# SEMI F57-1000
# PROVISIONAL SPECIFICATION FOR POLYMER COMPONENTS USED IN ULTRAPURE WATER AND LIQUID CHEMICAL DISTRIBUTION SYSTEMS

This specification was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on August 28, 2000. Initially available on SEMI OnLine August 2000; to be published October 2000.

NOTE: This specification is considered provisional since it lacks a complete set of requirements for particles in Table 2 as well as particle test methods for components as noted in Table 1. At the time of publication, only a small database of values existed for PFA valves. Test methodologies will be generated for components and this document will be re-balloted at a later date.

## 1 Purpose

1.1 This document specifies minimum performance requirements for ultrahigh purity (UHP) polymer components used throughout semiconductor ultrapure water and liquid chemical distribution systems including bulk supply, facility distribution, and process equipment applications.

## 2 Scope

2.1 Polymer component purity and mechanical specifications are included in this standard along with references for qualification test methods. Certification, traceability, and packaging requirements are also included.

Purity Requirements:

- Particle Contribution
- Ionic Contamination
- Metallic Contamination
- Total Organic Carbon Contamination
- Surface Roughness

Mechanical Requirements:

- Temperature/Pressure Rating
- Chemical Resistance Rating
- Reliability

2.2 Polymer piping system components consisting of but not limited to the items shown in Table 1 are designed to contain and supply the following types of liquid chemicals:

- Acids, bases and oxidizers
- Aqueous salt solutions
- Ultrapure Water (UPW)

**Table 1 Required Performance Specifications and Testing by Component Type**

| *Test* | *Particles* | *Ionic Contamination* | *Metallic Contamination* | *Total Organic Carbon* | *Surface Roughness* |
|---|---|---|---|---|---|
| *Section* | *7.2* | *7.3* | *7.4* | *7.5* | *7.6* |
| *Table* | *2* | *3* | *4* | *5* | *6* |
| Pipe/Tubing | | x | x | x | x |
| Fittings | | x | x | x | x |
| Valves | (See NOTE 1.) | x | x | x | x |
| Filter Housings | | x | x | x | x |
| Pressure Transducers | | x | x | | x |
| Flow Meters | | x | x | | x |
| Gauge Guards | | x | x | | x |
| Regulators | | x | x | | x |

NOTE 1: A method for this requirement is being developed. At the time of publication, only a small database of values existed for PFA valves. As the database encompasses more polymer materials, limits will be set for this parameter. Then, this document will be re-balloted.

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2.3 Unless purchased separately, polymer components constructed of sub-pieces, such as o-rings, gaskets, and diaphragms, must meet the requirements of this document at the functional component level, not as individual sub-pieces. For example an o-ring in a union must not degrade the overall quality of the union such that it fails to meet the requirements of this document.

2.4 This document and associated tests specify wetted stream performance requirements for polymer components in an as supplied, native state and reflect the current capabilities of the manufacturers of polymer components.

2.5 Leach out tests and associated requirements referenced within this document provide values from static, not dynamic, conditions. To determine the corresponding concentration that may result in a flowing dynamic stream, please see the Related Information Section on Theoretical Dynamic Concentration (TDC) located at the end of this document.

2.6 *Polymer Materials*

2.6.1 It is the intent of this specification to focus component qualification on performance. However, a discussion of recommended materials may benefit the reader and is therefore included.

2.6.2 Care must be taken to ensure that the materials are compatible with the liquid streams (as shown in Section 2.2) for long term applications. Additionally, it is important that the materials used be compatible with the application temperature and/or methods for bacterial reduction such as ozone, UV light and/or hydrogen peroxide.

2.6.3 The requirements of this specification often mandate the use of existing materials of choice, such as high purity grades of perfluoroalkoxy (PFA), polytetrafluoroethylene (PTFE), and polyvinylidene fluoride (PVDF). However, unique design specifications or new materials may result in instances where significant efficiencies may be achieved while maintaining substantially equivalent performance with regard to this specification. These scenarios could result in the use of new or existing materials such as ethylenechlorotrifluoroethylene (ECTFE), polyetheretherketone (PEEK), polypropylene (PP), acetal resin (such as Delrin®™[1], Celcon®™[1] and others), polyvinyl chloride (PVC), perfluoromethylether-based perfluoroalkoxy (MFA), etc.

2.6.4 Due to purity and traceability issues, reprocessed or regrind material must not be used.

1 Delrin is a trademark of DuPont; Celcon is a trademark of Hoechst Celanese.

2.7 This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

## 3 Limitations

3.1 This document applies solely to polymer components. Performance specifications for subassemblies or bulk distribution systems may be found in other SEMI standards (see Related Documents Section 12.6).

3.2 This document does not include specifications for pumps, storage tanks, ion exchange resin tanks, drums, day tanks, pressure vessels, lined stainless steel products, filters, UV sterilization systems, reverse osmosis systems and ancillary equipment, sensors, monitors, or ultra-filtration equipment.

3.3 Organic liquids, such as isopropyl alcohol and methyl alcohol, are typically in contact with stainless steel or other non-polymeric components. The polymer components described within this document are NOT intended for use with such organic liquids.

3.4 Polymer components described within this document are intended for use in UHP service only. Their specified performance requirements may exceed the needs of components used in drainage and other lesser quality liquids.

3.5 This standard is not intended to address design or materials issues related to safety which are addressed elsewhere in the SEMI guidelines (see SEMI S2).

3.6 The tests referenced in this document are designed to assess contamination from the polymer components in an as received state. Assembly steps, such as welding and cleaning, may actually add some contaminants. The effects of the assembly are beyond the scope of this document, but should be considered by the supplier and/or user (see SEMI E49.7).

3.7 Leach out values listed in Tables 3, 4 and 5 reflect testing in UPW for polymer component comparison purposes. The relative leach out performance of polymer components in actual use with other chemicals (e.g. acids and bases) cannot be directly derived by using the UPW data. It is incumbent upon the user to determine if a component is suitable for use based on these requirements (see Section 2.6.2).

3.8 This document is not intended to supersede international, national or local codes, regulations, and laws. Each should be consulted to ensure that the manufactured polymer components meet regulatory requirements in each location.

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## 4 Referenced Documents

NOTE 1: As listed or revised, all documents cited shall be the latest publications of adopted standards.

4.1 *SEMI Standards*

SEMI E49.7 — Guide for Subsystem Assembly and Testing Procedures - Polymer Systems

SEMI F40 — Practice For Preparing Liquid Chemical Distribution Components for Chemical Testing

SEMI S2 — Safety Guideline for Semiconductor Manufacturing Equipment

4.2 *ASTM Standards*[2]

ASTM D4327 — Anions in Water by Chemically Suppressed Ion Chromatography

ASTM D4779 — Total, Organic, and Inorganic Carbon in High Purity Water by Ultraviolet (UV) or Persulfate Oxidation, or Both, and Infrared Detection

ASTM D5904 — Standard Test Method of Total Carbon, Inorganic Carbon, and Organic Carbon in Water by UV, Persulfate Oxidation and Membrane Conductivity Detection

4.3 *ISO Standards*[3]

ISO 1167 — Plastic pipes for the transport of fluids - Determination of the resistance to internal pressure

ISO 12162 — Thermoplastic materials for pipes and fittings for pressure applications - Classification and designation - Overall service (design) coefficient

## 5 Terminology

5.1 *Definitions*

5.1.1 *Liquid Chemical Distribution System* — the collection of components and subsystems used to deliver liquid process chemicals from a source location to a point of use.

5.1.2 *Ultrapure Water Distribution System* — the collection of components and subsystems used to deliver ultrapure water from a source location to a point of use.

## 6 Ordering Information

6.1 Device manufacturers may use this standard when procuring facilities or processing equipment to specify required component performance to the supplier. Facilities services and process equipment suppliers may also use this document to specify performance requirements to component and subassembly suppliers.

6.2 Orders for polymer components or subassemblies in accordance with this standard shall include the specification number and date of issue.

## 7 Purity Requirements

7.1 The values found in Tables 3 through 6 were constructed from existing databases of high purity grades of PVDF and PFA. They represent characteristics of piping system polymer components, which are currently providing end-users with satisfactory results. Other materials with other particle leach out or surface roughness characteristics may or may not be acceptable. The end-user may need to test such materials to determine if they will meet both the static values of this document as well as any final delivered fluid requirements.

7.2 *Particle Contribution*

7.2.1 Importance of Test: Particles released from within polymer components can come into direct contact with wafers and cause unwanted surface contamination or disrupt photolithography process steps, thereby decreasing yields.

7.2.2 Particle contribution specification and testing are restricted to polymer components as indicated in Table 1.

7.2.3 Polymer components shall conform to the particle contribution specifications appearing in Table 2.

7.2.4 A Rinse Time Test (see Table 2) provides a measure of the particle shedding from a component when it is initially removed from its packaging in a cleanroom environment and immediately tested.

7.2.5 The various cycle evaluations (see Table 2) provide a measure of the particle shedding that results from actuating the valve and the subsequent cleanup over time. In addition, these tests provide a measure of degradation (increased particle shedding) of the valve as it is cycled.

7.2.6 The performance requirement values in Table 2 for the Initial Cycle Test, the 2000 Cycle Test and the 200,000 Cycle Test represent averages after subtracting a pre-cycle test background average.

7.3 *Ionic Contamination*

7.3.1 Importance of Test: Ionic contamination can have a corrosion and/or etching effect on semiconductor devices during fabrication, causing immediate or future device failure. Evaporation of solutions containing ionics may leave surface residue.

2 American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohoken, PA 19428-2959, USA

3 International Organization for Standardization, 1 rue de Varembé, Case postale 56, CH-1211 Genève 20, Switzerland

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7.3.2 Ionic contamination specification and testing are required for all polymer components as indicated in Table 1. The ionic contaminants specified within this document have been derived, in part, from industry guidelines for UPW used in semiconductor processing.

7.3.3 Polymer components shall conform to the ionic contamination specifications appearing in Table 3. Use SEMI F40 to prepare the component for analysis and ASTM D4327 to analyze polymer components.

7.3.4 The Static Value is derived from a prolonged static leach out test, using UPW as the test media and lasting for a period of 7 days. Static values do not directly relate to the trace contaminant values, which could be present in a flowing stream of liquid. Testing temperature of polymer components shall be 85 ± 5°C. A specific testing temperature is specified to achieve comparable data for polymer components and is not indicative of service temperatures. For most contaminants, testing at a lower temperature will give lower static values.

7.3.5 A mathematical relationship between the static leach out value (provided in this specification) and the corresponding concentration which may result in a flowing stream can be theoretically calculated. This value is offered for demonstration purposes only and is known as the Theoretical Dynamic Concentration (TDC). It is expressed in parts per billion ($\mu$g/liter) in the example calculation provided in the Related Information 1 Section of this document.

7.4 *Metallic Contamination*

7.4.1 Importance of Test: Metallic contamination can have an effect on altering the electrical properties of semiconductor devices.

7.4.2 Metallic contamination specification and testing are required for all polymer components as indicated in Table 1. The metallic contaminants specified within this document have been derived, in part, from industry guidelines for UPW used in semiconductor processing

7.4.3 Polymer components shall conform to the metallic contamination specifications appearing in Table 4. Use SEMI F40 to prepare the component for analysis and an industry standard test method to analyze polymer components (see Related Documents Section 12.5 for an applicable leachable trace inorganics test method).

7.4.4 See Section 7.3.4 for Static Value definition.

7.4.5 See Related Information 1 for Theoretical Dynamic Concentration calculation.

7.5 *Total Organic Carbon (TOC)*

7.5.1 Importance of Test: TOC can have an effect on silicon oxidation, uniformity of etching and gate oxide breakdown voltage of semiconductor devices.

7.5.2 TOC specification and testing are restricted to polymer components as indicated in Table 1.

7.5.3 Polymer components shall conform to the TOC contamination specifications appearing in Table 5. Use SEMI F40 to prepare the component for analysis and ASTM D4779 or D5904 to analyze polymer components.

7.5.4 See Section 7.3.4 for Static Value definition.

7.5.5 See Related Information 1 for Theoretical Dynamic Concentration calculation.

7.6 *Surface Roughness*

7.6.1 Importance of Test: Surface roughness can influence microbial proliferation, provide an entrapment area for microcontamination build up and/or promote shedding of the polymer itself within a distribution system.

7.6.2 Surface Roughness specification and testing is required for all polymer components as indicated in Table 1.

7.6.3 Polymer components shall conform to surface roughness specifications appearing in Table 6. For ease of use and comparison purposes, the preferred method of testing is by use of a stylus in direct contact with the component surface, known as contact profilometry (see Related Documents Section 12.5 for an applicable surface roughness test method).

7.6.4 As softer plastics may exhibit microscopic damage due to the stylus and give smoother than expected results, additional testing may be required. When initially setting up the equipment, evaluate softer plastics immediately with a 10x magnification visual examination to make sure damage has not occurred. Lines, scratches or artifacts originating from stylus contact would indicate damage. In the event that damage is present, a lighter stylus head should be used.

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