

SEMI E49.8-1103

GUIDE FOR HIGH PURITY AND ULTRAHIGH PURITY GAS DISTRIBUTION SYSTEMS IN SEMICONDUCTOR MANUFACTURING EQUIPMENT

This guide was technically approved by the Global Gases Committee and is the direct responsibility of the North American Gases Committee. Current edition approved by the North American Regional Standards Committee on September 3, 2003. Initially available at www.semi.org October 2003; to be published November 2003. Originally published in 1996; previously published February 1998.

NOTICE: This document was completely rewritten in 2003.

1 Purpose

1.1 This document specifies guidelines for high purity (HP) and ultrahigh purity (UHP) gas distribution systems in semiconductor manufacturing equipment.

2 Scope

2.1 This guide applies to gas distribution systems consisting of stainless steel components designed to supply the following types of gases to the process chamber:

2.1.1 *Specialty Gases* — Corrosive, flammable, pyrophoric, oxidizer, toxic, inert, and mixtures.

2.1.2 *Bulk Gases* — Nitrogen, oxygen, argon, hydrogen, and helium.

2.2 Typical processes include diffusion, anneal, plasma etch, chemical vapor deposition, physical vapor deposition, and ash.

NOTICE: 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 health practices and determine the applicability or regulatory limitations prior to use.

3 Referenced Standards

3.1 SEMI Standards

SEMI E49 — Guide for Standard Performance, Practices, and Sub-Assembly for High Purity Piping Systems and Final Assembly for Semiconductor Manufacturing Equipment

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

SEMI F1 — Specification for Leak Integrity of High-Purity Gas Piping Systems and Components

SEMI F17 — Specification for High Purity Quality Electroplished 316L Stainless Steel Tubing, Component Tube Stubs, and Fittings Made from Tubing

SEMI F19 — Specification for the Finish of the Wetted Surfaces of Electropolished 316L Stainless Steel Components

SEMI F20 — Specification for 316L Stainless Steel Bar, Extruded Shapes, Plate, and Investment Castings for Components Used in High Purity Semiconductor Manufacturing Applications

SEMI F37 — Method for Determination of Surface Roughness Parameters for Gas Distribution Components

SEMI F58 — Test Method for Determination of Moisture Dry-Down Characteristics of Surface-Mounted and Conventional Gas Distribution Systems by Atmospheric Pressure Ionization Mass Spectroscopy (APIMS)

SEMI F60 — Test Method for ESCA Evaluation of Surface Composition of Wetted Surfaces of Passivated 316L Stainless Steel Components

SEMI F70 — Test Method for Determination of Particle Contribution of Gas Delivery System

SEMI F73 — Test Method for Scanning Electron Microscopy (SEM) Evaluation of Wetted Surface Condition of Stainless Steel Components

SEMI F78 — Practice for Gas Tungsten Arc (GTA) Welding of Fluid Distribution Systems in Semiconductor Manufacturing Applications

SEMI F81 — Specification for Visual Inspection and Acceptance of Gas Tungsten Arc (GTA) Welds in Fluid Distribution Systems in Semiconductor Manufacturing Applications

SEMI S2 — Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment

3.2 ASTM Document¹

¹ American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959, USA. Telephone: 610.832.9585, Fax: 610.832.9555, Website: www.astm.org

ASTM F 1397 — Test Method for Determination of Moisture Contribution for Gas Distribution System Components

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

4 Terminology

4.1 See Section 4 in SEMI E49.

5 Design Guidelines

5.1 All weld joints should be automatically orbital butt-welded in accordance with SEMI F78 and SEMI F81.

5.2 Directional changes in the process flow path should be minimized. Required directional changes should be accomplished by butt-weld elbows or block components. Tube bends may be used on tubing $\leq \frac{1}{2}$ inch O.D. and should be formed using manual or CNC bending equipment. CNC tube bending is preferred to manual tube bending because during manual bending uniform deformation of the tubing is more difficult to control and reproducibility of bend geometries is much less than that achieved by bending using CNC methods. An internal mandrel must not be used during bending as it can contaminate and/or damage the internal surface. Recommended minimum bend radii are the following:

- For inert gas lines, a bend radius (as measured from the tube centerline) as small as $2 \times$ tube diameter may be used for 90 degree directional changes.
- For reactive gas lines, a bend radius (as measured from the tube centerline) as small as $5 \times$ tube diameter may be used for 90 degree directional changes; however, it is recommended that corrosion testing be performed to determine if bent tubing is suitable in each particular reactive gas application.

5.3 Components that may need to be removed or replaced should be installed with metal seal fittings.

5.4 Dead volumes should be minimized in the process gas stream. The system internal volume should be minimized.

5.5 All potentially pyrophoric or reactive gases should have upstream and downstream purge/vacuum capability for MFC maintenance. To speed the purge process and allow the system to be evacuated even if the MFC is clogged, the design should also have the ability to provide vacuum both upstream and downstream of the MFC. A gas is defined to be reactive

if it has a Hazardous Production Material (HPM) rating of 3 or 4 per SEMI S2.

5.6 Inert gases do not need an input for an independent purge gas. Inert gases can act as their own purge gas and only need to purge in the intended direction of flow. Inert gas lines do not need upstream vacuum capability or downstream purge capability. To speed the purge process, the design should have the ability to provide vacuum downstream of the MFC.

5.7 For low pressure equipment, the vacuum path from the MFC manifold to the pump should bypass the process chamber during purging or maintenance and should connect directly to the foreline.

5.8 For atmospheric pressure equipment, a vacuum Venturi to vent/exhaust method should be required for reactive gases.

5.9 Design should include a means of cycle purging upstream and downstream of removable components or subassemblies for reactive gases and should include a means of flow-through purging for all removable components.

5.10 Backflow/back pressure protection should be included for all purge gases in the system.

5.11 All incoming gas lines should have filters.

5.12 Any additional filters, located at point of use before a process chamber or loadlock, should have a means of isolation from atmosphere.

5.13 Test/sample ports should be located on each process chamber supply line or the designated purge/vent line.

5.14 For processes requiring additional purification of process gases, purifiers should be included in the gas system and located upstream of MFC's. The system should include a means of purging and removing purifiers in a safe manner.

6 Materials Guidelines

6.1 *Stainless Steel*

6.1.1 Components should be fabricated from electropolished 316L stainless steel per SEMI F17, or SEMI F20.

6.2 *Other Materials*

6.2.1 Materials for valve seals, diaphragms, gaskets, and O-rings should be chemically compatible with the process gas. All materials exposed to process gas should be reported.