

**SEMATECH Provisional Test Method
for Electrical Resistivity of UPW**

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Technology Transfer # 92010935B-STD

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Abstract: This test method provides a procedure for determining the electrical resistivity of water. It can be used to detect ionizing impurities dissolved in treated water prepared for electronics manufacturing facilities. It is intended for UPW components including tubing, piping, fittings, valves, regulators, filter housings and vessels, and filter cartridges, o-rings, gaskets, and ion-exchange resins. 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.

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SEMASPEC #92010935B–STD

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1. Introduction

1.1 Purpose

1.1.1 This test method provides a procedure for the determination of the electrical resistivity of ultrapure water (UPW) used in distribution systems, before and after exposure to specific ultrapure water components. This test method can be used for detecting ionized impurities dissolved in treated waters that are prepared for electronics plants.

1.1.2 The purpose of this test method is to initially screen UPW components for extraction levels of ionic impurities.

1.2 *Scope*—This method can be used to analyze UPW for resistivity. Ultrapure water components for analysis include tubing, piping, fittings, valves, regulators, filter housings/vessels, filter cartridges, O-rings, gaskets, and ion-exchange resins. This method applies to samples previously prepared according to SEMASPEC #92010934B–STD and can only be applied to dynamic systems.

1.3 Limitations

1.3.1 The accuracy of the method is limited by the detection limits of the instrument and by the sample preparation technique.

1.3.2 This test method may indicate that contaminants are present, but the method does not apply to identification of contaminants.

2. Referenced Documents

2.1 ASTM Standards¹

ASTM D1125	Standard Test Methods for Electrical Conductivity and Resistivity of Water
ASTM D1129	Standard Definitions of Terms Relating to Water
ASTM D1192	Standard Specification for Equipment for Sampling Water and Steam
ASTM D3370	Standard Practices for Sampling Water
ASTM D4453	Standard Practice for Handling Ultra-Pure Water Samples
ASTM D5127	Standard Guide for Electronic Grade Water

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

2.2 *SEMATECH*²

SEMASPEC #92010933B–STD SEMATECH Guide to Test Methods for UPW Distribution System Components

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

3. Terminology3.1 *Acronyms and Abbreviations*3.1.1 *PFA*—perfluoroalkoxy3.1.2 *UPW*—ultrapure water (see Section 7.1)3.2 *Definitions*3.2.1 *For the purposes of this method*, the term electrical resistivity shall be defined in accordance with ASTM D1129 as follows:

electrical resistivity—the resistance in ohms measured between opposite faces of a centimeter cube of an aqueous solution at a specified temperature.

[Note: The unit of electrical resistivity is ohm-centimeter. The actual resistance of the cell, R_x , is measured in ohms, and is proportional to the length of the path, L (cm), and inversely proportional to the cross-sectional area, A (cm²):

$$R_x = R \cdot L/A$$

The resistance measured between opposite faces of a centimeter cube, R , is called resistivity. Resistivity values are usually expressed in ohm-centimeter, or megohm-centimeter, at a specified temperature of 25°C.]

3.2.2 For definitions of other terms used in this test method, refer to ASTM D1129.

3.3 *Descriptions of Terms*

3.3.1 Symbols used in this standard are defined as follows:

3.3.1.1 J —cell constant (cm⁻¹)3.3.1.2 R —resistivity (megohm-cm at 25°C)3.3.1.3 R_x —measured resistance (megohm)3.3.1.4 *spool piece*—a section of clean perfluoroalkoxy (PFA) pipe of appropriate size.**4. Summary of Test Method**

This test method uses a flow-type conductivity cell to sample a continuous stream of water under test for electrical resistivity. Temperature correction methods are also provided.

²SEMATECH. 2706 Montopolis Dr. Austin, TX 78741.

5. Significance and Use

- 5.1 Leaching from a water component is an important criterion for determining the suitability of a component. Contaminants in UPW may adversely affect microelectronic and other processes.
- 5.2 If a component is found to have a resistivity of two standard deviations below the mean as compared to other, similar components, no further testing need be performed on that component. This is intended as a cost-saving measure so that extremely contaminated components can be eliminated from UPW consideration. This test alone does not identify the contaminant; it only identifies the contaminant's ionic nature.
- 5.3 This method may be used to determine qualitative differences in the ionic extraction of various components.

6. Apparatus

- 6.1 *In-Line Meters or Cells*, as follows:
- 6.1.1 Flow-through or in-line meters shall be used for measuring resistivities of UPW (typically, resistivities greater than 1.0 megohm-cm) to avoid contamination from the atmosphere.
- 6.1.2 This meter shall use a cell with a constant of 0.01 or 0.1 cm⁻¹ that is appropriate for resistivity measurements in the range of 1.0 to 18.3 megohm-cm.
- 6.1.3 Flow-through or in-line meters shall be mounted so that continuous flow of UPW through or past the cell is possible. Recommended flow through the cell is 0.3 m/sec (see ASTM D3370). Follow manufacturer's instructions for instrument parameters and assembly.
- 6.1.4 The flow chamber and cell mounting shall retain calibration under conditions of pressure, flow, and temperature change. Check temperature calibration before use to ensure that the meter is accurate.
- 6.1.5 Materials of construction, such as cell housings and electrodes, must be chemically inert and resistive to corrosion. They should not contaminate the sample stream.
- 6.1.6 The flow chamber shall be equipped with a means to accurately measure the temperature.

7. Materials

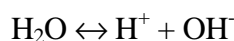
- 7.1 *Test Fluid*. For purposes of this test, references to water shall be understood to mean ultrapure water as defined by maximum individual metal and anion impurity levels of 0.1 ppbw or less, total organic carbon (TOC) levels of 10 ppbw or less, nonvolatile residue levels of 0.1 ppmw or less, resistivity of 18 megohm-cm or greater, and reactive silica impurity of less than 1.0 ppb.

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*—The resistivity of water and aqueous solutions depends greatly upon the temperature. The resistivity varies depending upon the nature and composition of the dissolved electrolytes and upon the concentration. The lower the concentration, the higher the resistivity, due to the effect of temperature upon the dissociation of water:



To avoid making a correction, it is necessary to hold the temperature of the sample to $25 \pm 0.5^\circ\text{C}$. If this cannot be done, the temperature coefficient must be determined and a correction applied.

- 8.3 *Interferences*—Exposure of a sample to the atmosphere may cause changes in resistivity due to gain of dissolved gases. This is extremely important in the case of water with low concentrations of dissolved ionized materials. Carbon dioxide, normally present in the air, will drastically change the resistivity of ultrapure waters. Avoid sample contact with air by using flow-through or in-line instrumentation.

9. Sampling

All sampling shall be via continuous, in-line flow of water through the meter and shall contact the cell directly.

10. Preparation of Apparatus

Follow the manufacturer's recommended procedure.

11. Calibration and Reference Standards

11.1 Calibration

- 11.1.1 Measuring Instrument—A precision calibrating resistor (0.1% accuracy) is usually furnished by the manufacturer with resistivity instruments and with information about the correct scale reading the instrument shall assume when the resistor is connected to the display in place of the conductivity cell. Follow the manufacturer's instructions and check the instrument periodically and frequently.

- 11.1.2 When using an instrument provided with a manual or automatic temperature compensator, follow the manufacturer's instructions to calibrate the compensator and check its accuracy and applicability to the samples being tested.

12. Conditioning

This test shall be performed using $25 \pm 5^\circ\text{C}$ water.

13. Test Procedure

- 13.1 Install spool piece upstream of the resistivity meter. See Figure 1.

- 13.1.1 For testing filter cartridges, it is recommended that an empty filter housing be chosen as the spool piece.

- 13.2 Flow UPW through the spool piece at 0.3 m/sec and measure the resistivity until a baseline level is established.
- 13.3 Remove and reinstall the spool piece in the same location. Repeat Section 13.2 to determine the effect of handling on resistivity measurements.
- 13.4 Remove the spool piece and replace it with the test component at the same location.
 - 13.4.1 For filter cartridges, open the filter housing and insert the cartridge prior to testing.
 - 13.4.2 For O-rings and gaskets, arrange to retain the components within the spool piece, which also serves as the test component housing.
- 13.5 Flow UPW through the test component at 0.3 m/sec and measure resistivity with a resistivity meter.
- 13.6 Continue testing until the resistivity returns to the baseline level. Discontinue testing if the baseline has not been attained after one hour.

14. Data Analysis

- 14.1 Record resistivity measurements for spool pieces and test components.
- 14.2 Record the time required for water quality to return to baseline after insertion of test component.
- 14.3 Record the time required for water quality to return to baseline after removal and reinsertion of the spool piece.
- 14.4 If all components exceed the one-hour time limitation, record resistivity at one hour.

15. Data Presentation

Resistivity measurements may be plotted versus time or tabulated.

16. Precision and Bias

No formal study of precision and bias is presently available. Resistivity instruments are susceptible to loss of calibration. Thus, recalibration should be performed frequently either by the user or by the manufacturer to avoid loss of precision.

17. Illustrations

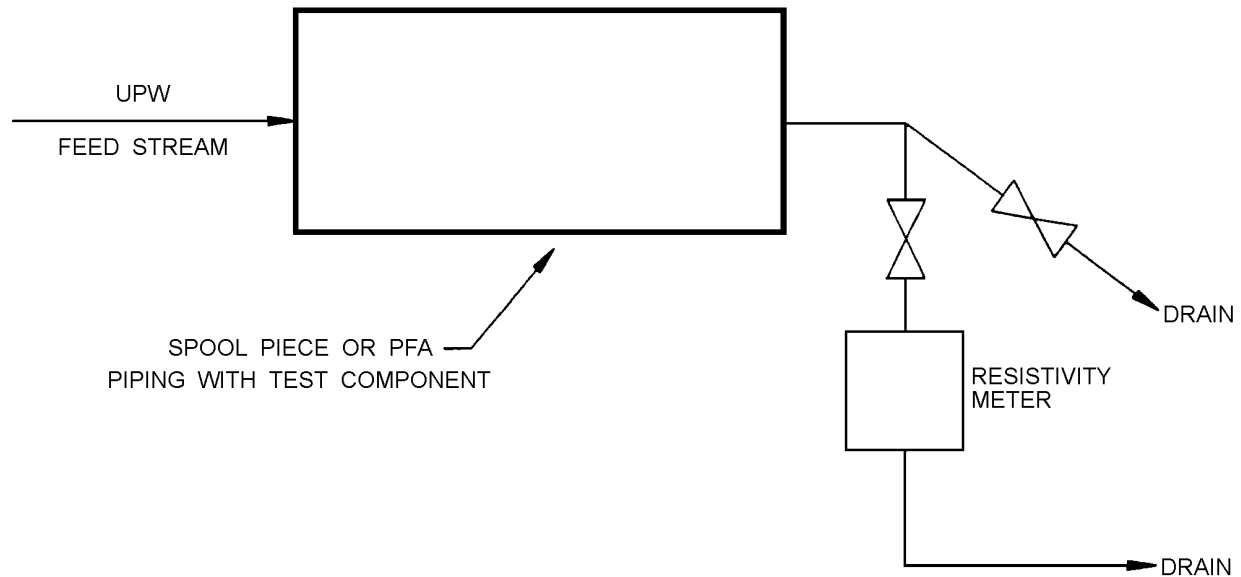


Figure 1 Schematic of Test Apparatus

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