASPEC 92010955B	SEMASPEC 92010956B		SEMASPEC 92010958B
<b>Regulators Valves</b>	SEMASPEC 92010951B	SEMASPEC 92010955B	SEMASPEC 92010956B		SEMASPEC 92010958B
<b>Filter Housings</b>	SEMASPEC 92010951B	SEMASPEC 92010955B	SEMASPEC 92010956B		SEMASPEC 92010958B
<b>Filter Cage</b>	SEMASPEC 92010951B	SEMASPEC 92010955B	SEMASPEC 92010956B		SEMASPEC 92010958B
<b>O-Rings</b>	SEMASPEC 92010951B	SEMASPEC 92010955B	SEMASPEC 92010956B		SEMASPEC 92010958B
<b>Gaskets</b>	SEMASPEC 92010951B	SEMASPEC 92010955B	SEMASPEC 92010956B		SEMASPEC 92010958B
<b>Ion-Exchange Resin Beads</b>				SEMASPEC 92010957B	

6.2 *Referenced Documents (Surface)*

## 6.2.1 American Society for Testing and Materials (ASTM)

D4449 Standard Test Method for Visual Evaluation of Gloss Differences Between Surfaces of Similar Appearances

## 6.2.2 SEMATECH

92010950B–STD SEMATECH Provisional Test Method for Visual Characterization of Surface Roughness for Plastic Surfaces of UPW Distribution System Components

92010951B–STD SEMATECH Provisional Test Method for Optical Analysis of Plastic Surface Condition of UPW Distribution System Components

92010952B–STD SEMATECH Provisional Test Method for Determination of Surface Roughness of UPW Distribution System Components (AFM Method)

92010953B–STD SEMATECH Provisional Test Method for Determination of Surface Roughness of UPW Distribution System Components (STM Method)

92010954B–STD SEMATECH Provisional Test Method for Determination of Surface Roughness of UPW Distribution System Components (Noncontact Optical Profiling Techniques)

- 92010955B–STD SEMATECH Provisional Test Method for Analysis of Plastic Surface Condition of UPW Distribution System Components (SEM Method)
- 92010956B–STD SEMATECH Provisional Test Method for Analysis of Plastic Surface Composition and Chemical Bonding of UPW Distribution System Components (ESCA Method)
- 92010957B–STD SEMATECH Provisional Test Method for Optical Analysis of Ion–Exchange Resin Beads Used in UPW Distribution Systems
- 92010958B–STD SEMATECH Provisional Test Method for Determination of Surface-Associated Biofilms of UPW Distribution Systems

### 6.3 *Applicability of Surface Test Methods*

- 6.3.1 SEMASPEC #92010950B–STD, SEMATECH Provisional Test Method for Visual Characterization of Surface Roughness for Plastic Surfaces of UPW Distribution System Components

This method provides a visual test to detect and define surface anomalies on plastic components used in UPW distribution systems. An appendix includes information on additional analytical techniques for fine resolution of surface defects and topography. The appendix is useful as a guide for selecting the appropriate technique(s) for analyzing various levels of surface topography or roughness.

- 6.3.2 ASTM D4449, Standard Test Method for Visual Evaluation of Gloss Differences Between Surfaces of Similar Appearances

This is a method for evaluating gloss differences of coating surfaces using special types of lamps for illumination. Six aspects or types of gloss are identified, and four levels of visual gloss differences are distinguished.

- 6.3.3 SEMASPEC #92010951B–STD, SEMATECH Provisional Test Method for Optical Analysis of Plastic Surface Condition of UPW Distribution System Components

This method may be used to test functional surfaces of plastic components for gross surface morphology (imperfections or defects). The method applies to pipes, fittings, and valves being considered for installation into UPW distribution systems.

The method employs an optical microscope to assess pits, tears, grooves, inclusions, and other surface anomalies.

- 6.3.4 SEMASPEC #92010952B–STD, SEMATECH Provisional Test Method for Determination of Surface Roughness of UPW Distribution System Components (AFM Method)

This method is used to obtain 3-dimensional topographical maps of surfaces of plastic components being considered for installation into a UPW distribution system. The method uses atomic force microscopy (AFM), a noncontact profilometry technique, to measure surface features in the nanometer-to-micrometer size range. This method applies to the characterization of plastic surfaces within a  $Z_{\max}$  of 5  $\mu\text{m}$  or less per scan.

Optical or scanning electron microscopy should be used to determine the field of view necessary to obtain representative surface roughness characteristics. (See SEMASPECs 92010950A–STD, 92010951B–STD, and 92010955B–STD.)

6.3.5 SEMASPEC #92010953B–STD, SEMATECH Provisional Test Method for Determination of Surface Roughness of UPW Distribution System Components (STM Method)

This method is used to obtain 3-dimensional topographical maps of surfaces of plastic components being considered for installation into a UPW distribution system. Scanning tunneling microscopy (STM), a noncontact profilometry technique, is used to measure surface feature in the nanometer-to-micrometer size range. This method applies to the characterization of plastic surfaces within a  $Z_{\max}$  of 5  $\mu\text{m}$  or less per scan.

Optical or scanning electron microscopy should be used to determine the field of view necessary to obtain representative surface roughness characteristics. (See SEMASPECs 92010950A–STD, 92010951B–STD, and 92010955B–STD.)

6.3.6 SEMASPEC #92010954B–STD, SEMATECH Provisional Test Method for Determination of Surface Roughness of UPW Distribution System Components (Noncontact Optical Profiling Techniques)

This method provides noncontact optical techniques for measuring surface roughness of plastic surfaces with an average roughness ( $R_a$ ) between 0.01  $\mu\text{m}$  and 1  $\mu\text{m}$ . This method applies to plastic components intended for installation into a UPW distribution system. This method is limited to surfaces that consist of uniform materials and that are free of films or other materials that may prevent accurate profiling.

6.3.7 SEMASPEC #92010955B–STD, SEMATECH Provisional Test Method for Analysis of Plastic Surface Condition of UPW Distribution System Components (SEM Method)

This method uses a scanning electron microscope to test functional surfaces of plastic components for surface morphology and for identification of inclusions on those surfaces. The method is designed for components such as pipes, tubes, fittings, and valves intended for installation in a UPW distribution system. This test may be used to evaluate imperfections or defects of 0.1  $\mu\text{m}$  or larger.

6.3.8 SEMASPEC #92010956B–STD, SEMATECH Provisional Test Method for Analysis of Plastic Surface Composition and Chemical Bonding of UPW Distribution System Components (ESCA Method)

This method uses ESCA to test surfaces of plastic and elastomer components of UPW distribution systems to determine surface compositions and chemical species (functional groups or bonding information). It measures the elemental composition within the ESCA detection depth of 5 to 10 nm. All elements except helium and hydrogen are detected if present in excess of one atomic percent (one atom in one hundred). This method may also be used to characterize bulk compositions by exposure immediately prior to analysis.

6.3.9 SEMASPEC #92010957B–STD, SEMATECH Provisional Test Method for Optical Analysis of Ion–Exchange Resin Beads Used in UPW Distribution Systems

This method uses an optical microscope at 20x magnification for analyzing the physical integrity of ion-exchange resin bead products. The technique is limited to the assessment of beads to determine the percentage of perfect beads.

6.3.10 SEMASPEC #92010958B–STD, SEMATECH Provisional Test Method for Determination of Surface Associated Biofilms of UPW Distribution Systems

This procedure is used to determine the presence of biofilms on all functional surfaces of plastic UPW distribution system components, either before installation or after the component is placed in service.

## 7. Additional References

ASME B16.34, Valves - Flanged, Threaded, and Welding End

ASME B16.37, Hydrostatic Testing of Control Valves

ANSI B46.1, Surface Texture (Surface Roughness, Waviness, and Lay).

This standard is concerned with the geometric irregularities of surfaces of solid materials and physical specimens for gaging roughness, and with the characteristics of instrumentation for measuring roughness. It defines surface texture and its constituents—roughness, waviness, lay, and flaws. It also provides specifications for precision reference specimens and roughness comparison specimens and establishes requirements for instruments. This standard is not concerned with luster, appearance, color, corrosion resistance, wear resistance, hardness, subsurface microstructure, and surface integrity, and it does not define the degrees of surface roughness and waviness or type of lay suitable for specific purposes.

ASME/ANSI<sup>8</sup> B93.2, Fluid Power Systems and Products - Glossary

ASME/ANSI B93.22, Hydraulic Fluid Power - Filter Elements-Verification of Fabrication Integrity.

This standard specifies a method for verifying the fabrication integrity of a hydraulic fluid power filter element, i.e., the acceptability of the filter element for further testing and use. It is not intended to be used for measuring filter performance.

ASME/ANSI B93.24, American National Standard Method for Verifying the Flow Fatigue Characteristics of a Hydraulic Fluid Power Filter Element.

This method is intended to provide a uniform method for verifying the ability of a filter element to withstand the flexing caused by cyclic differential pressures without altering its collapse/burst rating.

ASME/ANSI B93.25, Hydraulic Fluid Power - Filter Elements-Verification of Collapse/Burst Resistance (Technically identical to ISO 2941)(NFPA/T3.10.8.5-1972)(Metric only).

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<sup>8</sup> American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI)

This standard specifies a method for verifying the collapse/birth rating of a hydraulic fluid power filter element, i.e., the capability of the filter element to withstand a designated differential pressure at the normal (intended direction of) flow.

ASME/ANSI B93.80, Hydraulic Fluid Power - Filters - Evaluation of Pressure Drop Versus Flow Characteristics.

This standard specifies a procedure for evaluating the pressure drop versus flow characteristics of industrial oil hydraulic filters under various conditions of flow and provides a basis of agreement between the filter manufacturer and user.

ASME/ANSI B93.112M, Hydraulic Fluid Power - Valves - Method for Determining the Internal Leakage Characteristics.

This standard specifies procedures for the determination of leakage characteristics of any fluid power valve and is intended to provide a uniform laboratory procedure for obtaining and reporting the fluid flow across a valve element that is considered blocked.

ASTM D5127, Standard Guide for Electronic Grade Water

This guide contains recommendations for the purity of water suitable for use in the electronics industry for purposes such as washing and rinsing in etch and clean operations, steam for oxidation of silicon, mask preparation, luminescent material deposition, and other applications related to solid state, thin film, lasers, light-emitting diodes, vacuum tubes, printed circuit, and electrolytic devices.

ASTM E432, Standard Guide for Selection of a Leak Testing Method

This guide is intended to assist in the selection of a leak testing method. The type of item to be tested and selection of the test system and the method for leak measurement or location are related in order of increasing sensitivity.

ASTM E479, Standard Guide for Preparation of a Leak Testing Specification

This guide enumerates factors to be considered in preparing a definitive specification for maximum permissible gas leakage of a component, device, or system. The guide relates and provides examples of data for the preparation of leak testing specifications, primarily halogen leak testing methods. It addresses operational specifications and testing specifications.

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

This is a method for determining diameter, wall thickness, and length dimensions of thermoplastic fittings. It includes procedures for measuring the inside diameter of pipe intended to be joined by internal fittings, the average outside diameter for roundable pipe where out-of-roundness is not a primary concern, the average outside diameter of non-roundable pipe, and length and straightness of pipe. It also includes procedures for dimensioning molded thermoplastic pipe fittings.

ASTM D2143, Standard Test Method for Cyclic Pressure Strength of Strength of Reinforced, Thermosetting Plastic Pipe

This test method may be used to determine the failure characteristics of reinforced plastic pipe when the pipe is subjected to cyclic internal hydraulic pressure. It is limited to pipe in which the ratio of outside diameter to wall thickness is 10:1 or more. This method omits creep and nonrecoverable deformation measurements. The method consists of exposing pipe specimens to cyclic internal pressures and measuring the cycles to failure at the different levels. Test temperatures are obtained by circulating hot salt solution through the test specimens.

MIL-STD-105, Sampling Procedures and Tables for Inspection by Attributes<sup>9</sup>

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<sup>9</sup> Available from Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA 19120.





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