

SEMI E49.5-0419

GUIDE FOR THE DESIGN OF ULTRAHIGH PURITY SOLVENT DISTRIBUTION SYSTEMS WITH NON-METALLIC FLUID PATHS IN SEMICONDUCTOR MANUFACTURING EQUIPMENT

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NOTICE: This Document was completely rewritten in 2018.

1 Purpose

1.1 This Document provides design guidelines for liquid solvent distribution systems in semiconductor production equipment.

2 Scope

2.1 The distribution systems consist of polymeric piping designed to supply flammable liquid solvents only, at system operation and delivery pressures of less than 75 PSIG.

2.2 Systems may have metallic piping components as well as polymeric, for metallic piping guidelines see SEMI E49.4.

2.3 Typical processes include photolithography, solvent distribution systems, clean, etch, and solvent vapor dryers.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 This Guide, if used, is applicable only for systems that have both polymeric and mixed polymeric/stainless steel wetted process designs. Refer to SEMI E49.4 for systems that utilize exclusively stainless steel wetted process designs.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI E10 — Specification for Definition and Measurement of Equipment Reliability, Availability, and Maintainability (RAM) and Utilization

SEMI E49 — Guide for High Purity and Ultrahigh Purity Piping Performance, Subassemblies, and Final Assemblies

SEMI E49.6 — Guide for Subsystem Assembly and Testing Procedures – Stainless Steel Systems

SEMI E49.7 — Guide for the Design and Manufacture of Polymer Assemblies Used for Liquid Chemical Systems in Semiconductor Equipment

SEMI F20 — Specification for 316L Stainless Steel Bar, Forgings, Extruded Shapes, Plate, and Tubing for Components Used in General Purpose, High Purity and Ultra-High Purity Semiconductor Manufacturing Applications

SEMI F32 — Test Method for Determination of Flow Coefficient for High Purity Shutoff Valves

SEMI F34 — Guide for Liquid Chemical Pipe Labeling

SEMI F57 — Specification for Polymer Components Used in Ultrapure Water and Liquid Chemical Distribution Systems

SEMI F51 — Guide for Elastometric Sealing Technology

SEMI S14 — Safety Guideline for Fire Risk Assessment and Mitigation for Semiconductor Manufacturing Equipment

4.2 ASM International Document¹

UNS S31603 — Composition of Standard Stainless Steels

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 See § 4 of SEMI E49.

5.2 Definitions

5.2.1 *maximum allowable working pressure (MAWP)* — maximum pressure (based on the applicable design codes) that the weakest component of a system can withstand.

5.2.2 *maximum allowable operating pressure (MAOP)* — maximum pressure that the system may be operated at. This is usually the lowest value of the considered rated pressure and MAWP of all system components.

6 Performance Guidelines

6.1 See SEMI E49.2 for recommended system testing procedures for assemblies.

6.2 In situations where testing with deionized/ultrapure water is undesirable due to possible contamination or incompatibility issues, an alternate inert gas testing method may be considered.

6.3 *Reliability and Maintainability Indices* — Equipment supplier should provide actual gas system performance data and/or component reliability data, accompanied by the associated failure analysis method. (Refer to SEMI E10 for definition and development of indices.) Examples of indices that are typically provided are shown in the Table 1 below.

Table 1 Tool Indices

<i>Indices</i>	<i>Hours</i>
Mean time between failure (MTBF)	
Mean time between assists (MTBA)	
Mean time to repair (MTTR)	
Start-up time (Initial)	

7 Design Guidelines

7.1 Any weld joints made with fluoropolymer tubing or pipe should be performed using joining methods that minimize or eliminate potential material or surface contamination. It is desirable to minimize the ID bead size of any such welding to reduce possibility of particle entrapment and improve flow characteristics. Please reference SEMI E49.7 § 8.3 for additional considerations. Pipe should be joined with welds that minimize dead space and entrapment areas. Preparation and welding should be performed in accordance with component manufacturer's recommendations.

7.2 Mechanical fittings should be used where required for component removal/replacement. Care should be taken to ensure that dissimilar mechanical fittings are not joined together. When possible, one style of fitting should be used throughout the system. Manufacturers should be consulted prior to using similar style fittings from different manufacturers interchangeably. If multiple types of fitting are required, minimize the number of fitting type transitions in the system, assembly or subassembly.

7.3 No-flow ("Dead") volumes should be less than three pipe diameters in length/height. Blind runs such as pressure gauges should not be used.

7.4 A means of process liquid sampling should be installed as close as possible to point of dispense.

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7.5 Incoming process liquids require filters and should be located downstream of any regulator and as close as possible to point of dispense.

7.5.1 The system internal volume should be minimized by use of low or no-flow free branch valves (zero dead leg [ZDL]) and/or multicomponent integrated assemblies. Examples of components and practices which help minimize system volume include:

- No flow-free branch valves.
- Multicomponent integrated assemblies.
- Use of direct flow paths.

7.6 Design should include a means of flow through flushing and draining for removable components or assemblies.

7.7 Pumping systems should include surge/pulse suppression devices and provisions for vibration isolation, if applicable.

7.8 Supply and drain lines on a recirculation system should be separated by an isolation valve. The system should not use one line to perform both functions.

7.9 All filters should be able to be isolated from process stream for maintenance.

7.10 Due to the low surface tension and often higher solvent vapor pressures, it is recommended not to utilize valves that have dynamic seals (such as ball valves and needle valves). Designs with static type seals are preferred (diaphragm valves).

7.11 Backflow/back pressure protection should be included in the system.

7.12 For processes requiring pressure control, regulators should be included in the system. Pressure transducers and a means of pressure display should be included on the equipment.

7.13 The systems should have a means of manifolding supply and drain lines onboard, so that there is a single point connection for each individual liquid.

7.14 Design should allow for thermal expansion if system operates at an elevated temperature. Increased system pressure is also a consideration in solvent systems downstream of heating. Likewise, flash point of the solvent should also be reviewed in terms of elevated system design and performance.

7.15 For systems that require fire suppression see SEMI S14.

8 Materials Guidelines

8.1 Enclosures

8.1.1 Stainless steel can be 316L for solvent or solvent-chemical mixtures or as specified by the customer (see SEMI F20).

8.1.2 All coated steel should conform to ASM UNS S31603 for chemical composition with the following exceptions:

- Sulfur as reported by the SMTR $\leq 0.030\%$
- Carbon as reported by the SMTR $\leq 0.030\%$

8.1.3 Materials for valve seats, diaphragms, gaskets, and O-rings should be chemically compatible with the liquid flowing through the system. All materials exposed to the liquid should be reported.

8.2 Internal Components and Assemblies

8.2.1 Components should limit system exposure to or addition of ionic, metallic, total organic carbon, and particle contamination.

8.2.2 For material types refer to SEMI E49.

8.2.3 For material purity, labelling, material physical properties, and traceability see SEMI F57.