

SEMI E49.8-0298

GUIDE FOR HIGH PURITY GAS DISTRIBUTION SYSTEMS IN SEMICONDUCTOR MANUFACTURING EQUIPMENT

1 Purpose

1.1 This document specifies guidelines for high purity (HP) gas distribution systems in semiconductor production equipment.

2 Scope

2.1 Gas distribution systems consist of stainless steel (SS) piping 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.

3 Referenced Documents

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

3.2 ASM Document¹

ASM UNS S31603 — Composition of Standard Stainless Steels

3.3 ASTM Standards²

See Section 3.3 of SEMI E49.

3.4 NFPA Documents³

NFPA 49 — Hazardous Chemicals Data

NFPA 704 — Standard System for the Identification of the Fire Hazards of Materials

1 American Society of Metals, Metals Park, OH 44073

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

3 National Fire Protection Association, Batterymarch Park, Quincy, MA 02269

4 Terminology

See Section 4 of SEMI E49.

5 Performance Guidelines

5.1 Purity Indices

- Particle Count (ptc), at $\geq 0.1 \mu\text{m}$
 - $\leq 0.18 \text{ ptc/L}$ (5 ptc/ft^3) average single count
 - $\leq 1.8 \text{ ptc/L}$ (50 ptc/ft^3) maximum single count
- Moisture Level $\leq 100 \text{ ppb}$
- Oxygen Level $\leq 100 \text{ ppb}$
- Total Hydrocarbon (THC) $\leq 100 \text{ ppb}$
- Inboard Helium Leak Rate $\leq 10^{-9} \text{ atm. cc/sec.}$

5.2 All performance measures are absolute values, relative to respective test instrument background level.

5.3 See SEMI E49.6 for recommended gas system testing procedures.

5.4 *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.

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

6 Design Guidelines

6.1 All weld joints should be automatically orbital butt welded.

6.2 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 up to sizes of $\leq 1/2 \text{ in. O.D.}$, with a minimum of $8 \times$ tube diameter.

6.3 Metal face seal type mechanical fittings should be used where required for component removal/replacement.

6.4 Dead volumes and system internal volume should be minimized by use of miniature type weld fittings. Multi-valve arrangements are optional.

6.5 Purge and vent connections to process gas stream should be accomplished by tee fittings and branch valves. Flow through branch valves or multivalve block arrangements are optional.

6.6 All corrosive, toxic, and flammable gases (i.e., reactive) should have upstream and downstream purge/vacuum capability for MFC maintenance. A gas should be defined to be reactive if it has a Hazardous Production Material (HPM) rating of 3 or 4 per NFPA 49 and NFPA 704.

6.7 All inert gases should have downstream purge capability as a minimum. Atmospheric gas services (e.g., N₂, Ar) can use the process gas as a purge gas.

6.8 For low pressure equipment, the vacuum path from the MFC manifold to the pump should be through the process chamber as a minimum. Piping for chamber bypass to vacuum pump foreline is optional.

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

6.10 Design should include a means of flow-through purging for removable components or component sticks for reactive gases and should include a means of flow-through purging for all removable components.

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

6.12 All incoming gas lines should have filters included. Filters for process gases should be located downstream of any regulator or check valve and upstream of any MFC. Screen filters (e.g., wire mesh) should not be used.

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

6.14 For processes requiring pressure control, regulators should be included in the gas system and located upstream of MFC's. Pressure gauges or transducers, with a display, should be used for process measurement.

6.15 The gas system should have a means of manifolding supply lines onboard, so that there is a single point connection for each individual gas (consisting of the same chemical composition and purity level).

7 Materials Guidelines

7.1 Material Mechanical Characteristics - Stainless Steel

7.1.1 All tubing greater than or equal to 1.27 cm (1/2 in.) diameter should conform to ASTM A 269.

7.1.2 Tubing less than 1.27 cm (1/2 in.) diameter should conform to ASTM A 632.

7.1.3 All bar stock should conform to ASTM A 479.

7.1.4 All 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 $\leq 0.030\%$

7.2 Stainless steel should be 316L electropolished for gas system wetted flow streams and/or as specified by the customer.

7.3 Materials for valve seals, diaphragms, gaskets, and O-rings should be chemically compatible with the process gas.

7.4 Material Performance Guidelines

7.4.1 The performance guidelines below are SS qualification values to be demonstrated by the original component manufacturer. Semiconductor equipment suppliers should provide proof that their components conform to these requirements.

7.4.2 The performance tests should be considered production qualification tests. It is the responsibility of the component manufacturer to provide statistically significant data which correlates their production tests to these qualification tests (e.g., Statistical Process Control, MIL-STD-105D).

7.4.3 The equipment supplier should be responsible for maintaining and supplying, upon request, documentation that proves their components meet the user's materials performance requirements.