![SEMI logo] semi™

Figure 1 (continued)
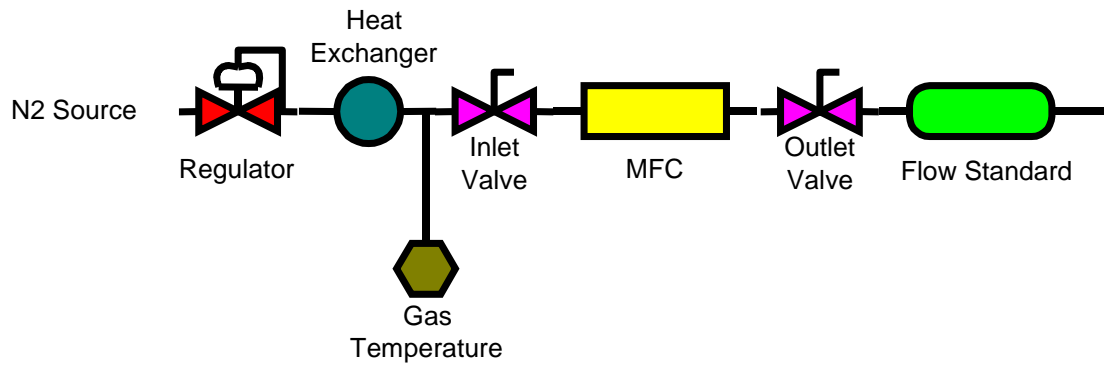**Flow Chart of Test Method**

Figure 2
MFC Test Setup

NOTE 1: Change Power Amp as Required.
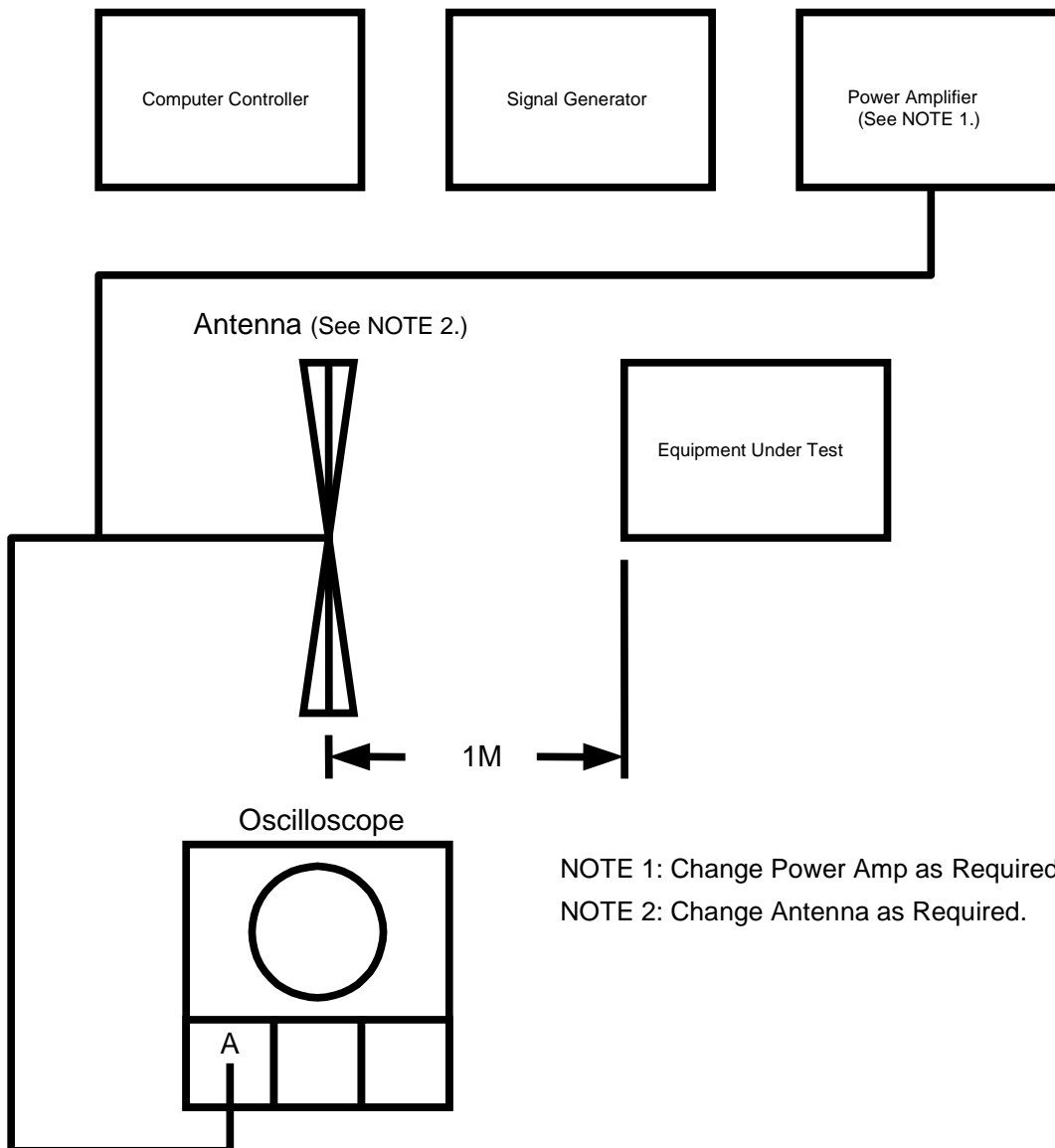
NOTE 2: Change Antenna as Required.

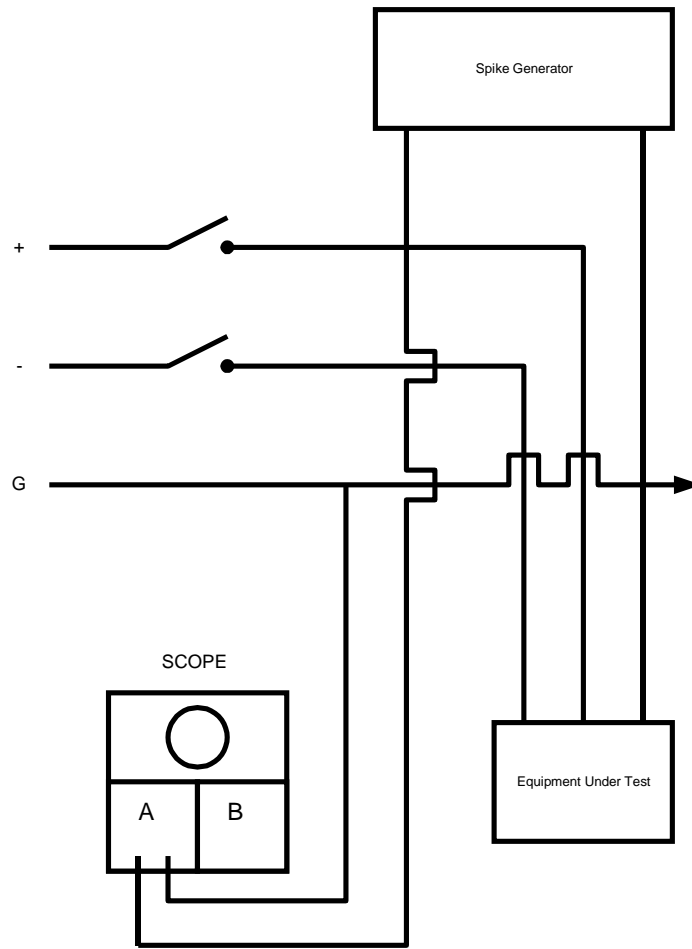**Figure 3**
Radiated Electric Field Susceptibility Test Setup

Figure 4
Transient Susceptibility (Conducted) Test Setup

Table 1 Data Sheet for EM Susceptibility Testing

Initial Condition	
MFC Indicated Output	
Flow Standard Output	
Ambient Temperature	°C
Gas Temperature	°C
Gas Pressure	psig

MFC Cable Shielding and Connector	
Cable Shielding	
Type of MFC Connector	

EM Susceptibility Testing					
I. EM Field-Radiated					
Data Points	Frequency (Hz)	Field Strength (V/m)	MFC Indicated Flow (V)	Flow Standard Output	MFC Indicated Flow (%FS)	Flow Standard (%FS)
1						
2						
3						
: :						

EM Susceptibility Testing					
II. EM Field-Conducted					
Data Points	Spike Amplitude (V)	Location of Spike Input	MFC Indicated Flow (V)	Flow Standard Output	MFC Indicated Flow (%FS)	Flow Standard (%FS)
1						
2						
3						
: :						

Table 2   Results of Electromagnetic Susceptibility Testing

					A. Radiated Susceptibility	
Data Points	Freq. (Hz)	Field Strength (V/m)	MFC Indicated Flow (%FS), corrected for zero	Flow Standard (FS%), corrected for zero	Change in Flow from Reference	
					MFC (%FS)	Std. (%FS)
1						
2						
3						
4						
5						
: :						

					B. Conducted Susceptibility	
Data Points	Spike Amplitude (V)	Location of Spike Input	MFC Indicated Flow (%FS), corrected for zero	Flow Standard (FS%), corrected for zero	Change in Flow from Reference	
					MFC (%FS)	Std. (%FS)
1						
2						
3						
4						
5						
6						
: :						

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SEMI F54-1000
TEST METHOD FOR MEASURING THE COUNTING EFFICIENCY OF CONDENSATION NUCLEUS COUNTERS

1 Purpose

1.1 Particle specifications for gases require the use of condensation nucleus counters (CNCs) having specified counting efficiencies. This document provides the test method for determining the counting efficiencies of CNCs.

2 Scope

2.1 This document provides the method for 1) generating an aerosol standard consisting of sodium chloride (NaCl) particles having sizes 0.01 micrometer and larger suspended in air at atmospheric pressure (1×10^5 Pa), 2) controlling the size and concentration of particles in the aerosol, and 3) using the aerosol to determine the counting efficiency of a CNC as a function of particle size. This method is suitable for CNCs having a lower size sensitivity of 0.01 micrometer or larger.

NOTE 1: Suitable test methods for calibrating optical particle counters are contained in ASTM F328 and JIS B 9921.

2.2 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 does not provide the method for adjusting the CNC's counting efficiency.

3.2 This document does not provide the method for determining the CNC's background noise level, maximum concentration limit, or maximum detectable particle size.

4 Referenced Standards

4.1 *ASTM standards*[1]

ASTM D1193 — Standard Specification for Reagent Water

ASTM F328 — Standard Practice for Calibration of an Airborne Particle Counter Using Monodisperse Spherical Particles

4.2 *JIS standard*[2]

JIS B 9921 — Japanese Industrial Standard, Light Scattering Automatic Particle Counter

NOTE 2: As listed or revised, all documents cited shall be the latest publications of adopted standards.

5 Terminology

5.1 *aerosol electrometer* — an instrument that converts the charge flow in an aerosol stream to an electrical current signal.

5.2 *aerosol standard* — an aerosol containing particles of a known size and concentration.

5.3 *coincidence error* — the inaccuracy in a measured particle concentration caused by multiple particles in the optical sensing volume of an instrument.

5.4 *concentration limit* — the maximum concentration of particles in an aerosol to avoid a coincidence error of 10% or greater in an instrument.

5.5 *counting efficiency* — the ratio of the concentration of particles reported by the CNC to that reported simultaneously from the same aerosol by a reference instrument.

5.6 *lower size sensitivity* — the particle size corresponding to 50% counting efficiency for the CNC.

5.7 *monodisperse aerosol* — an aerosol having a narrow distribution of particle sizes. The maximum band width of a monodisperse aerosol is defined in Section 8.7.

5.8 *particle concentration* — the number of particles per unit volume in a gas.

5.9 *polydisperse aerosol* — an aerosol having a wide distribution of particle sizes.

NOTE 3: Additional terminology is contained in ASTM F328 and JIS B 9921.

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6 Summary of Method

6.1 The measurement is performed using aerosol standards consisting of NaCl particles suspended in air. Aerosols are produced by nebulizing a solution of NaCl in water. After drying and charge neutralization, particles of the required size are extracted from the aerosol using an electrostatic classifier (EC). The concentration of particles in the resulting monodisperse aerosol is then recorded by the CNC and compared to that measured simultaneously by a reference instrument. Examples of suitable reference instruments are described in Section 8.8.

NOTE 4: This method has been shown to provide repeatable results in tests performed in separate laboratories on similar CNCs. Examples of these tests are found in Agarwal and Sem[3] and Bartz, et al[4].

7 Requirements

7.1 The reference instrument must have a proven counting efficiency of not less than 95% over the entire range of particle sizes tested. Low counting efficiency in the reference instrument results in an error in the measured particle concentration. The counting efficiency for the reference instrument must be checked by the manufacturer against a calibrated standard, such as a calibrated aerosol electrometer.

7.2 Coincidence error in either the CNC or the reference instrument causes inaccuracy in the measured particle concentration. The concentration limit for each instrument must be obtained from the manufacturer's specifications. The particle concentration in the aerosol standard must be kept below both concentration limits.

7.3 When an aerosol electrometer is used as the reference instrument, the minimum detectable particle concentration must be obtained from the manufacturer's specifications. A particle concentration below the minimum detectable value will cause inaccurate results. The particle concentration in the aerosol standard must be kept above the minimum detectable particle concentration.

7.4 The transport loss of particles from the EC to the CNC, and from the EC to the reference instrument must be checked. Any disparity in particle transport loss to the two instruments will cause erroneous results. The method for calculating the transport loss of particles in

sample lines is found in Pui, et al[5]. The transport loss must be calculated for each particle size tested. Record all transport loss calculations.

7.5 When an aerosol electrometer is used as the reference instrument, a correction must be made for multiple charging of particles in the aerosol standard. Multiple charging can cause substantial error when measuring particles larger than 0.06 micrometer. The correction factor for multiple charging must be obtained from the manufacturer of the EC. An example of the method for calculating the correction factor is found in Liu and Pui[6].

8 Apparatus

8.1 *Atomizer* — A sub-micrometer aerosol generator capable of nebulizing a liquid solution. The atomizer must be capable of producing a stable aerosol containing particles as small as 0.01 micrometer after drying.

8.2 *Liquid Trap* — A device which allows free passage of an aerosol stream containing sub-micrometer particles, but which removes the entrained liquid phase by gravitational settling into a reservoir.

8.3 *Diffusion Drier* — A device which allows free passage of an aerosol stream containing sub-micrometer particles, but which dries the aerosol by diffusion of water vapor into a surrounding desiccant medium. The design flow rate of the diffusion drier must at least match the output flow rate of the atomizer.

8.4 *Aerosol Neutralizer* — A bipolar charging device which neutralizes aerosols by producing both positive and negative air ions. The neutralizer must reduce the charge on the particles to the Boltzmann equilibrium level. The design flow rate of the neutralizer must at least match the output flow rate of the atomizer.

8.5 *Bypass Filter* — A high efficiency point of use gas filter. The design flow rate of the bypass filter must at least match the output flow rate of the atomizer.

8.6 *Mixing Vessel* — A device which disperses particles in a flowing aerosol by inducing turbulence.

8.7 *Electrostatic Classifier* (EC) — A device which extracts particles from a polydisperse aerosol according to their electrical mobility. The electrical mobility of a particle depends upon its size and charge. The EC must extract a monodisperse aerosol standard having a

3 Agarwal, J. K. and Sem, G. J. Continuous Flow, Single-Particle-Counting Condensation Nucleus Counter. Journal of Aerosol Science, 11: 343-357 (1980)

4 Bartz, H., Fissan, H., Helsper, C., Kousaka, Y., Okuyama, K., Fukushima, N., Keady, P. B., Kerrigan, S., Fruin, S. A., McMurry, P. H., Pui, D. Y. H. and Stolzenburg, M. R. Response Characteristics for Four Different Condensation Nucleus Counters to Particles in the 3-50 nm Diameter Range. Journal of Aerosol Science, 16 (5): 443-456 (1985)

5 Pui, D. Y. H, Ye, Y. and Liu, B. Y. H. Sampling, Transport, and Deposition of Particles in High Purity Gas Supply System. Proceedings 9th ICCCS: 287-293, (1988)

6 Liu, B. Y. H. and Pui, D. Y. H. A Submicron Aerosol Standard and the Primary, Absolute Calibration of the Condensation Nuclei Counter. Journal of Colloid and Interface Science, 47 (1): 155-171 (1974)

narrow band width. The mobility band width of the extracted aerosol must be no greater than 20% of the mean particle mobility. The method for calculating electrical mobility and mobility band width are found in Liu and Pui[6].

8.8 *Reference Instrument* — An instrument which can measure the concentration of particles in an aerosol. The calibration of the reference instrument must have been checked against a calibrated standard within the past 12 months. Calibration and maintenance records for the reference instrument must be maintained. Suitable reference instruments include aerosol electrometers and CNCs having lower size sensitivities below 0.01 micrometer.

8.9 *Condensation Nucleus Counter (CNC) or Condensation Particle Counter (CPC)* — The particle counter to be used in process gas particle measurements, and for which the calibration check is required. The CNC detects sub-micrometer particles using nucleation and droplet growth of a super-saturated working fluid.

8.10 *Tubing* — In order to minimize particle losses, all tubing used to transport charged aerosol particles must be constructed from electrically conductive materials (e.g., stainless steel) and grounded.

9 Reagents and Materials

9.1 De-ionized or distilled water in accordance with ASTM D1193, Type 1 is required to dissolve NaCl for aerosol generation.

9.2 NaCl is required for aerosol generation.

9.3 A supply of dry, oil-free compressed air is required to generate and transport aerosols in the apparatus.

10 Preparation of Apparatus

10.1 The test apparatus is shown in Figure 1. The particle concentration in the aerosol is controlled using a bypass filter. If the flow rate of the monodisperse aerosol from the EC is insufficient to supply the CNC and reference instrument simultaneously, filtered air must be added to the stream. The air must be added to the aerosol upstream of a mixing vessel. If the flow rate of the monodisperse aerosol from the EC is greater than that required to supply the CNC and reference instrument simultaneously, the excess aerosol must be vented.
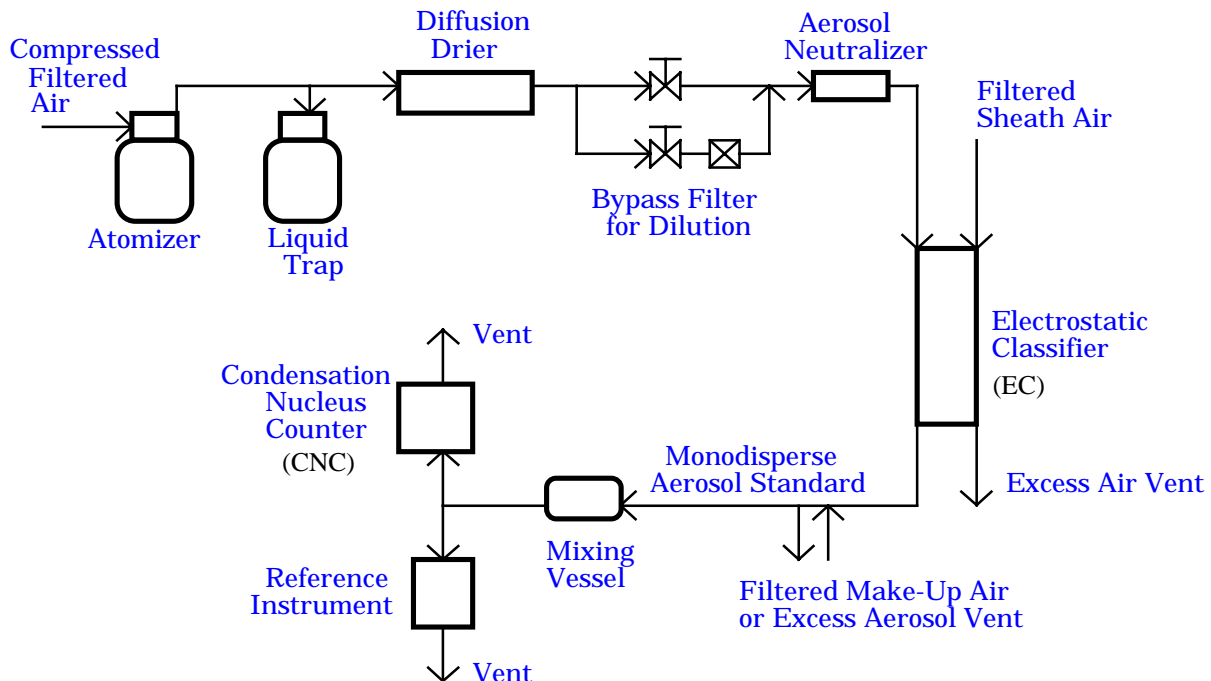

Figure 1
Schematic Diagram of Test Apparatus

11 Calibration and Standardization

11.1 All flow meters and voltage indicators used in the apparatus, including instruments incorporated into the EC and particle counters, must have been checked for proper calibration against calibrated standards within the past 12 months. Record all calibration data.

12 Procedure

12.1 Fill the atomizer reservoir with a solution of NaCl in water. The required NaCl concentration depends upon the range of particle sizes to be tested, and must be determined from the atomizer manufacturer's specifications. Record the concentration of NaCl in the solution.

12.2 Determine the required aerosol, sheath air and excess air flow rates for the EC. The flow rates depend upon the range of particle sizes to be tested and the required mobility bandwidth, and must be determined from the EC manufacturer's specifications.

12.3 Close the bypass filter valve. Adjust the flow rates of the atomizer, CNC, and reference instrument to their manufacturer's specified values. Adjust the flow rates of the EC to their required values as described in Section 12.2. Adjust the flow rate of the make-up air or aerosol vent to the required value as described in Section 10.

12.4 Set the EC voltage to obtain the selected particle size for testing. Record the voltage setting and the selected particle size.

12.5 Observe the particle concentration indicated by the reference instrument. If the particle concentration exceeds the concentration limit of the reference instrument or the CNC, adjust the flow rate through the bypass filter to lower the aerosol particle concentration. After adjusting the bypass flow rate, check all flow rates to ensure that they remain at the required values. Record all flow rates.

12.6 Wait for the particle concentrations indicated by the CNC and reference instrument to become steady; the concentrations indicated by each instrument must not change by more than 5% over a five minute interval. In order to minimize the error in the recorded particle concentrations, a minimum of 500 particles must be counted in a sample. Record the steady particle concentrations indicated by the CNC and reference instrument.

12.7 If another particle size is to be tested, return to Section 12.4.

NOTE 5: At least eight different particle sizes must be tested. The particle sizes must be selected such that the measured CNC counting efficiency at least spans the range 50% to 95%

(0.50 to 0.95). In order to eliminate systematic error, the particles sizes must be tested in random order.

13 Calculation and Interpretation of Results

13.1 When an aerosol electrometer is used as the reference instrument, correct the measured particle concentrations for multiple charging, as described in Section 7.5.

13.2 For each particle size tested, calculate the ratio of the concentration of particles reported by the CNC to that reported by the reference instrument. This ratio represents the counting efficiency of the CNC.

13.3 Plot the calculated counting efficiency against the particle size as shown in Figure 2. This plot shows the measured counting efficiency curve of the CNC.

Figure 2
Schematic Plot of Measured Counting Efficiency

13.4 Determine the lower size sensitivity of the CNC, as defined in Section 5. (The counting efficiency at any particle size can be estimated using linear interpolation between the data points.)

14 Reporting Results

14.1 The test record must include the following items:

a. test date;

b. test operator;

c. serial numbers of the reference instrument, CNC and EC;

d. all particle transport loss calculations as described in Section 7.4;

e. all flow meter and voltage indicator calibration data as described in Section 11;

f. all raw data and calculations utilized in the test method as listed in Sections 12 and 13;

g. counting efficiency of the CNC as a function of particle size; and

h. the lower size sensitivity of the CNC.

Appendix 1 contains an example report form.

15 Precision and Accuracy

15.1 This method requires a minimum of 500 particles counted in a sample. For Poisson distributed data, the relative standard deviation of the measured particle concentration is less than 5% when at least 500 particles are counted in a sample.

APPENDIX 1
EXAMPLE REPORT FORM

NOTE: The material in this appendix is an official part of SEMI F54 and was approved by full letter ballot procedures on July 13, 2000 by the North American Regional Standards Committee.

A1-1 Test dates: _____

A1-2 Operator(s) performing test: _____

A1-3 Serial numbers: _____ Reference instrument _____

CNC _____ EC _____

A1-4 Attach flow meter and voltage indicator calibration data as described in Section 11.

A1-5 Data and calculations: _____

_____

Data Point (Use Additional Sheets as Necessary)

	1	2	3	4	5	6	7	8
NaCl Concentration (gm/l)								

Flow Rates (cm^3/s)

	1	2	3	4	5	6	7	8
EC Aerosol								
EC Sheath								
EC Excess Air								
CNC								
Reference Instrument								
Make-up Air or								
Excess Aerosol Vent								

	1	2	3	4	5	6	7	8
EC Voltage (V)								
Particle Size (micrometer)								

Measured Particle Concentrations (Particles/cm^3)

	1	2	3	4	5	6	7	8
CNC **(1)**								
(1) Corrected for Transport Loss **(2)***								
Reference Instrument **(3)**								
(3) Corrected for Multiple Charging (Electrometers Only) **(4)***								
(4) Corrected for Transport Loss **(5)***								
Counting Efficiency = (2)/(5)								

A1-6 Attach plot of counting efficiency as a function of particle size

A1-7 Lower size sensitivity (micrometer)* _____

---

* Attach calculations.

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NOTICE: SEMI makes no warranties or representations as to the suitability of the test method set forth herein for any particular application. The determination of the suitability of the test method is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These test methods are subject to change without notice.

The user's attention is called to the possibility that compliance with this test method may require use of copyrighted material or of an invention covered by patent rights. By publication of this test method, SEMI takes no position respecting the validity of any patent rights or copyrights asserted in connection with any item mentioned in this test method. Users of this test method are expressly advised that determination of any such patent rights or copyrights, and the risk of infringement of such rights, are entirely their own responsibility.

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SEMI F55-0600
TEST METHOD FOR DETERMINING THE CORROSION RESISTANCE OF MASS FLOW CONTROLLERS

1 Purpose

1.1 A mass flow controller (MFC) is often used to control corrosive gases under unfavorable conditions. This test method is intended to help differentiate between MFC designs on the basis of relative resistance to corrosion-induced failure.

2 Scope

2.1 This test is intended to show the effect of corrosion caused when a corrosive gas such as HCl is contaminated by an oxidizer such as atmospheric moisture. For the purpose of this test HCl is the preferred test gas, however this test can also be performed with other gasses. This test method describes a corrosive gas exposure test for mass flow controllers. The test is intended to accelerate the corrosion while simulating conditions that may be found within process equipment and gas systems in the semiconductor industry. As the relationship between corrosion and performance may differ with MFC design, corrosion is not measured directly. The effects of corrosion are detected by observing changes in MFC calibration and other operating parameters.

2.2 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 test method should not be expected to yield comparable quantitative results from one test facility to another.

3.2 Results may be compromised by the methods used to construct the apparatus.

3.3 This test is designed to be a destructive test. The MFC tested will be destroyed. This test is intended only for MFCs manufactured for use in HCl or a similar highly corrosive gaseous environment. MFCs manufactured for non-corrosive service may develop leaks or other catastrophic failures if tested by this method. For practical reasons in constructing and operating the test bed, test samples may be limited to 100 sccm N_2 equivalent full scale (FS) flow.

3.4 This method does not measure corrosion directly by analyzing or inspecting the gas-wetted surfaces following exposure to a corrosive. No attempt is made to detect particles in the exit gas stream resulting from the corrosion process.

4 Referenced Documents

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

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

5 Terminology

5.1 *Acronyms and Abbreviations*

5.1.1 *DUT* — device under test

5.1.2 *FS* — full scale

5.1.3 *kPa* — kiloPascal

5.1.4 *MFC* — mass flow controller

5.1.5 *MFM* — mass flow meter

5.1.6 *ppbv* — parts per billion by volume

5.1.7 *ppmv* — parts per million by volume

5.1.8 *sccm* — standard cubic centimeters per minute using a standard temperature of 0° C and a standard pressure of 101.32 kPa.

5.2 *Definitions*

5.2.1 *actual flow* — for the purpose of this standard, the output value of the reference flowmeter.

5.2.2 *ambient temperature* — the temperature of the medium surrounding the device. Under ordinary laboratory benchtop conditions, ambient temperature is the temperature of the room.

5.2.3 *indicated flow* — the electrical output of the device under test (DUT).

5.2.4 *valve drive* — electrical output from the DUT which is analogous to the level of power supplied to the

control valve. This output is sometimes called valve voltage.

6 Summary of Method

6.1 Corrosive gas and moisture-containing N_2 are alternately flowed through the DUT with intervening dry N_2 purges. The test MFC is monitored over time for changes in performance resulting from corrosion.

6.2 This test is intended to be an accelerated simulation of the effects of alternating corrosive and moisture-exposure conditions. The test records how long it takes for corrosion to affect calibration. MFCs that are more resistant to corrosion failures should last longer under the test conditions. A dry N_2 purge separates each MFC's exposure to the corrosive gas and to the moisture-containing gas. This purging favors MFC designs that perform well in corrosive service because those MFCs can be dried out quickly with limited purging.

6.3 This method is expected to yield data that can be used to compare the relative performance of components tested for the purpose of qualification.

7 Interference's

7.1 Portions of the gas system exposed to HCl may require replacement or cleaning and refurbishment between test sequences to avoid invalidating subsequent tests by prematurely contaminating DUTs. Take care in the design and maintenance of the system so that particles shed from upstream piping components as a byproduct of corrosion are minimized so that they do not affect the DUT.

8 Apparatus

8.1 *Containment System* — to contain corrosive gas leaks that may develop in the DUT or gas system. The portion of the system that contains the corrosive gas should be operated in a suitable secondary containment environment.

8.2 *Power Supply*, *Controls*, and *Data Collection Devices* — capable of recording data 20 times per second. Signals should be measured with a resolution of one mV or better. Data may be recorded in convenient units such as volts, sccm, or percent of FS. For the purpose of analysis and reporting, data should be converted to percent of FS except for valve drive, which may be reported in either percent of maximum drive or volts.

8.3 *DUT*

8.4 *Data Acquisition System* — Recommended as a data collection system to facilitate test sequencing and data collection.

8.5 *Plumbing* — with tubing and gas-switching valves constructed from 316L electropolished stainless steel or other material that exhibits superior corrosion resistance compared to 316L. The use of materials such as plastics, which retain or are permeable to water vapor, are not appropriate. All-metal sealed valves (no elastomers) are readily available and must be used.

8.6 The test plumbing is intended to represent the technology level found in the semiconductor process gas piping in which a typical DUT will operate.

8.7 A filter has not been specified immediately upstream of the DUT because it would harbor contaminates and make it difficult to alternate gas types.

8.8 *Dry N_2 Source* — pressure regulated source with a moisture level no greater than 50 ppbv.

8.9 *Dry HCl Source* — pressure regulated source with a moisture level no greater than 500 ppbv.

8.10 *Reference Flowmeter* — traceable with calibration certificate, calibrated for N_2, FS flow 100% to 125% of the FS N_2 equivalent flow range of the DUT Accuracy better than 5%, linear to 0.5% FS repeatable to 0.15% over a three-hour period, and reproducible to 0.3% of the test flow for the duration of the test.

NOTE 2: As this test is concerned with changes in DUT calibration and not the value of DUT calibration itself, the accuracy of the reference flowmeter is not paramount.

8.11 *Moisture Generator* — to introduce water vapor in a concentration of 100 ppmv (μl/l) $\pm$ 20% in N_2.

8.12 *Moisture Analyzer* — to periodically verify the output of moisture generator.

9 Reagents and Materials

9.1 *HCl*

9.2 *N_2*

10 Safety Precautions

10.1 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

NOTE 3: The DUT will be contaminated with corrosive material at the conclusion of this test. Caution should be exercised in handling. A contaminated DUT should be properly decontaminated.

10.2 Become familiar with the safe handling practices associated with the corrosive gas before undertaking this test.

11 Preparation of Apparatus

11.1 The test apparatus is the source of three gases—dry N_2, dry HCl, and N_2 containing a known level of water vapor. Each gas can be valved through the DUT individually with minimal cross contamination. The DUT actively controls the gas flow in each case. The gas then flows into either a scrubbed exhaust system for safe disposal or a reclamation system. A reference flowmeter in the dry N_2 supply line is used to detect changes in calibration of the DUT when dry N_2 is flowing in series through both devices.

11.2 *Setup and Schematic* — See Figure 1 for a schematic of the test apparatus. This schematic may not show in detail all the components required in an actual system.

11.3 Supply the manufacturer's recommended power to the DUT. Provide MFC setpoint and purge command (if available). Monitor the following:

11.3.1 DUT setpoint input.

11.3.2 DUT indicated flow output.

11.3.3 DUT valve drive output (if available)

11.3.4 actual flow (output of reference flowmeter)

11.4 Verify that the proper moisture levels exist in each of the test gases.

11.5 Provide a purge flow loop that maintains a constant flow of dry N_2 in the line from the DUT to the exhaust system. Flow in this loop must be sufficient to prevent back diffusion into the DUT of moisture generated in the exhaust system, particularly when flow into the DUT is shut off for measuring zero.

11.6 If the moisture generator is supplied from the same N_2 source that supplies the dry N_2, take precautions to avoid the diffusion of moisture from the moisture generator into the dry N_2 line. Such precautions may include the use of separate pressure regulators and other valving.

11.7 Moisture generators typically take time to stabilize. A continuous flow should be maintained through the moisture generator during the test to maintain a stable moisture flow. This may require diverting the output flow to a vent when not flowing through the DUT.

11.8 Periodically verify the moisture concentration of wet N_2 with a suitable moisture analyzer.

11.9 Follow manufacturer set-up procedures for all equipment.

11.10 Conduct the test at an ambient temperature of 22 ± 2°C.

11.11 The DUT moisture generator, flowmeters, and other instrumentation should have been stabilized at room temperature for 24 hours before beginning the tests. It is not necessary to flow gas during this stabilization time.

11.12 All portions of the plumbing system that could contain HCl must be helium leak tested per SEMI F1 before introducing HCl into the system. When changing the DUT or other components, at least those portions of the system that were changed must be re-tested.

NOTE 4: Small leaks in a corrosive gas system can become much larger without warning.

12 Calibration and Standardization

12.1 Calibrate all instrumentation using current standards that are traceable to an appropriate standards laboratory. In the absence of appropriate standards, use manufacturer recommendations for calibration.

13 Procedure

NOTE 5: Refer to Figure 2 for a flowchart of the following test.

13.1 Set the pressure of each of the HCl and Dry N_2 gas sources at 140 kPa ± 5%. Set the pressure of the N2 to the moisture generator to the appropriate value recommended by the manufacturer. If the test must be run at some other pressure, because of a limitation of the DUT, report this fact in the test results.

13.2 Start the wet N_2 flow to vent or through the moisture analyzer. Establish a stable moisture concentration at 100 ppmv ± 20% before beginning the test sequence. Set the wet N_2 to flow within ± 5% of the DUT flow that will be run during the test.

13.3 Place the DUT control valve in the purge or fully open position by supplying a purge command or a 200% setpoint. Purge with dry N_2 at a rate of one to two times FS flow for one hour to establish initial conditions. The purge rate is controlled by adjusting the supply pressure and is monitored by a purge-rate flowmeter located in the gas-supply path. Follow the manufacturer's procedure for fully opening the DUT control valve.

13.4 Provide a setpoint to the DUT for 80 ± 5% of FS flow.

13.5 Determining the Test Baseline and Measurement Repeatability.

NOTE 6: Data throughout this test may be recorded in a format similar to that found in Table A1.1.

13.6 Open valve V1 and flow dry N_2 at a setpoint of 80% ± 5% of the DUT FS and wait 10 minutes.

13.7 Record:

13.7.1 DUT setpoint

13.7.2 DUT indicated flow

13.7.3 DUT valve drive output (if available)

13.7.4 Actual flow

13.8 Stop flow by closing V1. Drive the MFC control valve to a closed position by providing a zero setpoint or as otherwise provided by the manufacturer. Allow the MFC indicated flow output to stabilize for a minimum of three minutes.

13.9 Record the DUT indicated flow and the actual flow during the zero flow condition.

13.10 Repeat Sections 13.6 through 13.9 twelve times. This will yield 12 data points for each of the six measured parameters.

13.11 For each of the six parameters recorded, perform the following calculation on the 12 baseline data points to determine the repeatability of the measurement:

$$\frac{\text{(highest value - lowest value)}}{\text{average of the 12 values}} \times 100$$

13.12 If each of the six parameters is not repeatable within 0.2% during these two hours, subsequent test data may not be valid and the problem should be resolved before proceeding with the test.

13.13 Baseline

NOTE 7: Use the averaged value of the measurements made in Section 13.13 for each parameter as the baseline for that parameter in the following tests.

13.14 *Test Sequence* — Without changing the DUT setpoint, repeat the test sequence in Sections 13.19-13.22 every 30 minutes, continuously, 24 hours per day, seven days per week until one of the following test termination conditions is met.

13.15 The test should not be interrupted because the DUT may continue to corrode during the interruption, making test results non-repeatable. The output of the moisture generator should be measured periodically during the test sequence to ensure that it remains within the test specifications.

13.16 Terminate the test sequence if:

13.16.1 The DUT fails to function

13.16.2 The actual-flow shift from baseline exceeds 25%

13.16.3 The valve drive exceeds the manufacturer's limits

13.16.4 The DUT indicated flow differs from commanded setpoint by > 5%

13.16.5 The test exceeds 5000 cycles

13.17 Flow dry N_2 for five minutes. After five minutes, record data on the six test parameters as done in Section 13.7, interrupting flow to record the DUT indicated flow and reference flowmeter output at zero flow. After taking measurements, flow dry N_2 again so that the total length of this step is 10 minutes. Record data as shown in Figure 3.

13.18 Flow dry HCl for seven minutes.

13.19 Repeat Section 13.19 and then proceed to Section 13.22.

13.20 Flow wet N_2 for three minutes. If no test termination condition is met as described in Section 13.18, repeat Sections 13.19 - 13.22. If a test termination condition is met, proceed to Section 13.23.

13.21 After the test has been completed, place the DUT control valve in the purge or fully open position. Purge with dry N_2 for one hour or at least 50 volume changes. Cycle the purge gas for 15 seconds on and 15 seconds off by opening and closing V1 for the duration of the purge. Follow the manufacturer's procedure for fully opening the DUT control valve.

NOTE 8: Verify purge flow with the reference flowmeter or by using other means. Corrosion may have rendered the control valve inoperable. An alternate approach for purging any corrosive material from the system may have to be followed.

13.22 Alternate Approach to Purging.

13.23 If gas cannot be purged through the DUT, cycle-purge each end of the DUT separately using Sections 13.26 through 13.28.

13.24 With valves V2 and V3 closed for the duration of the procedure, close valve V6 and pressurize both sides of the system by opening V1 and V7 for 15 seconds.

13.25 Vent pressure through the exhaust system by closing V1 and opening V6 for 15 seconds.

13.26 Repeat pressure and vent cycles for a minimum of one hour.

13.27 Remove the DUT. Preserve the test system, if desired, by taking steps to exclude atmospheric moisture. Such steps could include capping the system and shutting all valves. Alternately, the DUT may be

replaced with a spool piece. The system can then be continuously purged with dry N_2.

NOTE 9: The DUT will be contaminated with corrosive material. See *Precautions* in Section 10. Preserve the DUT for failure analysis, if desired.

14 Calculations or Interpretation of Results

14.1 Report data in a tabular format and graph per Appendix 1. Any parameter which changes more than 1% from its baseline should also be graphed. Note the reason the test was terminated. Test results may be summarized in a single parameter by reporting the number of test cycles to reach a 2% shift in actual flow or to reach DUT failure, whichever occurs first. In this test, more data is reported than is required to calculate the gross test result. The extra data is used when analyzing test results to determine the cause of failure. Further explanation of the significance of the data is beyond the scope of this test method.

15 Data Analysis.

15.1 Calculate any parameter-shift in percent as follows:

$$\frac{(\text{baseline value - current value}) \times 100}{\text{baseline value}}$$

16 Reporting Results

16.1 Report the number of test cycles to reach a 2% shift in actual flow or to reach DUT failure, whichever occurs first.

17 Precision and Accuracy

17.1 This method is limited in its precision by the calibration of the measurement devices, the temperature of the apparatus, and the concentration of water vapor in N_2. Sources of bias are unknown at this time, but they probably include peculiarities in the construction of the apparatus.

18 Related Documents

18.1 Material safety data sheet (MSDS) for hydrogen chloride, which can be obtained from a supplier of the gas.
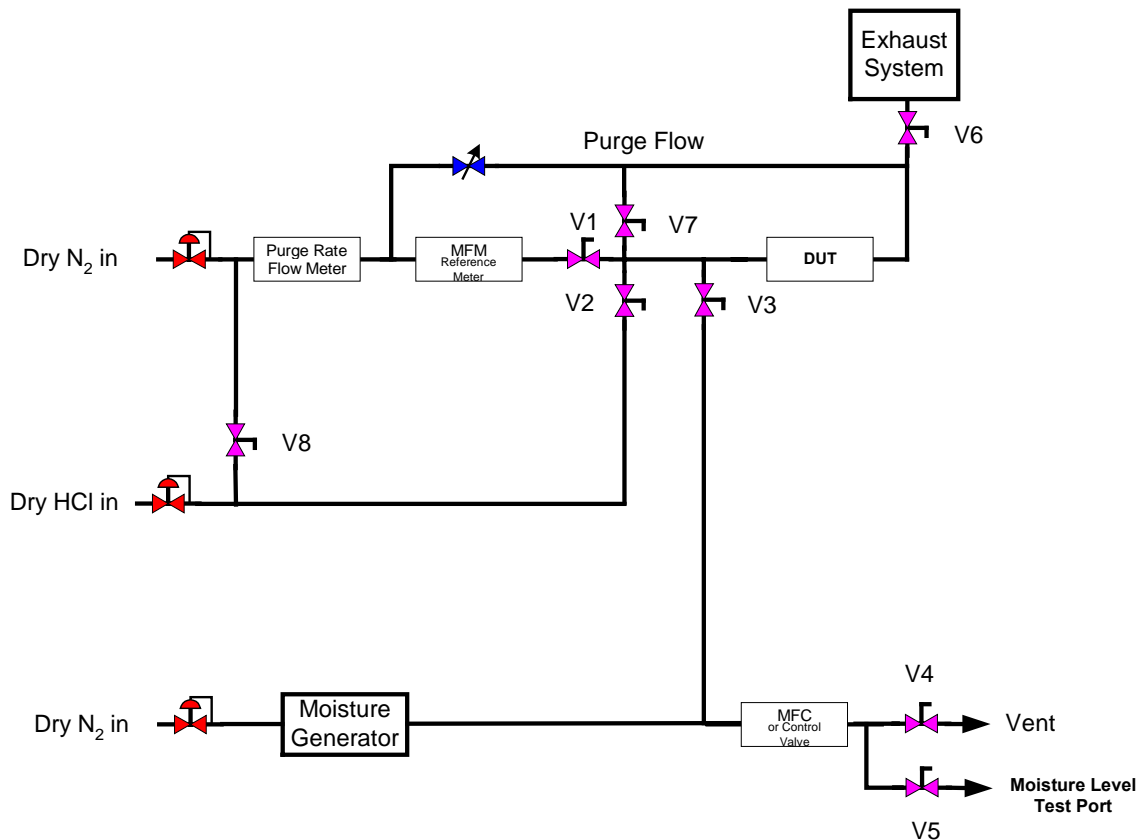
19 Illustrations
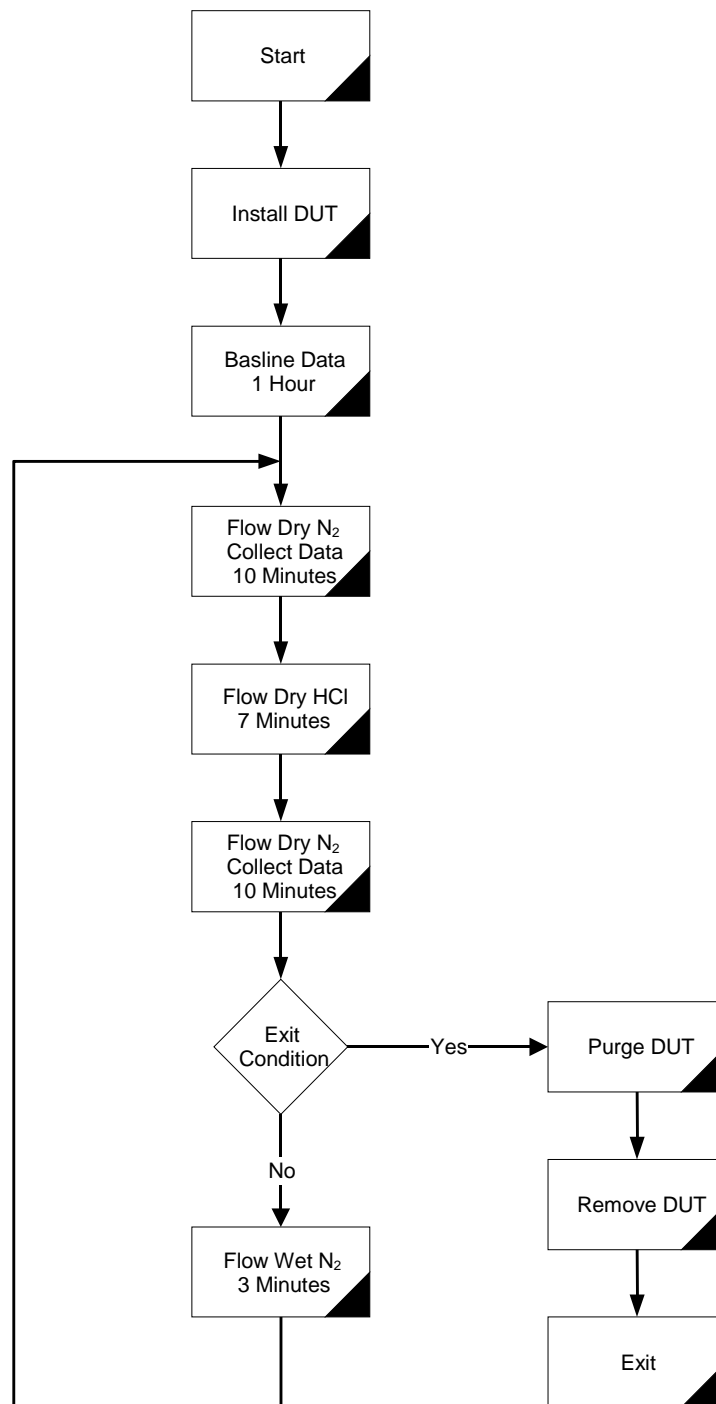

Figure 1
Schematic of Apparatus

Figure 2
Test Flowchart

APPENDIX 1
TEST REPORT CORROSION TEST

NOTE: The material in this appendix is an official part of SEMI F55 and was approved by full letter ballot procedures on April 10, 2000 by the North American Regional Standards Committee.

MFC Identification:	Wxyz Instruments, Model 123, Serial 230967
Calibrated for:	100 scm^3 HCl
Reference Flowmeter:	Mnop Company, Model 1023, Serial 37863, 100 sccm N_2
Test dates:	March 28 to May 5, 1993
Test Laboratory:	Flow Test and S.D. Associates, Inc.
Test supervised by:	George Smith

Table A1-1 Data in tabular format

A	B	C	D	E	F	G	H	J
TEST CYCLE #	TEST CYCLE HOURS	DUT SET-POINT %	DUT INDICATED %	DUT ZERO %	REFERENCE FLOW ZERO %	ACTUAL FLOW %	CALIBRATION SHIFT % CHANGE	VALVE DRIVE VOLTS
base line	base line	75.04	75.05	-0.13	0.03	71.12	0.0	-7.062
100	50	75.01	74.8	0.14	0.04	71.56	0.6	-7.066
200	100	75.00	74.82	0.13	-0.04	71.38	0.4	-7
300	150	74.99	75.1	-0.01	-0.03	71.26	0.2	-7.056
400	200	75.02	75.01	0.02	0.01	71.3	0.3	-7.049
500	250	74.98	74.96	-0.01	-0.03	71.36	0.3	-7.009
600	300	75.02	74.96	0.00	0.03	71.18	0.1	-6.997
700	350	74.99	74.92	0.11	-0.04	71.32	0.3	-7.042
800	400	75.00	75.15	-0.06	-0.04	71.37	0.4	-7.010
900	450	75.02	74.9	0.04	0.01	71.69	0.8	-6.997
1000	500	74.99	75.01	-0.09	0.04	71.96	1.2	-7.056
1100	550	75.01	74.82	0.13	0.04	72.55	2.0	-7.136
1200	600	75.03	75.1	-0.13	-0.02	72.92	2.5	-7.100
1300	650	75.05	75.19	-0.15	-0.03	74.17	4.3	-7.277
1400	700	74.96	75.09	-0.12	-0.01	76.15	7.1	-7.348
1500	750	75.04	75.05	-0.09	-0.01	79.86	12.3	-7.666
1600	800	74.96	75.15	-0.13	0.05	88.36	24.2	-8.278
1700	850	74.96	74.99	0.03	-0.02	110.53	55.4	-9.732

MFC Corrision Test

Figure A1-1
Test Results Graph

![semi logo]

SEMI F56-0600
TEST METHOD FOR DETERMINING STEADY-STATE SUPPLY VOLTAGE EFFECTS FOR MASS FLOW CONTROLLERS

1 Purpose

1.1 The purpose of this document is to define a method for characterizing mass flow controllers (MFCs) being considered for installation into a high-purity gas distribution system. This method will quantify the steady-state supply voltage effects on the MFC's ability to accurately deliver set point flow values.

2 Scope

2.1 This procedure applies to thermal mass flow controllers. It is intended to measure the delivered mass flow rate variation as a function of deviation from the reference steady-state supply voltage. The test method is designed for DC-powered MFCs. The supply voltage effects include voltage depression and over-voltage variations in the DC supply.

2.2 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 test method is not designed for AC-powered MFCs. This test method addresses steady-state effects and does not address any effects caused by transient power supply behavior.

4 Referenced Standards

4.1 None.

5 Terminology

5.1 *Acronyms and Abbreviations*

5.1.1 *DUT* — device under test

5.1.2 *MFC* — mass flow controller

5.1.3 *NIST* — National Institute of Standards and Technology

5.1.4 *psia* — pounds per square inch absolute

5.1.5 *psig* — pounds per square inch gauge

5.2 *Definitions*

5.2.1 *actual flow* — flow value measured by the flow standard.

5.2.2 *indicated flow* — flow value derived from the MFC.

5.2.3 *Reference voltage(s)* — manufacturer's recommended power supply voltage(s).

5.2.4 *stable* — the state a signal level obtains when its magnitude varies by less than or equal to ±2.0% of full scale over a one-minute period.

6 Summary of Method

6.1 This test method consists of varying the steady-state supply voltage to an MFC in ±1% (of rated supply) increments from the reference voltage span. Both the positive and negative supply voltages will be varied independently and together in 1% increments. The MFC flow output is monitored at 0% and 100% of its operating range (see Table 1). At each incremental change as well as at the reference supply voltage, the MFC flow and flow standard outputs are recorded at 0% and 100% of its operating range. The test shall end when a ±3% of full-scale output flow change is noted between the flow at the reference voltage and at an incremental change point. A flow chart outlines the procedure (see Figure 1).

7 Interference's

7.1 Because of fluctuations in ambient temperature or a changing load on the power supply, the reference steady-state supply voltages may change. These changes in supply voltages may adversely effect the MFC's ability to deliver setpoint flow. The magnitude of this effect can be measured by this test method.

7.2 The user of an MFC can use the data generated by this method to evaluate the impact of steady-state supply voltage variations on the MFC's ability to deliver setpoint flow values. Knowing the magnitude of this effect and the power level variations, allows the user to decide on what measures to take to reduce this effect, if necessary.

8 Apparatus

8.1 The equipment and instrumentation required to complete this test method are shown in Figure 2.

8.2 *DC Power Supply*, to provide the required voltage to the MFC under test, with the capability to vary its output over the range of ±30 VDC at 500 mA, and with ripple less than 0.1% rms.

8.3 DC Power Supply Monitor/Recorder, placed in parallel with the DC power supply, and capable of measuring the DC voltage to within ±5 mV over the entire operating range of the supply.

8.4 Flow Output Monitor, connected to the MFC output and signal common/ground points. The monitor/recorder shall be capable of measuring over a range of 0–10 VDC to within ±5 mV.

8.5 *Flow Standard*, installed downstream and in series with the flow through the MFC. The flow standard shall be capable of measuring flow changes within ±0.3% of full scale.

8.6 *Current Meter*, connected in series in the power common line of the DC power supply, capable of measuring over a range of 0–200 mA to within ±1 mA.

9 Reagents and Materials

9.1 *Test Gas*, nitrogen

10 Safety Precautions

10.1 The user must know the respective instrumentation, practice proper handling of test components, and understand good laboratory practices.

10.2 The user should not exceed the ratings (such as pressure, temperature, flow, and voltage) of the components.

11 Preparation of Apparatus

11.1 *Setup and Schematic* — See Figures 2 and 3.

11.2 The test gas source and delivery system must be capable of satisfying the test volume flow rate at a constant pressure, ±0.1 psia.

11.3 The test gas source and delivery system must be capable of delivering a gas at ambient temperature ±2°C for the duration of each analysis. The ambient temperature shall be held to 22 ±1°C.

12 Calibration and Standardization

12.1 All instrumentation shall be calibrated with NIST traceable standards and shall be under current calibration.

13 Procedure

13.1 Install the MFC into the test setup per manufacturer's recommendations.

13.2 Apply power to all devices shown in Figure 2 per manufacturer's specifications. Allow the devices to warm up for the duration specified by the equipment manufacturer.

13.3 Set the DC power supply to the manufacturers recommended reference voltage. Verify the voltage magnitude using the power supply monitor.

13.4 Purge the system with nitrogen for a length of time equal to ten times the amount of time it takes to replace the system volume with the test MFC at its full-scale rated flow rate.

13.5 Close the inlet shut-off valve and then the outlet shut-off valve located adjacent to the MFC (see Figure 3). Adjust the MFC setpoint to zero flow. Follow the manufacturer's recommendations for adjusting the MFC zero. If the MFC has an auto-zero function, leave it active and note this fact on the data sheet in Table 1. Wait for the signals to become stable. Record on the data sheet (see Table 1) three separate readings of the MFC flow output, the power supply voltages, and the current of the power supply common.

13.6 Vary the positive DC power supply voltage in +1% steps from the reference value while holding the negative supply at its reference value.

NOTE 1: If reference voltage is +15 V, the first step is a change in voltage of +0.15 V.

13.7 After the monitored signals become stable, record the MFC zero value, the current value, and the power supply voltage magnitudes. Record the measurements at each step-change of power level on the data sheet. Continue to increase the positive supply voltage span until the MFC zero point changes by ±3% of full scale flow, the MFC zero output point remains unstable for five minutes, or the voltage level changes to +115% of original value.

13.8 Return the power supply level to the original reference value and repeat Section 13.5.

13.9 Repeat the procedure described in Section 13.6, with the following exception: Decrease the power supply span in 1% decrements until either the MFC zero changes by ±3% of full scale, the zero output point remains unstable for five minutes, or 85% of the original value is reached.

13.10 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 13.10.

13.11 Repeat Sections 13.6 through 13.9, with the following exception: Vary the negative DC power supply while holding the positive power supply at its reference value.

13.12 Vary both DC power supply voltages together in +1% steps from the reference value.

NOTE 2: If the reference voltages are ±15 V (30 V span), the first step is a change in voltage of ±0.15 V increasing the span to ±15.15 V (30.3 V span).

13.13 After the monitored signals become stable, record the MFC zero value, the current value, and the power supply voltage magnitudes. Record the measurements at each step change of power level on the data sheet. Continue to increase the supply voltage span until the MFC zero point changes by ±3% of full scale flow, the MFC zero output point remains unstable for five minutes, or the voltage level changes to +115% of original value.

13.14 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 13.13.

13.15 Repeat Section 13.11, with the following exception: Decrement the power supply voltages by 1% and go to Section 13.14.

13.16 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 13.15.

13.17 Open the inlet and outlet shut-off valves that are adjacent to the MFC (see Figure 3) and adjust the MFC set point to 100%. Insure that all reference conditions are within the specified tolerances. Once the output signals become stable, record the MFC output signal, the power supply voltage, the flow standard output, and the current value.

13.18 Vary the positive DC power supply voltage in +1% increments from the reference while holding the negative power supply at its reference value as described in Section 12.6. Record, on the data sheet, the measurements of MFC flow output, power supply voltage, flow standard output, and current meter signal after the values become stable. Continue to increase the voltage in 1% increments until the MFC or flow standard signal changes by ± 3% of full scale, or the MFC output signal remains unstable for five minutes, or the voltage level changes to +115% of original value.

13.19 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 13.18.

13.20 Open the inlet and outlet shut-off valves that are adjacent to the MFC and adjust the MFC setpoint to

100%. Repeat the procedure described in Section 12.16, but decrease the positive supply voltage in 1% decrements until either the flow signal changes by ±3% of full scale, the MFC output signal remains unstable for five minutes, or 85% of the original value is reached.

13.21 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 13.20.

13.22 Repeat Sections 13.15 through 13.19, with the following exception: Vary the negative DC supply voltage level while holding the positive power supply at its reference value and go to Section 13.21.

13.23 Repeat Section 13.15 and then go to Section 13.22.

13.24 Vary both DC power supply voltages together in +1% steps from the reference value.

NOTE 3: If the reference voltages are ± 15 V (30 V span), then the first step is a change in voltage of ±0.15 V increasing the span to ±15.15 V.

13.25 After the monitored signals become stable, record the MFC flow and flow standard values, the current value, and the power supply voltage magnitudes. Record three measurements at each step-change of power level on the data sheet. Continue to increase the supply voltage span until either the flow changes by ± 3% of full scale flow, the MFC zero output point remains unstable for five minutes, or the power level has been changed to +110% of span (±16.5 V).

13.26 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 13.24.

13.27 Open the inlet and outlet shut-off valves that are adjacent to the MFC and adjust the MFC setpoint to 100%. Repeat the procedure described in Section 13.22, with the following exception: Decrease the supply voltages together in 1% decrements until either the flow signal changes by ± 3% of full scale, the MFC output signal remains unstable for five minutes, or until the supply voltage span has changed ± 15% (± 12.75 V). Then go to Section 13.25.

13.28 Return the power supply level to the original reference value, repeat Section 13.5, and go to Section 14.

14 Calculations or Interpretation of Results

14.1 Convert the MFC indicated flow output data and the flow standard output data to percent of full scale flow as follows:

14.2 MFC Indicated Flow:

$$\% \, FullScaleFlow\cdots = \cdots \left(OutputData(v) \div FullScaleOutput\right) \times 100$$

where the output data is in Column B in data sheet. Record this result in Column G on the data sheet.

14.3 Flow Standard (actual flow):

14.3.1 Follow the manufacturer's recommendation for the flow standard output (Column C in data sheet) conversion to percent of full-scale flow. Record this result in Column H of the data sheet.

14.4 Calculate the average value of the three data-flow points at each power level setting for the MFC indicated flow (Column G) and the flow standard (Column H) in the data sheet. Record the averages in Columns I and J of the data sheet, respectively.

14.5 Determine the span by subtracting the zero value (Column G or H) at a particular power supply variation setting from the 100% flow value (Column G or H) at the same power variation setting. These span values for the MFC and the flow standard are to be recorded in Table 2.

$$Span = 100\% \, avg.(ColumnG\!:\!or\!:\!H) - 0\% \, avg.(ColumnG\!:\!or\!:\!H)$$
$$@ \, the\!:\!same\!:\!power\!:\!\mathrm{var}iation\!:\!setting$$

14.6 Calculate the change in flow at a power supply level by subtracting the MFC indicated value (Column I) from the flow standard value (Column J). Record these results in Column K of the data sheet. Calculate the voltage variation from the reference voltage value as a percent change as follows:

$$\text{voltage change (VC)} = \frac{\text{voltage value - reference voltage}}{\text{reference voltage}} \times 100$$

Record this result in Column L and M of the data sheet for the positive and negative power supplies, respectively.

15 Reporting Results

15.1 Present the data as shown in Table 2 for both zero and span.

15.2 Present the data plots for the values in Table 2 as illustrated in Figure 4.

16 Precision and Accuracy

16.1 The precision and bias of this test method will be determined during validation.

17 Related Documents

SAMA Standard PMC 31.1-1980, Generic Test Methods for the Testing and Evaluation of Process Measurement and Control Instrumentation.[1]

IEC Publication 546-1976, Methods of Evaluating the Performance of Controller with Analogue Signals for Use in Industrial Process Control.[2]

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[1] Portions of this method are excerpted from SAMA Standard PMC 31.1-1980 with permission of the publisher, Process Measurement and Control Section, SAMA, 1101 16th St., N. W., Washington, DC 20036.

[2] Available from the Institute of Environmental Sciences, 940 East Northwest Highway, Mount Prospect, IL 60056.
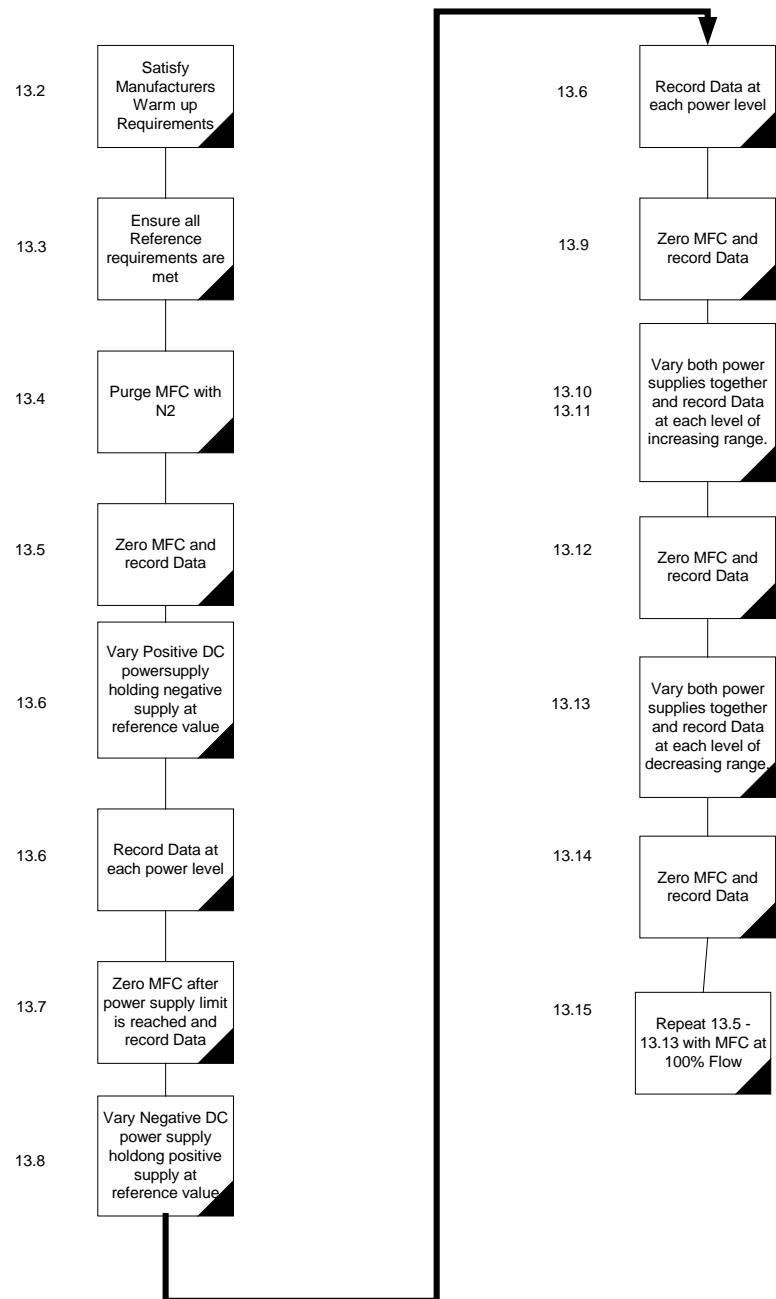
18 Illustrations

13.2	Satisfy Manufacturers Warm up Requirements	
13.3	Ensure all Reference requirements are met	
13.4	Purge MFC with N2	
13.5	Zero MFC and record Data	
13.6	Vary Positive DC powersupply holding negative supply at reference value	
13.6	Record Data at each power level	
13.7	Zero MFC after power supply limit is reached and record Data	
13.8	Vary Negative DC power supply holdong positive supply at reference value	
13.6	Record Data at each power level	
13.9	Zero MFC and record Data	
13.10 13.11	Vary both power supplies together and record Data at each level of increasing range.	
13.12	Zero MFC and record Data	
13.13	Vary both power supplies together and record Data at each level of decreasing range.	
13.14	Zero MFC and record Data	
13.15	Repeat 13.5 - 13.13 with MFC at 100% Flow	

Figure 1
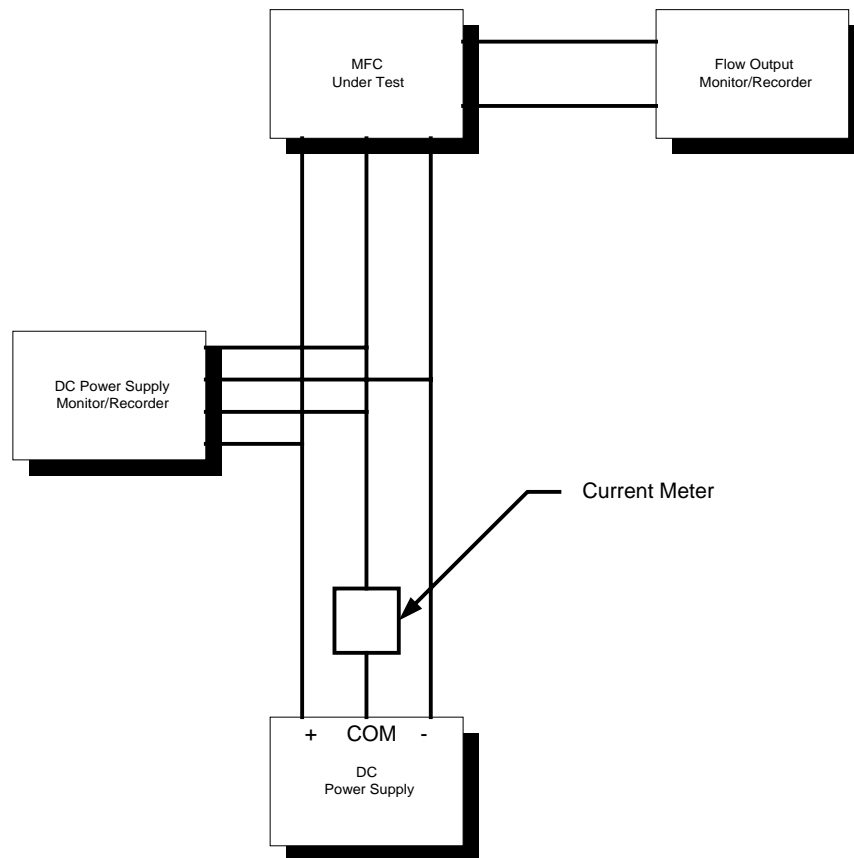**Flow Chart**

Figure 2
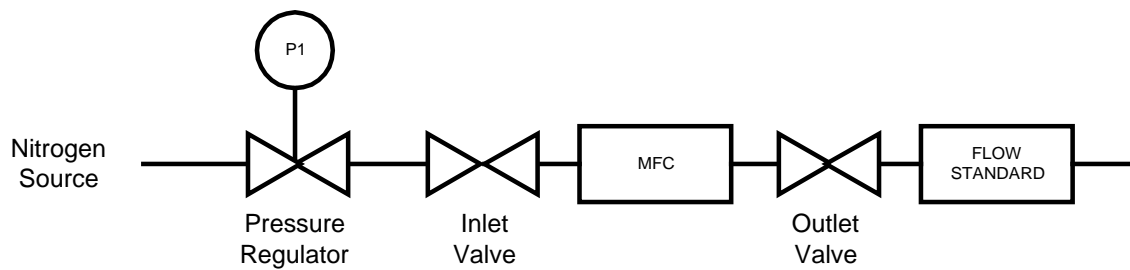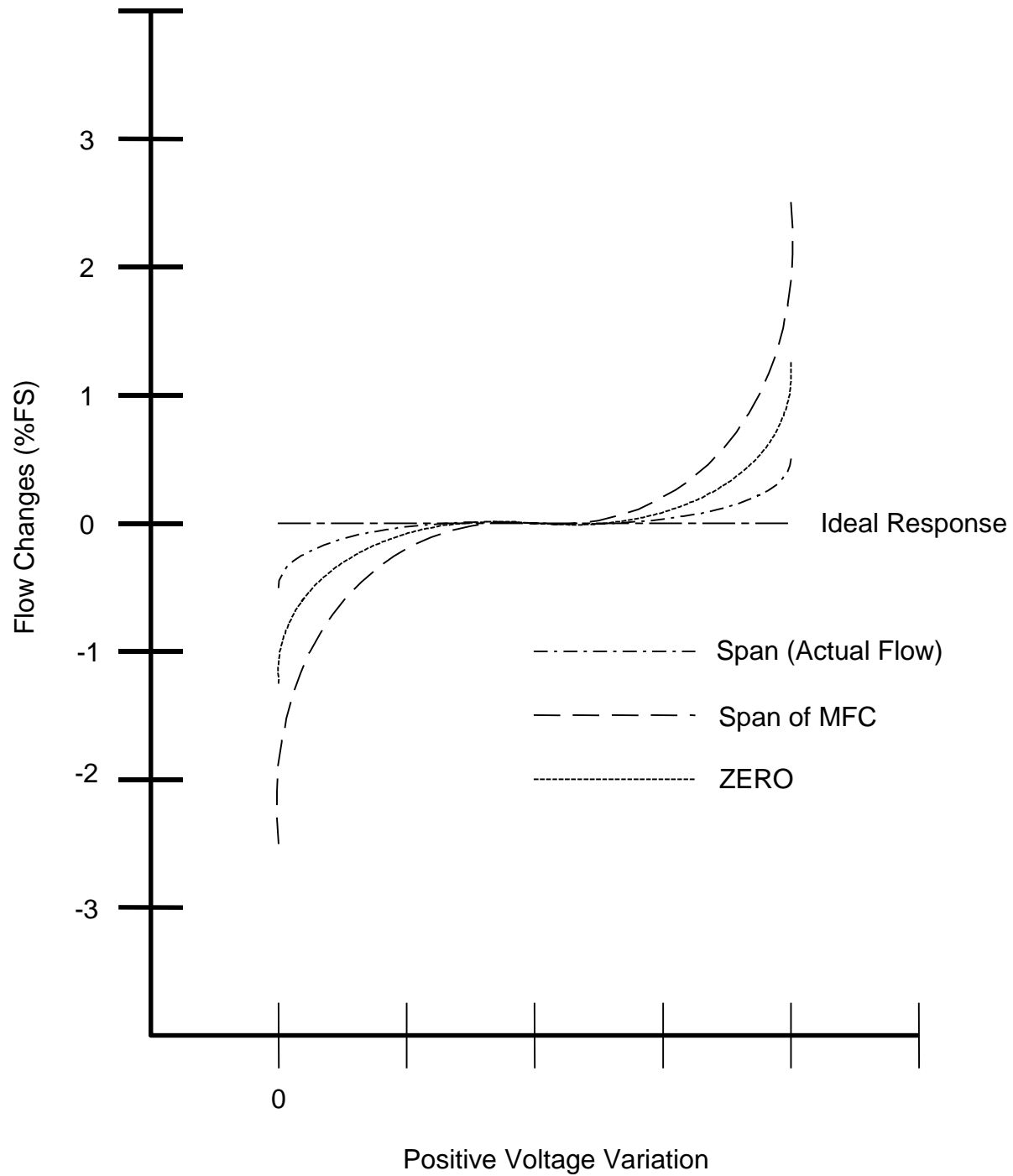**Test Setup for DC Supply Voltage effects**

Figure 3
Flow Setup

A similar plot would be obtained:
Zero and span effects as a result of varying the negative power
zero and span effects as a results of varying both power supplies

Figure 4
Data Plots

Table 1 Data Sheet

	Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H	Column L	Column M
					Data Sheet 1 Data from Steady State Power Supply Effects					
Data Pnts	MFC Setpoint	MFC Indicated Flow (V)	Flow Standard Output (V)	Positive Power Supply Level (V)	Negative Power Supply Level (V)	Power Supply Current Level (mA)	MFC Indicated Flow %FS	Flow Standard %FS	Positive Power Supply Var. (%)	Negative Power Supply Var. (%)
1	0	0	0	15	-15	30	0	0	0	0
2	0	0	0	15	-15	30	0	0		
3	0	0	0	15	-15	30	0	0		
. . .										
4	0	0.015	0	15.15	-15	30	0.3	0	1.0	0
5	0	0.010	0	15.15	-15	30	0.3	0		
6	0	0.010	0	15.15	-15	30	0.3	0		
. . .										
7	0	0.015	0	14.85	-15	30	0.3	0	-1.0	0
8	0	0.010	0	14.85	-15	30	0.2	0		
9	0	0.015	0	14.85	-15	30	0.3	0		
.										
10	0	0.010	0	15	-15.15	30	0.3	0	0	1.0
11	0	0.010	0	15	-15.15	30	0.3	0		
12	0	0.010	0	15	-15.15	30	0.3	0		
.										
13	0	0.005	0	15	-14.85	30	0.1	0	0	-1.0

Table 2 Zero and Span Effects as a Function of Steady-State Power Supply

Power Supply Voltage Change (% of reference)		Change in Zero of MFC (%FS)	Span of MFC (%FS)	Span - Actual Flow (%FS)
Positive	*Negative*			
0	0	0	0	0
-1	0	0.25	99.8	100.0
. . .	. . .	. . .	. . .	. . .
0	0	0	0	0
-1	0			
. . .	. . .			
0	0			
0	+1			
. . .	. . .			
0	0			
1	-1			
. . .	. . .			
0	0			
1	1			

NOTICE: SEMI makes no warranties or representations as to the suitability of the test method set forth herein for any particular application. The determination of the suitability of the test method is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These test methods are subject to change without notice.

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SEMI F57-0301

PROVISIONAL SPECIFICATION FOR POLYMER COMPONENTS USED IN ULTRAPURE WATER AND LIQUID CHEMICAL DISTRIBUTION SYSTEMS

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. Components and spare parts purchased separately, such as gaskets and O-rings, must meet this standard, if applicable.

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.

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

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

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.

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.

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

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

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.

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 $85 \pm 5°C$. 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 (μg/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.

Table 2 Particle Contribution Requirements

Description	Qualification Test Method	Units	Value	Notes
Rinse Time Test	TBD	Hours	TBD	Section 7.2
Initial Cycle Test	TBD	*Particles/liter ≥ 0.1 μm	TBD	Section 7.2
2000 Cycle Test	TBD	*Particles/liter ≥ 0.1 μm	TBD	Section 7.2
200,000 Cycle Test	TBD	*Particles/liter ≥ 0.1 μm	TBD	Section 7.2

* Cycle Test values are a result of subtracting the pre-cycle test background average. See Section 7.2.6.
TBD = To be determined (see NOTE 1 under Table 1).

Table 3 Surface Extractable Ionic Contamination Requirements

Description	Component Preparation Practice	Qualification Test Method	Static Value at $85 \pm 5°C$ for 7 days ($\mu g/m^2$)	Notes
Bromide	SEMI F40	ASTM D4327	≤ 100	Section 7.3
Chloride	SEMI F40	ASTM D4327	≤ 3000	Section 7.3
Fluoride	SEMI F40	ASTM D4327	$\leq 60,000$	Section 7.3
Nitrate	SEMI F40	ASTM D4327	≤ 100	Section 7.3
Nitrite	SEMI F40	ASTM D4327	≤ 100	Section 7.3
Phosphate	SEMI F40	ASTM D4327	≤ 300	Section 7.3
Sulfate	SEMI F40	ASTM D4327	≤ 300	Section 7.3

NOTE 1: Optional testing may be required by the end user for ammonium.

Table 4 Surface Extractable Metallic Contamination Requirements

Description	Component Preparation Practice	Qualification Test Method	Static Value at $85 \pm 5°C$ for 7 days ($\mu g/m^2$)	Notes
Aluminum	SEMI F40	(See NOTE 1.)	≤ 10	Section 7.4
Barium	SEMI F40	(See NOTE 1.)	≤ 15	Section 7.4
Boron	SEMI F40	(See NOTE 1.)	≤ 10	Section 7.4
Calcium	SEMI F40	(See NOTE 1.)	≤ 30	Section 7.4
Chromium	SEMI F40	(See NOTE 1.)	≤ 1	Section 7.4
Copper	SEMI F40	(See NOTE 1.)	≤ 15	Section 7.4
Iron	SEMI F40	(See NOTE 1.)	≤ 5	Section 7.4
Lead	SEMI F40	(See NOTE 1.)	≤ 1	Section 7.4
Lithium	SEMI F40	(See NOTE 1.)	≤ 2	Section 7.4
Magnesium	SEMI F40	(See NOTE 1.)	≤ 5	Section 7.4
Manganese	SEMI F40	(See NOTE 1.)	≤ 5	Section 7.4
Nickel	SEMI F40	(See NOTE 1.)	≤ 1	Section 7.4
Potassium	SEMI F40	(See NOTE 1.)	≤ 15	Section 7.4
Sodium	SEMI F40	(See NOTE 1.)	≤ 15	Section 7.4
Strontium	SEMI F40	(See NOTE 1.)	≤ 0.5	Section 7.4
Zinc	SEMI F40	(See NOTE 1.)	≤ 10	Section 7.4

NOTE 1: See Related Documents Section 12.5 for an applicable leachable trace inorganics test method.

Table 5 Surface Extractable Total Organic Carbon (TOC) Contamination Requirements

Description	Component Preparation Practice	Qualification Test Method	Static Value at $85 \pm 5°C$ for 7 days ($\mu g/m^2$)	Notes
TOC	SEMI F40	ASTM D4779 or D5904	$\leq 60,000$	Section 7.5

Table 6 Surface Roughness Requirements

Description	Qualification Test Method	Units	Ra max. Value	Notes
Extruded	(See NOTE 1.)	μm (μin)	≤ 0.25 (≤ 10)	Section 7.6
Injection Molded	(See NOTE 1.)	μm (μin)	≤ 0.38 (≤ 15)	Section 7.6
Machined	(See NOTE 1.)	μm (μin)	≤ 0.62 (≤ 25)	Section 7.6

NOTE 1: See Related Documents Section 12.5 for an applicable surface roughness test method.

8 Mechanical Requirements

8.1 Upon request, suppliers shall provide data and/or information for the following polymer components mechanical requirements. This information is typically found in product catalogs and component data sheets.

- dimensional tolerances
- flow characteristics
- leak integrity
- mechanical strength characteristics

8.2 All polymer components will conform to supplier's provided data and/or information regarding dimensional tolerances, flow characteristics, leak integrity, and mechanical strength characteristics.

8.3 *Temperature/Pressure Rating*

8.3.1 Polymer components are required to be manufactured in such a manner so as to meet the temperature and internal pressure requirements of ISO 1167, ISO 12162, or other superseding local regulations as applicable.

8.4 *Chemical Resistance Rating*

8.4.1 Polymer components are required to be manufactured to meet the chemical resistance requirements specified by the component suppler, and/or other superseding local regulations as applicable.

8.5 *Reliability*

8.5.1 Upon request, the manufacturer should provide component reliability data accompanied by the associated test and failure analysis methods. This typically involves life cycle testing of components to include results expressed in cycles (e.g. >1,000,000 cycles for valves). The test media used for life cycle testing of polymer components can effect life cycle testing results and should be considered when comparing and selecting polymer components.

9 Certification

9.1 The component supplier is responsible for defining, establishing, and executing a testing program for polymer components based on the requirements outlined within this document.

9.2 Such a program will specify the frequency of testing, the test component(s) and any necessary corrective action plan in the event that a test component fails to meet these requirements during testing.

9.3 To avoid the inefficiencies involved in testing every size of every product type, test polymer components shall be selected by the component supplier which will be representative product of similar processing, or production techniques.

9.4 Upon request, the component supplier is responsible for maintaining and supplying documentation that proves their polymer components consistently meet the requirements of this document.

9.5 The supplier is not required to perform all tests on each individual lot or product type of polymer components shipped. Instead, the product will be certified as meeting the requirements in this document based on the outcome of the representative component tests and periodic testing program. However, if the purchaser performs the test(s) and the product fails to meet the requirement(s), the product may be subject to rejection.

9.6 Qualification tests and certification documents shall reflect current production capabilities.

10 Traceability Requirements

10.1 It will be the responsibility of the component supplier to establish and maintain an incoming raw material certification, inspection, and traceability process, which will ensure that manufactured polymer components meet the requirements of this document.

10.2 Every deliverable item shall have some scheme of identification on the exterior bag or box so that traceability is provided from the raw material supplier to the final finished, packaged product.

10.3 In addition, piping, tubing, valves, gauge guards, pressure transducers, and pressure regulators shall have permanent, non-contaminating identification (e.g. laser marking, heat stamping, or chemical resistant label) on the product itself to provide traceability.

10.4 In the event that component installation by the purchaser obliterates such identification, it becomes the

responsibility of the purchaser to maintain traceability records.

11 Packaging Requirements

11.1 Double bagging using a clear material that will allow inspection is required for polymer components specified in this document. Both the inner and outer bags will be heat-sealed and shall prevent damage from normal handling. Vacuum sealing, air evacuation, and/or dry inert gas purging are optional on the inner bag.

11.2 The ends of valves, gauge guards, pressure regulators, and tubing will be protected using some non-contaminating method before bagging.

11.3 The outer bag will have a label affixed which clearly identifies the component, part number, lot number and any other necessary traceability characteristics (see Section 10).

11.4 Shipping containers and cartons must provide adequate protection of polymer components so those articles will meet the requirements contained within this document upon delivery to the purchaser.

11.5 It should be noted that some packaging materials could release substantial amounts of TOC when they are heat-sealed. This might lead to an organic deposition on the polymer component.

12 Related Documents

NOTE 2: As listed or revised, all documents cited shall be the latest publications of adopted standards.

12.1 *SEMI Standards*

SEMI E49.2 — Guide for High Purity Deionized Water and Chemical Distribution Systems in Semiconductor Manufacturing Equipment

SEMI E49.3 — Guide for Ultrahigh Purity Deionized Water and Chemical Distribution Systems in Semiconductor Manufacturing Equipment

12.2 *ASTM Standards[1]*

ASTM D1784 — Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds

ASTM D3222 — Unmodified Poly (Vinylidene Fluoride) (PVDF) Molding, Extrusion, and Coating Materials

ASTM D3275 — E-CTFE-Fluoroplastic Molding, Extrusion, and Coating Materials

ASTM D3307 — PFA-Fluorocarbon Molding and Extrusion Materials

ASTM D3915 — Rigid Poly (Vinyl Chloride) (PVC) and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds for Plastic Pipe and Fittings Used in Pressure Applications

ASTM D4101 — Propylene Plastic Injection and Extrusion Materials

12.3 *DIN Standards[4]*

DIN 16774-1 — Plastic Moulding Materials; Polypropylene And Propylene Copolymer Thermoplastics; Classification and Designation

DIN 3442-1 — Fittings of PP (Polypropylene); Requirements and Testing

DIN 3442-2 — Fittings of PP (Polypropylene); Ball Valves, Dimensions

DIN 3442-3 — Polypropylene (PP) Valves; Diaphragm Valves; Dimensions

DIN 8077 — Polypropylene (PP) Pipes PP-H 100, PP-B 80; PP-R 80 - Dimensions

DIN 8078 — Polypropylene (PP) Pipes - PP-H (Type 1), PP-B (Type 2), PP-R (Type 3) - General Quality Requirements and Testing

12.4 *CEN Standards[5]*

PREN 1452-1 — Plastics Piping Systems for Water Supply - Unplasticized Poly (Vinyl Chloride) (PVC-U) Part 1: General

PREN 1452-2 — Plastics Piping Systems for Water Supply - Unplasticized Poly (Vinyl Chloride) (PVC-U) Part 2: Pipes

PREN 1452-3 — Plastics Piping Systems for Water Supply - Unplasticized Poly (Vinyl Chloride) (PVC-U) Part 3: Fittings

PREN 1452-4 — Plastics Piping Systems for Water Supply - Unplasticized Poly (Vinyl Chloride) (PVC-U) Part 4: Valves and Ancillary Equipment

PREN 1452-5 — Plastics Piping Systems for Water Supply - Unplasticized Poly(Vinyl Chloride) (PVC-U) Part 5: Fitness for Purpose of the System

PREN 12202-1 — Plastics Piping Systems for Hot and Cold Water - Polypropylene (PP) - Part 1: General

PREN 12202-2 — Plastics Piping Systems for Hot and Cold Water - Polypropylene (PP) - Part 2: Pipes

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4 Deutsches Institut fur Normung e.v., available from Beuth Verlag, Burggrafenstrasse 6, D-10787 Berlin, Germany

5 European Committee For Standardization, 36, rue de Stassart, B-1050 Brussels, Belgium

PREN 12202-3 — Plastics Piping Systems for Hot and Cold Water - Polypropylene (PP) - Part 3: Fittings

PREN 12202-5 — Plastics Piping Systems for Hot and Cold Water - Polypropylene (PP) - Part 5: Fitness for Purpose of the System

12.5 *ISO Standard* [2]

ISO 10931-1 — Plastic piping systems for industrial applications - PVDF - Part 1: General

ISO 10931-2 — Plastic piping systems for industrial applications - PVDF - Part 2: Pipes

ISO 10931-3 — Plastic piping systems for industrial applications - PVDF - Part 3: Fittings

ISO 10931-4 — Plastic piping systems for industrial applications - PVDF - Part 4: Valves

ISO/FDIS 10931-5 — Plastic piping systems for industrial applications - PVDF - Part 5: Fitness for Purpose of the System

ISO/DIS 15874-1 — Plastics piping systems for hot and cold water -- Polypropylene (PP) -- Part 1: General

ISO/DIS 15874-2 — Plastics piping systems for hot and cold water -- Polypropylene (PP) -- Part 2: Pipes

ISO/DIS 15874-3 — Plastics piping systems for hot and cold water -- Polypropylene (PP) -- Part 3: Fittings

ISO/DIS 15874-5 — Plastics piping systems for hot and cold water -- Polypropylene (PP) -- Part 5: Fitness for purpose of the system

12.6 *SEMATECH Documents*[6]

SEMASPEC 92010936B-STD — Provisional Test Method for Determining Leachable Trace Inorganics in Ultra Pure Water Distribution System Components"

SEMASPEC 92010950B-STD — Provisional Test Method for Visual Characterization of Surface Roughness for Plastic Surfaces of UPW Distribution System Components

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6 SEMATECH, 2706 Montopolis Drive, Austin, Texas 78741, USA

Table 7 Related Standards for Plastic Piping Materials

	PP	*PVDF*	*PVC*	*PFA*	*ECTFE*
Materials	PREN 12202-1 DIN 16774 ISO/DIS 15874-1 ASTM D4101	ISO 10931-1 ASTM D3222	PREN 1452-1 ASTM D1784 ASTM D3915	ASTM D3307	ASTM D3275
Pipes	PREN 12202-2 DIN 8077 DIN 8078 ISO/DIS 15874-2	ISO 10931-2	PREN 1452-2	No standards	No standards
Fittings	PREN 12202-3 ISO/DIS 15874-3	ISO 10931-3	PREN 1452-3	No standards	No standards
Valves	DIN 3442-1 DIN 3442-2 DIN 3442-3	ISO 10931-4	PREN 1452-4	No standards	No standards
Systems	PREN 12202-5 ISO/DIS 15874-5	ISO/FDIS 10931-5	PREN 1452-5	No standards	No standards

NOTE 1: See Related Documents Sections 12.2, 12.3, 12.4, and 12.5.

RELATED INFORMATION 1
THEORETICAL DYNAMIC CONCENTRATION (TDC)

NOTE: This related information is not an official part of SEMI F57 and was derived from the work of the originating task force. This related information was approved for publication by full letter ballot procedures on August 28, 2000.

R1-1 TDC Definition and Calculation

R1-1.1 For purposes of demonstrating a theoretical mathematical relationship between the maximum allowed static leach out values (provided in this specification) and a corresponding concentration which may result in a flowing stream, this related information on Theoretical Dynamic Concentration (TDC) is being provided.

R1-1.2 The Static Value as defined in this document (see Section 7.3.4) is a measure of the weekly accumulated mass transfer of contaminant (contaminant flux per week) from the material being tested into static ultrapure water (UPW). The value is calculated based upon measurement of total leached mass of a contaminant per unit area of the surface that was wetted in the test apparatus. Since the duration of the static test is fixed at 7 days, the information is simply reported as mass/area (Tables 3, 4, and 5 use units of $\mu g/m^2$).

R1-1.3 The Theoretical Dynamic Concentration (TDC) is a mathematical conversion of the static value into a theoretical prediction of concentration of a contaminant incorporated into the flowing liquid by contact with the contaminant generating (or transmitting) polymer component wall. The conversion depends upon a model which assumes a uniform rate of contaminant generation that is equal to the average rate over the 7 day Static Value test (7d * 24 hr/d * 3600 sec/hr = 6.05 x 10^5 sec). The model also assumes a non-depleting source of the contaminant in steady state transport conditions through the component/liquid interface. In general, this assumption is only true early in the life of the piping system installation. Values have been found to decrease in time. Calculation of TDC for specification limit purposes can be derived by dividing the static value limit for the component (adjusted for wetted surface area of the component) by the volume of liquid affected by contact with the component.

R1-2 TDC Example

R1-2.1 Referring to the concentrations shown in Tables 3, 4 and 5, a 1 meter long, 60 mm inner diameter pipe with an UPW constant fluid velocity of 1.5 meters/second is selected as an example. Since several factors will affect the actual concentration in a flowing stream the TDC should be considered as approximate, not absolute.

I.D. $\qquad$ d = 60 mm

Length $\qquad$ l = 1.0 m

Fluid velocity $\qquad$ = 1.5 m/sec

R1- 2.2 Example of TDC Calculation:

a) Surface area of tube I.D.

$= \pi dl$
$= (\pi)(0.060 \text{ m})(1.0 \text{ m})$
$= 0.188 \text{ m}^2$
$= 1.88 \times 10^{-1} \text{ m}^2$

b) Volume of tube I.D.

$= \pi (d/2)^2 l$
$= (\pi)(0.060/2 \text{ m})^2 (1.0 \text{ m})$
$= 2.83 \times 10^{-3} \text{ m}^3$
$= (2.83 \times 10^{-3} \text{ m}^3)(1 \times 10^3 \text{ liter/m}^3)$
$= 2.83 \text{ liter}$

c) Volume of liquid transported through tube per second

$= (1.5 \text{ m/sec}) (2.83 \text{ liter/m})$
$= 4.25 \text{ liter/sec}$

d) Volume of liquid transported through tube per week

$= (4.25 \text{ liter/sec})(6.05 \text{ x } 10^5 \text{ sec/wk})$
$= 2.57 \times 10^6 \text{ liter/wk}$

e) Assume a Static Value limit of $10\mu g/m^2$

$= (10 \text{ } \mu g/m^2)(1.88 \times 10^{-1} \text{ m}^2)$
$= 1.88 \text{ } \mu g$

f) Using the values from d and e, above,

TDC = 1.88 µg / 2.57 × 10^6 liter

TDC = 7.3×10^{-7} µg/liter

(or, 7.3×10^{-4} parts per trillion in liquids with an approximate density of 1 gram/cm^3)

SEMI F58-1000
TEST METHOD FOR DETERMINATION OF MOISTURE DRY-DOWN CHARACTERISTICS OF SURFACE-MOUNTED AND CONVENTIONAL GAS DISTRIBUTION SYSTEMS BY ATMOSPHERIC PRESSURE IONIZATION MASS SPECTROMETRY (APIMS)

1 Purpose

1.1 This document describes the procedure for determination of the moisture dry-down characteristics (quantity of removable moisture) of surface mounted and conventional gas distribution systems (integrated gas distribution systems). APIMS is currently the method of choice for such dynamic tests because it is the commercially available technique capable of ppt moisture analysis with the fastest response time. This test method may provide guidelines for the application of other techniques with similar detection limits and response time to APIMS which are not commercially available at this time.

1.2 The results of this test can be used for qualitative ranking of gas delivery based on the design. It can also be used by a sufficiently sophisticated user as input for numerical simulation of distribution system behavior.

2 Scope

2.1 This test method applies to all types of surface mounted and conventional gas distribution systems used in semiconductor processing.

2.2 *Test Medium* — The test procedure will be carried out in nitrogen. Other "inert" gases will have different purging characteristics and may dry a system more quickly or slowly. Reactive gases may react chemically with moisture. Considerations relating to corrosion resistance are outside the scope of the present document, although the test procedure may prove useful in corrosion studies. The results will provide a ranking with respect to moisture contribution arising as a result of differences in design, which may be applied with due caution to systems intended for use in other gas applications.

2.3 *Operating Situations* — Moisture contribution from a gas delivery system may be the result of contamination arising in its manufacture, or from subsequent exposure to ambient air or non-dry gas. Thus, it is necessary to consider two main situations:

2.3.1 The "initial dry-down" situation, which is determined by the moisture content of the components in the system (as received) with the effects of manufacturing process and design, surface quality, pre-treatment and packaging convoluted together.

2.3.2 The "response to upset" situation, which is determined by the amount of moisture taken up by the system and subsequently released in any exposure after receipt.

2.4 *Safety Issues* — 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 test method allows the determination of moisture interactions which can be used, for example, to rank systems in order of decreasing moisture interaction. Because different degrees of moisture interaction are permissible in different situations, selecting the "best" system requires consideration of how they will be used, either qualitatively or through a numerical simulation of distribution system behavior. The results of this test can only be used for qualification for gas delivery systems based on different designs. It cannot be used for production purposes and/or certification/testing.

4 Referenced Standards

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

4.1 *SEMI Standards*

SEMI C15 — Test Method for ppm and ppb Humidity Standards

SEMI F27 — Test Method for Moisture Interaction and Content of Gas Distribution Systems and Components by Atmospheric Pressure Ionization Mass Spectrometry (APIMS)

SEMI F33 — Method for Calibration of Atmospheric Pressure Ionization Mass Spectrometer (APIMS)

4.2 *ASTM Standards*[1]

ASTM-F1397-93 — Standard Test Method for Determination of Moisture Contribution by Gas Distribution System Components

5 Summary of Test Method

5.1 This test method consists of initial drydown and moisture input tests for both surface-mounted and conventional gas delivery systems.

6 Terminology

6.1 *Abbreviations and Acronyms*

6.1.1 *APIMS* — Atmospheric Pressure Ionization Mass Spectrometry.

6.1.2 *EPSS* — electropolished stainless steel.

6.1.3 *ppm* — molar parts per million (μmole/mole). The same as ppmv.

6.1.4 *ppb* — molar parts per billion (nmole/mole). The same as ppbv.

6.1.5 *ppt* — molar parts per trillion (pmole/mole). The same as pptv.

6.1.6 *slpm* — standard liters per minute, the gas volumetric flow rate measured in liters per minute at 0°C and 1 atm.

6.2 *Definitions*

6.2.1 *baseline* — an instrument response under steady state conditions.

6.2.2 *glove box* — an enclosure that contains a controlled atmosphere, usually inert.

6.2.3 *induction time* — the elapsed time between when humidified gas is introduced to the test system and when moisture is detected at the moisture analyzer. For a test system which is perfectly transparent to moisture, the induction time is equal to the residence time of the gas in the system.

6.2.4 *peak height* — the maximum moisture concentration recorded when a moisture input of pre-defined length and concentration is introduced to a test system.

6.2.5 *response time* — the time required for the test system to reach steady state after a change in concentration.

6.2.6 *test system* — the gas delivery system under test

7 Required Equipment

7.1 *APIMS* — The APIMS used for moisture detection can be of any type. Calibration of the APIMS shall be performed as per SEMI F33, one at the beginning and one at the end of the series. These calibrations shall both be made under the same analytical conditions (flow, pressures, plate voltages, etc.) as the tests and the results shall be within 5% of each other. Provided this condition is met, the interval between calibrations may be left to the discretion of the operator; however, it is suggested that calibration should be carried out whenever the equipment is moved and/or every two weeks of operation.

7.2 *Dry Gas and Moisture Generator* — A source of extremely dry nitrogen (less than 200 ppt moisture) and a moisture generator capable of delivering up to 13 slpm nitrogen doped with 200 ppb moisture is required. This generator may be the same as used to calibrate the APIMS. The output of the generator shall be verified according to SEMI C15.

7.2.1 Most ultra-high purity gas panels are currently fitted with metal gasket type connectors. The same type of connector should, therefore, be incorporated into the test bench for connection to the test system.

7.3 *Test Blank* — Any series of tests shall include the results of testing a blank. The blank shall be the shortest convenient length (no more than 1 m) of 1/4" EPSS tubing with suitable fittings and/or adapters at either end to enable it to be inserted in place of the test system.

7.4 *Moisture Pulse Generator* — A valve arrangement capable of switching instantaneously between dry and humidified nitrogen is also required. An example of such a design is shown in Figure 1. In this design, flow is maintained in both the humidified and dry gas lines at all times. By simultaneously switching valves V_1 and V_3, or V_2 and V_3, either humidified or dry gas is directed through the test system while the other gas stream is directed to vent. Note that there is a bypass loop so that flow can be maintained to the APIMS when the test system is removed. In this design, all gas lines, but especially those lines between V_1 and V_3 and between V_2 and V_3, should be as short as possible and constructed of EPSS tubing of high quality. Maintaining gas lines at a constant temperature between 50 and 80ºC wherever possible is also recommended.

7.4.1 The bypass loop will contain a stagnant volume of gas during testing. To avoid exposing the APIMS to a large moisture upset whenever it is fed with the gas contained in the bypass loop, the loop should be thoroughly baked out (at ≥ 200°C) and protected from atmospheric contamination thereafter. Valve V_4 should

be such that some flow can be maintained through the bypass loop and the test system simultaneously as well as through each separately. Use of pneumatic valves to facilitate rapid and simultaneous switching is recommended.

7.4.2 Other arrangements than that shown may also be used. The moisture pulse generator should be designed so as to give the fastest possible response of the blank to a change in input moisture level.

7.5 *Temperature Control and Measurement* — A stable temperature during the test is of critical importance. The test system shall be kept at 30ºC. TESTS AT DIFFERENT TEMPERATURES CANNOT BE COMPARED. Ideally, the blank and test system should be maintained in a temperature-controlled chamber. However, if this is impractical, a heating tape can be used. Temperature control should be to ± 1ºC. A continuous record of temperature during the test shall be maintained.

8 Procedure

8.1 *Blank Tests* — A blank test shall be carried out after each calibration. If initial dry-down testing of system is not of interest, the initial dry-down test of the test blank may be omitted and the test blank brought to equilibrium with zero gas in whatever manner is most convenient, except that the test blank should not be heated above 200ºC. Permanent changes in moisture interaction have been observed at temperatures above this level.

8.1.1 *Initial Dry-down* — Start the experiment with the blank in place of the test system and a flow of dry gas through the APIMS. The APIMS output should be at equilibrium with the lowest moisture level of interest, and in any case no higher than 200 ppt.

8.1.1.1 Switch the gas flow to pass primarily through the bypass loop while maintaining a small flow through the test blank. Remove the test blank completely from the system. If a glove box or other such enclosure is used, do not remove the test blank from the glove box. Immediately reconnect the test blank to V_4, leaving it disconnected from V_5. Allow dry nitrogen to flow through the test blank for five minutes to purge the air from inside before reconnecting to V_5. Switch the gas to flow only through the blank and not through the bypass loop. The APIMS will show an increase in moisture concentration. Record the APIMS output until it reaches 800 ppt or 48 hours, whichever is less.

8.1.1.2 Repeat the above test twice for a total of three data sets.

8.2 *Tests on Actual Test System*

8.2.1 *Initial Dry-down* — This portion of the test is designed to determine the quantity of removable moisture on the wetted surfaces of the system in the condition in which it is typically supplied. Thus, the results of this test will reflect, by design, any precautions which the supplier has taken to remove moisture and maintain its dryness during shipping.

8.2.1.1 Start the test as in Section 8.1.1. The test system should not be unpacked until after the APIMS has equilibrated with the background moisture level. If a glove box or other such enclosure is used, unpack the system in the glove box. Switch the dry nitrogen flow to pass through the bypass loop while maintaining a small flow through the test blank. Bake the sample line to APIMS at 170°C for 10 min and the APIMS ion chamber at 150°C for 10 min. Undo the final layer of packing and any shipping caps or plugs on the system at this point. Remove the sample blank and connect the test system to valve V_4 as quickly as possible. Ensure that the gas lines going to APIMS will be under N_2 purge during the removal of test blank and installation of test system. Allow the dry nitrogen flow to purge out any ambient air in the system for five minutes, then connect the system to V_5. Switch the gas to flow (1.2 slpm) only through the test system and not through the bypass loop. The APIMS will show an increase in moisture concentration. Record the APIMS output until it reaches 200 ppt or for 24–48 hours, whichever is less.

8.2.1.2 After 24–48 hours, the initial dry-down part of the test can be terminated. Remove the filters from the test system and install special spool pieces. This is done since filters have a large surface area and would dominate the dry-down performance.

8.2.2 *Moisture Input Test* — Flow 1.2 slpm of dry nitrogen gas (200 ppt moisture) through appropriate process channels of the test system. Connect the outlet of the gas panel to the sample line connecting to the APIMS. Bake the appropriate process channels using heater tapes at 60°C for 12 h to remove atmospheric contamination.

8.2.2.1 At the conclusion of baking, equilibrate the test system to 30°C. Bake the sample line at 170°C for 10 min and ion source of APIMS at 150°C for 10 min. Perform a leak check at the inlet and outlet connections of the test system using 1% methane gas in nitrogen, after warming up the APIMS for 30 min. Switch the input gas to nitrogen with 200 ppb moisture (by switching valves V_1, V_2, and V_3 simultaneously, if the arrangement shown in Figure 1 is used) while recording the APIMS response. Maintain this input for 20 min and then switch the input gas to dry nitrogen (200 ppt moisture) and monitor the dry-down.

9 Reporting Results

9.1 Complete moisture response curves for all test systems and relevant test blanks should be included. A summary sheet may compare systems in terms of "induction time," peak height, and/or decay time (detected moisture concentrations may be plotted as a function of time for the test systems). Temperature, pressure, and flow measurements, and as complete a record as possible of all experimental variables should be noted.
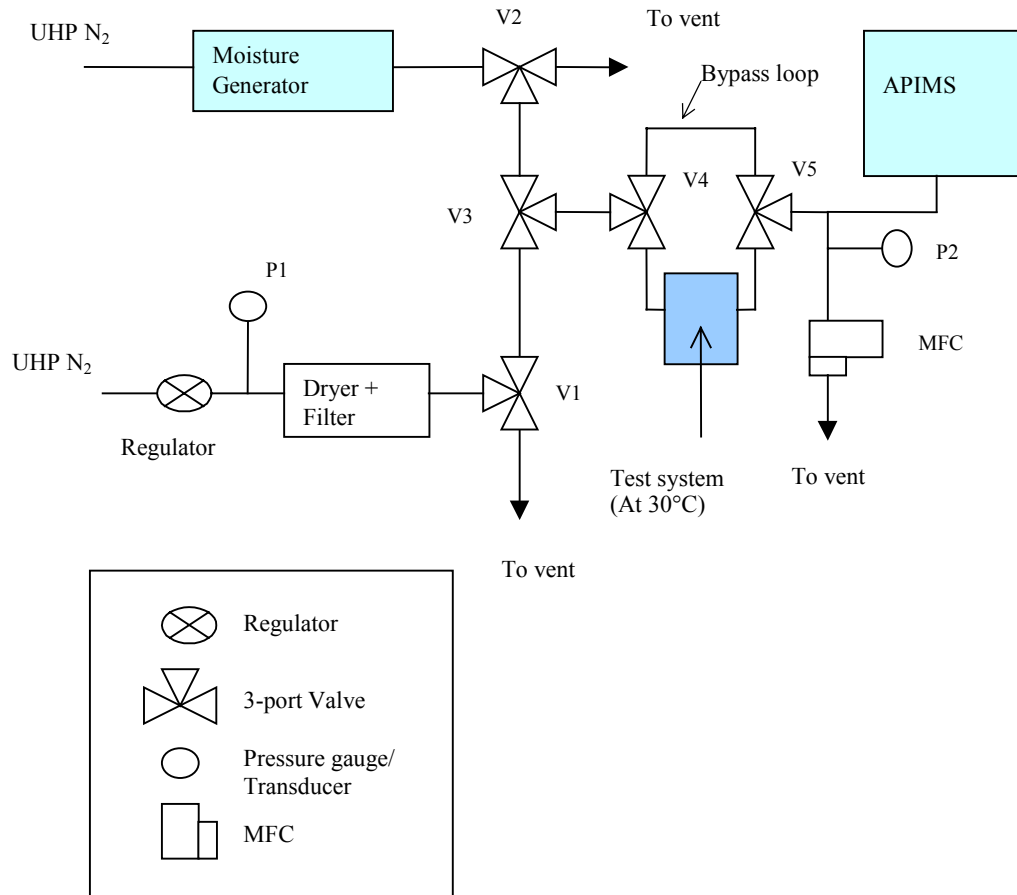

Figure 1
APIMS Moisture Test Schematic

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SEMI F59-0302
TEST METHOD FOR DETERMINATION OF FILTER OR GAS SYSTEM FLOW PRESSURE DROP CURVES

This test method was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition aproved by the North American Regional Standards Committee on November 27, 2001. Initially available at www.semi.org December 2001; to be published March 2002. Originally published October 2000.

NOTE: This document was entirely rewritten for publication in 2002.

1 Purpose

1.1 The purpose of this document is to define a method for testing filters or gas systems being considered for installation into a high-purity gas distribution system or on semiconductor manufacturing equipment, respectively. Application of this test method is expected to yield comparable data among filters or gas systems.

1.2 This document establishes a test method for preparing a pressure drop versus flow rate curves for filters and gas systems.

2 Scope

2.1 This procedure applies to clean filters including those cartridges of metal, ceramic and membrane construction. The pressure drops for integral housing/cartridge combination units are determined as a single set of values. For housings with removable filter cartridges, the flow curves of the housing and housing/cartridge combination are determined separately.

2.2 This procedure applies to high-purity gas systems. This procedure applies to face-seal, surface mount—modular, and monolithic integrated gas systems.

2.3 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 and safety health practices and determine the applicability of regulatory limitations prior to use.

3 Limitations

3.1 For separable filtration units, a single cartridge pressure drop value cannot be combined to give the pressure drop value for an extended length cartridge, because of the limitations imposed by a common outlet port for the assembly.

3.2 This method is written with the assumption that the operator understands the use of the apparatus at a level equivalent to six months of experience.

3.3 This method is written to test a filter under normal operating conditions. It does not prescribe a procedure for reverse flow testing since operation of the filter in this manner is not recommended by the manufacturers.

3.4 Components that induce line pressure changes on a system such as pressure regulators, and MFCs are not considered in this test method.

3.5 Proper flow of low vapor pressure gases can be effected by small pressure drops and may need to be evaluated independently.

4 Referenced Standards

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

4.1 *ASME Performance Test Code PTC 19.5, 1972 —* "Applications." Part II of "Fluid Meters, Interim Supplement on Instruments and Apparatus."[1]

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *CDA* — clean, dry air

5.1.2 *°C* — degrees Celsius

5.1.3 *DUT* — device under test

5.1.4 *kg* — kilogram

5.1.5 *kPa* — kilopascals, (kNm^{-2})

5.1.6 *m* — meter

5.1.7 *MFC* — mass flow controller

5.1.8 *N* — Newton (kg m/s^2)

5.1.9 *P* — pressure in kiloPascal (kPa)

5.1.10 *POC* — point of connection

5.1.11 *psi* — pounds per square inch

5.1.12 *psia* — pounds per square inch absolute

5.1.13 *psid* — pounds per square inch differential

5.1.14 *psig* — pounds per square inch gauge

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1 American Society of Mechanical Engineers (ASME) International, 3 Park Avenue, New York, NY 10016-5990

5.1.15 *s* —second

5.1.16 *scfm* — standard cubic feet per minute

5.1.17 *slpm* — standard liters per minute

5.1.18 *T* — (K) temperature in Kelvin

5.1.19 *ΔP* — differential pressure in kPa

5.1.20 *ΔP(Housing)* — (kPa, differential) differential pressure of housing in kiloPascal, differential

5.1.21 *ΔP(Unit)* — (kPa, differential) differential pressure of filtration unit in kiloPascal, differential

5.1.22 *ΔP(cartridge)* — (kPa, differential) differential pressure of cartridge element in kiloPascal, differential

5.2 *Definitions*

5.2.1 *filter cartridge* — the filtration element.

5.2.2 *filter housing* — the shell that contains the filter cartridge.

5.2.3 *filtration unit* — the assembly consisting of a filter cartridge and housing.

5.2.4 *gas box* — a gas distribution subsystem which generally contains the final shut-off valve(s) prior to the POC.

5.2.5 *gas pallet* — individual gas distribution subsystems within a gas box that control flow of gas to individual process chambers.

5.2.6 *gas stick* — a series of components for an individual gas within a gas box. It may contain valves, a regulator, a pressure transducer, a purge line, an MFC, and a filter.

5.2.7 *integral unit* — the filter cartridge and housing are not separable.

5.2.8 *normal conditions* — 101.3 kPa (14.7 psia) and ambient temperature conditions 293.15 K (20 ^{o}C).

5.2.9 *separable unit* — the filter cartridge and housing can be disassembled.

5.2.10 *spool flow through component* — a null component consisting of an electropolished flow passage and appropriate fittings used in place of the test component.

5.2.11 *standard conditions* — 101.3 kPa, 273.15 K (14.7 psia, 0°C).

6 Summary of Method

6.1 This test method describes the test equipment and procedures for determining the flow pressure drop of filters or gas systems. The differential pressure is measured across a DUT at various inlet pressures and flows. If the filtration unit is separable the individual contributions from the housing and cartridge are determined.

7 Interferences

7.1 Test stand must be of adequate dimensions so that it does not limit the flow through the test DUT. The pressure drop for the test stand must be insignificant compared to the pressure drop for a DUT at the test flow rate.

8 Apparatus

8.1 pressure regulator

8.2 downstream flow regulating valve

8.3 flow meter capable of measuring flow rates to better than 5% full scale and of appropriate range.

8.4 several pressure transducers or gauges

8.5 differential pressure transducer (0.67 kPa, (0.1 psi) sensitivity)

8.6 Test stand

8.7 Temperature measuring device (^{o}C)

9 Reagents and Materials

9.1 Test Gas nitrogen or CDA filtered to < 0.02 micrometer with a dew point of less than or equal to – 40°C.

10 Safety Precautions

10.1 *Safety Precautions* — This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to its use.

10.2 The user must have a working knowledge of the respective instrumentation, must practice proper handling of test components, and must understand good laboratory practices. The user should not operate the components in such a manner as to exceed the ratings (i.e., pressure, temperature, flow and voltage).

11 Test Specimen

11.1 A gas box may consist of several gas pallets that uniquely control flow of gases to a specific process chamber. More than one gas stick layout is possible on the pallet. The user shall test only one stick at a time

for pressure drop measurement. The gas stick may be removed from the pallet to attach to the test fixture.

11.2 Pressure regulators and MFCs shall be maintained in their fully open position during testing.

11.3 When comparing different gas system designs, it is useful to use components of similar design.

11.4 If the stick design contains a filter that dominates the pressure drop on the system, such filters shall be replaced by spool flow through components

12 Preparation of Apparatus

12.1 Construct a test stand for the measurement of gas flow rates and pressure drop across a DUT. Examples of such a test stand are shown in Figures 1a or 1b as schematic drawings.

12.2 The gas supply is filtered by an electronics grade high purity point-of-use gas filter before it is delivered to the DUT through a pressure regulator.

12.3 A flow meter can be installed either upstream or downstream of the DUT. See Figures 1a or 1b. The test filter is upstream of a throttle valve to allow for control of the flow through the DUT.

12.4 Inlet pressure is measured immediately upstream of the DUT by a pressure gauge or pressure transducer.

12.5 Pressure drop across the test specimen is measured by an electronic differential pressure transducer capable of reading 0.67 kPa (0.1 psid) across the test device.

12.6 Flow measurements are carried out through a flow meter installed upstream or downstream of the test filter. See Figures 1a or 1b.

NOTE 2: The flow measurement can be influenced by both upstream and downstream pressure fluctuations. It is necessary to verify the accuracy of any flow measurement under the test conditions used to complete this testing.

12.7 A temperature measurement device can be installed in the test stand to measure the gas stream temperature.

12.8 Figure 2 gives the piping requirements for the test stand configuration.

12.9 Figure 3 gives the recommended pressure connection to be followed in constructing the test apparatus.

13 Calibration and Standardization

13.1 For each test, verify that calibration of test equipment is up-to-date.

13.2 A series of flow meters should be used to cover the full range of flows that will be tested.

14 Procedure

14.1 *Integral Filtration Unit*

14.1.1 Assemble the filtration unit into the test apparatus. (See Figure 1.)

14.1.2 Set the inlet pressure using the pressure regulator to 10% of the filter's maximum rated inlet pressure or to 205 kPa (29.7 psia) whichever is less. Pressure is read on the inlet pressure gauge.

14.1.3 Adjust the flow rate using the regulating valve to give 10 % of the maximum rated flow. Adjustments to the inlet pressure regulator may be required to maintain a constant inlet pressure of 205 kPa (29.7 psia). The flow and pressure adjustments can be an iterative process requiring several iterations to achieve the desired flow rate and inlet pressure. The flow rate is read on the flow meter and recorded.

14.1.4 Read and record the ambient temperature, inlet pressure, pressure drop across the test filter, ambient pressure, and flow rate corrected for upstream pressure based on manufacturer's recommendation.

14.1.5 Repeat steps in Sections 14.1.3 and 14.1.4 at 25%, 50%, 75% and 100% of the maximum rated flow.

14.1.6 Repeat steps in Sections 14.1.2 through 14.1.5 at several inlet pressures: 309 kPa (44.7 psia), 516 kPa (74.7 psia), and 723 kPa (104.7 psia).

14.1.7 Additional testing of the filter at higher pressures can be completed up to the maximum rated pressure.

14.1.8 When the filter has a lower maximum pressure rating than 90 psig, it is recommended that the filter be tested at pressures of 33%, 67% and 100% of the filter's maximum pressure rating, with tests being limited by the sensitivity of the differential pressure device.

14.2 *Separable Filtration Unit - Filter Housing*

14.2.1 Assemble the empty filter housing into the test apparatus.

14.2.2 Set the inlet pressure using the pressure regulator to 10% of the housing's maximum rated inlet pressure or to 205 kPa (29.7 psia) whichever is less. The inlet pressure is read on the inlet pressure gauge and recorded.

14.2.3 Adjust the flow rate using the regulating valve to give 10% of the maximum rated flow. Adjustments to the inlet pressure regulator may be required to maintain a constant inlet pressure of 205 kPa (29.7 psia). The flow and pressure adjustments can be an iterative process requiring several iterations to achieve

the desired flow rate and inlet pressure. The flow rate is read on the flow meter and recorded.

14.2.4 Read and record the ambient temperature, ambient pressure, inlet pressure, pressure drop across the test filter, and flow rate corrected for upstream pressure based on manufacturer's recommendation.

14.2.5 Repeat steps in Sections 14.2.3 and 14.2.4 at 25%, 50%, 75%, 100% of the filter cartridge's maximum rated flow.

14.2.6 Repeat steps in Sections 14.2.2 through 14.2.5 at several inlet pressures. For example, test at 309 kPa (44.7 psia), 516 kPa (74.7 psia), and 723 kPa (104.7 psia).

14.2.7 Additional testing of the filter at higher pressures can be completed up to the maximum rated pressure.

14.2.8 When the filter has a lower maximum pressure rating than 90 psig, it is recommended that the filter be tested at pressures of 33%, 67% and 100% of the filter's maximum pressure rating, with tests being limited by the sensitivity of the differential pressure device.

14.3 *Separable Filtration Unit – Assembled Cartridge and Housing*

14.3.1 Assemble the filter cartridge into the filter housing.

14.3.2 Assemble the filtration unit into the test apparatus.

14.3.3 Set the inlet pressure using the pressure regulator to 10% of the filter's maximum rated inlet pressure, or to 205 kPa (29.7 psia), whichever is less. The inlet pressure is read on the inlet pressure gauge/transducer and recorded. This pressure should be the same as used for the filter housing test in Section 14.2.2.

14.3.4 Adjust the flow rate using the regulating valve to give 10% of the maximum rated flow. Adjustments to the inlet pressure regulator may be required to maintain a constant inlet pressure of 205 kPa (29.7 psia). The flow and pressure adjustments can be an iterative process requiring several iterations to achieve the desired flow rate and inlet pressure. The flow rate is read on the flow meter and recorded. This should be the same as used for the filter housing test in Section 14.2.3.

14.3.5 Read and record the ambient temperature, ambient pressure, inlet pressure, pressure drop, and flow rate.

14.3.6 Repeat steps in Sections 14.3.3 and 14.3.5 at 25%, 50%, 75% and 100% of the maximum rated flow.

These should be the same flow settings as used in Section 14.2.5.

14.3.7 Repeat steps in Sections 14.3.2 through 14.3.6 at several inlet pressures. For example, test at 309 kPa (44.7 psia), 516 kPa (74.7 psia), and 723 kPa (104.7 psia).

14.3.8 Additional testing of the filter at higher pressures can be completed up to the maximum rated pressure. These inlet pressure settings should be the same as used in Section 14.2.7.

14.3.9 When the filter has a lower maximum pressure rating, it is recommended that the filter be tested at pressures of 33%, 67% and 100% of the filter's maximum pressure rating, with tests being limited by the sensitivity of the differential pressure device.

14.3.10 The flow curve for the filter cartridge is determined by subtracting the pressure drop of the housing from the pressure drop of the assembled filtration unit at respective flow rates and inlet test pressures.

14.4 *Gas System*

14.4.1 Assemble the DUT into the test apparatus. (See Figure 1.)

14.4.2 Set the inlet pressure using the pressure regulator to 205 kPa (29.7 psia). Pressure is read on the inlet pressure gauge.

14.4.3 Adjust the flow rate using the regulating valve to give 1 slpm. Adjustments to the inlet pressure regulator may be required to maintain a constant inlet pressure of 205 kPa (29.7 psia). The flow and pressure adjustments can be an iterative process requiring several iterations to achieve the desired flow rate and inlet pressure. The flow rate is read on the flow meter and recorded.

14.4.4 Read and record the ambient temperature, inlet pressure, pressure drop across the DUT, ambient pressure, and flow rate.

14.4.5 Repeat steps in Sections 14.4.2 through 14.4.4 at flow rates of 5, 10, 25, 50, 75, and 100 slpm.

14.4.6 Repeat steps in Sections 14.4.2 through 14.4.5 at several inlet pressures: 308 kPa (44.7 psia), 515 kPa (74.7 psia), and 791 kPa (114.7 psia).

14.4.7 Additional testing of the DUT may be performed at higher pressures up to the maximum rated pressure. Where components are not specified to operate at the required flow rates and pressures listed in Sections 14.4.5 and 14.4.6 then tests shall be performed to the highest pressures and flows attainable while remaining within the component's maximum operating specification.

15 Calculations or Interpretation of Results

15.1 Complete Tables 1–3 as needed for the DUT.

15.2 Graph the pressure drop versus the flow rate. An example of such a graph is shown in Figure 4 with separate lines for different inlet pressure settings.

16 Precision and Accuracy

16.1 All measurements shall be recorded to the greatest precision allowed by the instruments unless accuracy in the overall measurement is not affected by lower precision.

16.2 Accuracy of all instruments shall be recorded.

Figure 1a
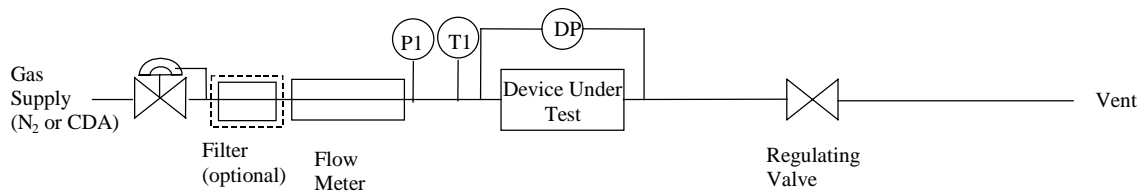**Flow Pressure Drop Test Stand Schematic, Option 1**

Figure 1b
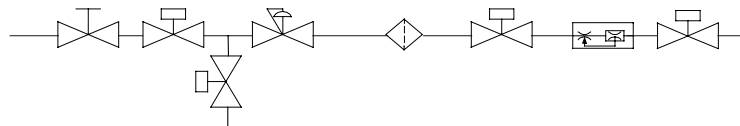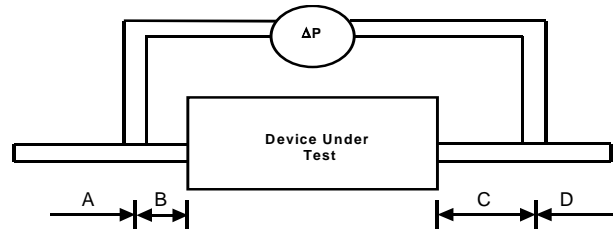**FLow Pressure Drop Test Stand Schematic, Option 2**

Figure 1c
Sample Gas System for Testing

A — At least 16 nominal pipe diameters of straight pipe.

B — 2 Nominal pipe diameters of straight pipe.

C — 6 Nominal pipe diameters of straight pipe.

D — At least 1 nominal pipe diameters of straight pipe.

NOTE 1: Dimension "A" may be reduced to 8 nominal diameters if straightening vanes are used. Design of straightening vnes can be found in ASME Performance Test Code PTC 19.5-1972, "Applications – Part 2 of "Fluid Meters, Interim Supplement on Instruments and Apparatus."

NOTE 2: If an upstream flow disturbance consists of two elbows in series and they are in different planes, dimension "A" must exceed 16 nominal pipe diameters unless straightening vanes are used.

Figure 2
Piping Requirements – Standard Test Section