

SEMI F1-96

SPECIFICATION FOR LEAK INTEGRITY OF HIGH-PURITY GAS PIPING SYSTEMS AND COMPONENTS

NOTICE: This entire document was revised in 1995.

1 Purpose

1.1 This specification defines the leak testing requirements and leakage rates for high-purity gas piping systems and components used in semiconductor manufacturing. It is also intended as an aid in the procurement and installation of equipment, materials, and services.

2 Scope

2.1 This specification applies to high-purity gas piping systems and components used in semiconductor manufacturing facilities and comparable research and development areas.

2.2 It includes testing methods for complete systems, subsystems, and individual components.

2.3 It states requirements for both the user and manufacturer and establishes leak rate limits for acceptance testing and qualification testing.

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 and health practices and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 This specification is not a replacement for safety regulations. It is the responsibility of the user to ensure that piping systems and components comply with all applicable safety regulations.

3.2 Interferences

3.2.1 Mass spectrometer leak testing with helium can result in misleading indications due to high permeability of polymeric materials by helium. Permeation is often indicated by a delayed leakage indication and a continually rising apparent leakage rate. Helium tracer gas under pressure is absorbed by permeable materials, and subsequent desorption can inhibit later testing at sensitive levels. Therefore, perform the tests in this order: inboard, internal, and outboard.

3.2.2 For low pressure tests, 1 MPa (147 psig) or less, the space to be filled with tracer gas must be purged or evacuated to avoid dilution. This applies both to enclosures and to the interiors of test objects.

3.2.3 Long tubing lines or small diameter tubing at an inlet may require purging to ensure that the tracer gas reaches the test object.

3.2.4 Conductance between the test object and the leak detector must be adequate to ensure test sensitivity. Restrictions such as regulators or check valves between the test object and the leak detector may require testing the test object before installing the downstream components.

3.2.5 Air flow can severely hinder capture of leaking gas by a detector probe. If possible, such air flow should be reduced to a minimum during testing. If testing must be performed in an area with substantial air flow, a protective film, such as is described in ASTM E499, Method B, should be placed around the probe tip when examining each joint.

3.2.6 Temperature variations may affect leak performance. However, this specification does not address this effect.

4 Referenced Standards and Documents

4.1 SEMI Standard

SEMI S2 — Safety Guidelines for Semiconductor Manufacturing Equipment

4.2 ASTM Standards¹

ASTM E493 — Standard Test Methods for Leaks Using the Mass Spectrometer Leak Detector in the Inside-Out Testing Mode

ASTM E498 — Standard Methods of Testing for Leaks Using the Mass Spectrometer Leak Detector or Residual Gas Analyzer in the Tracer Probe Mode

ASTM E499 — Standard Methods of Testing Leaks Using the Mass Spectrometer Leak Detector in the Detector Probe Mode

5 Terminology

5.1 Definitions

5.1.1 *acceptance test* — a test conducted on each component, subsystem, or system produced. It is the basis for acceptance or rejection by the purchaser. The purpose of acceptance testing is to provide a check to ensure that the component, subsystem, or system has been properly assembled or manufactured.

5.1.2 *component* — an individual piece or a complete assembly of individual pieces capable of being joined with other pieces or components. The typical components referred to by this specification are valves, fittings, regulators, pressure gauges, pressure and flow sensors, and tubing welded to fittings.

5.1.3 *design pressure* — of a system or subsystem, the pressure at the most severe condition of internal and external pressure expected during normal service. The maximum pressure expected in any portion of a system or subsystem is typically determined by the maximum adjustable setting of the last pressure regulator that supplies it, the supply pressure to the regulator, or the actuation pressure of any relief device incorporated.

5.1.4 *high-purity* — of a system, subsystem, or component used for the control of chemicals (gases or liquids), designed and constructed in such a manner that it does not introduce significant impurities, particulate or molecular, into the flow stream it controls or regulates.

NOTE 1: Such systems, subsystems, or components are designed and constructed such that, if an impurity is introduced into the flow path, it can be readily purged to an insignificant level.

5.1.5 *leak* — a path (or paths) in a sealed system that will pass tracer gas when a pressure differential or diffusion path exists. There are two leak mechanisms: a mechanical passage and a material through which gas can diffuse or permeate. A leak may have both mechanisms operating in parallel.

5.1.6 *leakage, inboard* — leakage from outside to inside occurring when the internal pressure is less than the external pressure acting on a component. Inboard leakage is typically determined by introducing a tracer gas around the exterior of the piping system or component under test.

NOTE 2: Inboard leak tests are easier tests to conduct to high sensitivity levels, but are typically not indicative of pressurized operating conditions. It is difficult to correlate an inboard leak test to the performance of a component, subsystem, or system when under internal pressure. Also, the internal collapsing forces created by external pressure may mask leaks which may exist under pressurized operating conditions.

5.1.7 *leakage, internal* — leakage occurring within a component across a flow barrier, such as the seat of a closed valve.

5.1.8 *leakage, outboard* — leakage from inside to outside occurring when the internal pressure is greater than the external pressure acting on a component. Outboard leakage is typically determined by introducing a tracer gas into the interior of the piping system or component under test.

5.1.9 *may* — a term indicating that a provision is neither required nor prohibited by this specification.

5.1.10 *measured leak rate* — the rate of leakage of a given component, subsystem, or system measured under specific conditions and employing a tracer gas.

NOTE 3: When testing with high-pressure 100% helium on a mass spectrometer leak detector, measured leak rates must be converted to equivalent standard leak rates.

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; <http://www.astm.org>

5.1.11 *qualification test* — a test conducted on samples of production articles manufactured to a single design to establish the performance rating of a product. The tests are extensive and closely controlled and completely analyze the characteristics of a component for use in a high-purity installation.

5.1.12 *rated pressure* — the manufacturer's recommended maximum allowable operating pressure at the manufacturer's rated temperature.

5.1.13 *shall* — a term indicating that a provision is a requirement of this specification.

5.1.14 *should* — a term indicating that a provision is recommended as good practice but is not a requirement of this specification.

5.1.15 *shutoff valve* — a valve designed for, and capable of, positive closure to prevent flow within a system. Typical shutoff valves include manually actuated, power-actuated, or spring-actuated, fail-safe shutoff valves. Generally excluded are self-actuated valves such as check valves, pressure regulators, flow controllers, and other devices not intended to provide positive shutoff.

5.1.16 *standard leak rate* — the flow of helium at 21.1°C (70°F) and 101.3 kPa (1 atm) through a leak when the partial pressure of helium on the high side is 101.3 kPa and the partial pressure on the low side is below 133 Pa (1 torr).

NOTE 4: Express leak rates in kiloPascal-liters per second (kPa-L/sec). Calculate the standard leak rate of helium from the measured leak rate by multiplying by the ratio of 101.3 kPa to the partial pressure of helium, as follows:

$$\text{Standard} = \left[\frac{101.3 \text{ kPa}(1 \text{ atm}) \times \text{measured leak rate}}{\text{actual He partial pressure}} \right] \quad (1)$$

5.1.17 *subsystem* — an assembly of two or more components manufactured as a single entity. A subsystem must be combined with one or more additional components or subsystems to form a complete system. The typical subsystems referred to by this specification are gas source manifolds, gas distribution manifolds, and gas control manifolds within the process equipment.

5.1.18 *system* — an integrated structure of components and subsystems capable of performing, in aggregate, one or more specific functions. For the purpose of this specification, a system includes the gas source manifold, its connection to the gas source, the distribution piping, and the gas control manifold within the process equipment.

6 Ordering Information

6.1 Orders for equipment or services requiring leak testing in accordance with this specification shall include:

- a) This specification number and date of issue.
- b) Acceptance test requirements and applicable test paragraphs of this specification for the specific product being purchased.
- c) Qualification test requirements, if any, and applicable test paragraphs of this specification for the specific product being purchased.
- d) The design pressure to be used for internal and outboard leakage testing of systems, subsystems, or components.
- e) Whether certification of the qualification or acceptance tests and a report of test results is required.

7 Requirements

7.1 *Personnel Qualifications* — Personnel performing tests in accordance with this specification shall have suitable training and experience. Such personnel should, as a minimum:

- a) be trained and experienced in the use of mass spectrometer leak detectors,
- b) be familiar with the use of the ASTM test methods referenced by this specification, and
- c) be familiar with the operation and calibration of the specific equipment used in performing the tests.

7.2 Tests

7.2.1 Prior to initial operation, test each component, subsystem, and system in accordance with this specification.

7.2.2 If repairs or additions are made after the leakage tests, retest the affected portions of the component, subsystem, or system.