

SEMI E66-1103

TEST METHOD FOR DETERMINING PARTICLE CONTRIBUTION BY MASS FLOW CONTROLLERS

This test method was technically approved by the Global Gases Committee and is the direct responsibility of the North American Gases Committee. Current edition approved by the North American Regional Standards Committee on July 27, 2003. Initially available at www.semi.org October 2003; to be published November 2003. Originally published September 1997.

1 Purpose

1.1 The purpose of this test is to measure particle contribution by mass flow controllers (MFCs) in high-purity gas systems.

2 Scope

2.1 This document describes a test method that yields statistically significant comparisons of particle contribution among mass flow controllers under test conditions.

NOTICE: This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 This document is not intended as a method for monitoring in situ particulate performance once a particular MFC has been tested.

3.2 The test medium is limited to nitrogen. Actual performance under normal operating conditions may differ.

3.3 The accuracy of the data generated by this method is limited to the accuracy of the particle measuring instruments used.

3.4 This test method is intended for use by operators who understand the use of the apparatus at a level equivalent to one year of experience.

3.5 This test method should not be expected to yield comparable results from one test set up to another, due to the limitations of current particle counting technology.

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

4 Referenced Standards

4.1 SEMI Standards

SEMI E29 — Standard Terminology for the Calibration of Mass Flow Controllers and Mass Flow Meters

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

4.2 ANSI Standards¹

ANSI B46.1 — Surface Texture (Surface Roughness, Waviness, and Lay)

4.3 ISO Standards²

ISO 14644-1 — Cleanrooms and associated controlled environments Part 1: Classification of air cleanliness.

ISO 14644-2 — Cleanrooms and associated controlled environments Part 2: Specifications for testing and monitoring to prove continued compliance with ISO 14644-1

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

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 *CNC* — condensation nucleus counter

5.1.2 *dof* — degrees of freedom

5.1.3 *DUT* — device under test

5.1.4 *FS* — full scale

5.1.5 *IKS* — isokinetic sampler

5.1.6 *kPa* — kiloPascal

5.1.7 *LPC* — laser particle counter

5.1.8 *ppm* — parts per million

5.1.9 *psia* — pounds per square inch absolute

5.1.10 *psid* — pounds per square inch differential

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² International Organization for Standardization
ISO Central Secretariat, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland. Telephone: 41.22.749.01.11; Fax: 41.22.733.34.30 Website: www.iso.ch

- 5.1.11 *psig* — pounds per square inch gauge
- 5.1.12 *Ra* — roughness average per ANSI B46.1
- 5.1.13 *RH* — relative humidity per ANSI B46.1
- 5.1.14 *Rmax* — roughness maximum
- 5.1.15 *scfm* — standard cubic feet per meter
- 5.1.16 *SFC* — supply mass flow controller
- 5.1.17 *slpm* — standard liters per minute
- 5.1.18 *SPC* — statistical process control

5.2 Definitions

5.2.1 *background counts* — Counts contributed by the test apparatus (including counter electrical noise) with the spool piece in place of the test object.

5.2.2 *condensation nucleus counter (CNC)* — A light scattering instrument that detects particles in a gaseous stream by condensing supersaturated vapor on the particles.

5.2.3 *dynamic control mode test* — A test performed to determine particle contribution as a result of test flow variation within the normal range of MFC operation (i.e., 0 to 100% flow).

5.2.4 *impact or vibration test* — A test performed to determine particle contribution as a result of test flow variation within the normal range of MFC operation (i.e., 10 to 100% flow).

5.2.5 *normal statistical distribution* — Measurements that randomly fall about an average, within a range of ± 3 standard deviations.

5.2.6 *observation* — A 10-minute sample/data collection period.

5.2.7 *purge mode* — Control valve fully open.

5.2.8 *sample flow* — The volumetric flow drawn by the counter for particle detection.

5.2.9 *sampling time* — The time increment over which counts are recorded.

5.2.10 *spool piece* — A null component consisting of a straight piece of electropolished tubing and appropriate fittings used in place of the test component to establish the background.

5.2.11 *stable particle level* — Particle level that has been consistent, as described in Appendix 1, for at least eight consecutive readings.

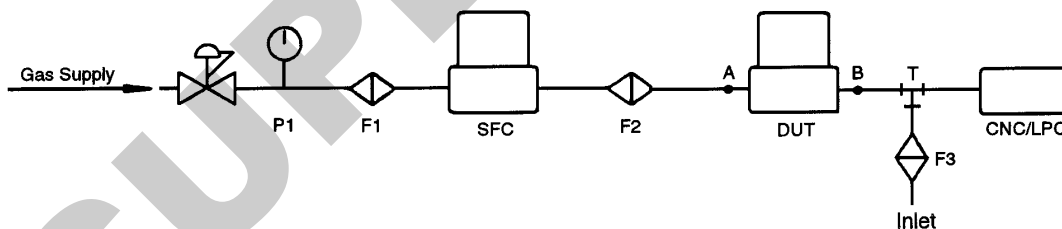
5.2.12 *standard reference conditions* — 101.32 kPa, 0.0°C (14.7 psia, 32°F) (see SEMI E29)

5.2.13 *statistical process control* — A method used by this standard for analyzing experimental data that follows a normal statistical distribution to determine if the test is stable.

5.2.14 *steady state control mode test* — A test performed to determine particle contribution during steady state test flow within the normal operating range of the MFC (i.e., 10 to 100% full scale).

5.2.15 *supply pressure* — Pressure immediately upstream of filter F1. (See Figures 1 and 2.)

5.2.16 *test flow* — Mass flow through the device under test.



Legend

P = Pressure Gauge
 F = Filter
 SFC = Supply Flow Controller
 DUT = Device Under Test
 CNC = Condensation Nucleus Controller
 LPC = Laser Particle Counter
 T = Piping Tee

Notes

- (1) Inlet F3 facing down.
- (2) Distance between DUT and center of tee to be kept at a minimum.
- (3) All tubing to be 6.35 mm (1/4") OD.
- (4) A, B are connection points.

Figure 1
Test Set-Up when Test Flow < Sample Flow

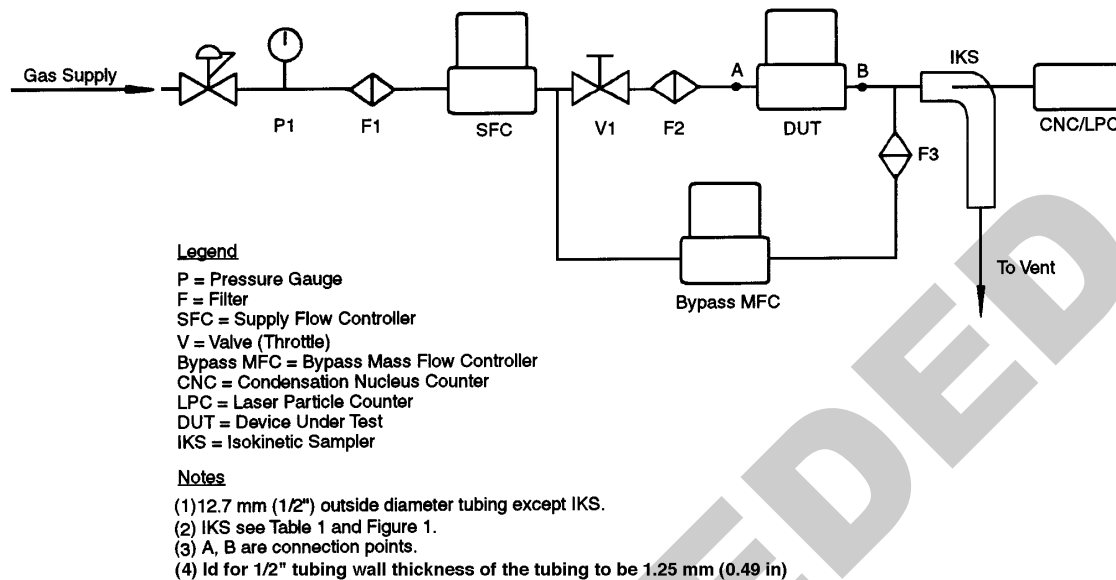


Figure 2
Test Set-Up when Test Flow > Sample Flow

6 Summary of Test Method

6.1 Background count is determined for steady state control, dynamic control, and impact tests. The steady state control mode test, dynamic control mode test, and impact test are run by counting particles for the time necessary to achieve a stable particle level. Background testing is performed again.

7 Significance and Use

7.1 The significance of this test method is that it defines a procedure for testing mass flow controllers intended for installation into a high-purity gas system. It is intended for use by manufacturers and end users.

8 Apparatus

8.1 *Test Gas* — Nitrogen of minimum dryness, with -40°C (-40°F) dew point at 790.57 kPa (100 psig) and with < 10 ppm of total hydrocarbons.

8.2 *Membrane Filters* — To provide filtered test gas, nine-log retentive to larger than 0.01 mm particles, with a pressure drop of less than 7.91 kPa (1 psid) at 283,170 sccm (10 scfm) for a 790.57 kPa (100 psig) inlet, and capable of achieving less than one particle³ 0.01 mm per cubic foot of test gas under test conditions.

8.3 *Pressure Regulator* — Made of electropolished 316L stainless steel, with an internal surface finish of

0.18 mm (7 µin.) R_a and 0.25 mm (10 µin.) R_{max} , to maintain system test pressure.

8.4 *Pressure Gauge or Transducer* — Made of electropolished 316L stainless steel, with an internal surface finish of 0.18 mm (7 µin.) R_a and 0.25 mm (10 µin.) R_{max} , to monitor system test pressure.

8.5 *Throttle Valve* — Made of electropolished 316L stainless steel, with an internal surface finish of 0.18 mm (7 µin.) R_a and 0.25 mm (10 µin.) R_{max} , to proportion flow in test system.

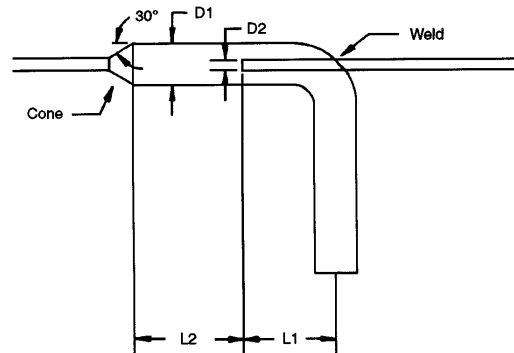
8.6 *Tubing* — Made of electropolished 316L stainless steel, with an internal surface finish of 0.18 mm (7 µin.) R_a and 0.25 mm (10 µin.) R_{max} .

8.7 *Supply Flow Controller (SFC)* — Metal-sealed, used to establish a flow rate through the spool piece in the absence of the DUT, with a settling time less than or equal to that of the DUT. More than one range SFC may be required to run all the tests.

8.8 *Sampler* — Constructed according to the drawing and design parameters shown in Figure 3 and Table 1, to collect gas from the stream exiting the test device, where the sample is near-isokinetic in design.

8.9 *Upstream Adapter* — To connect 12.7 mm (1/2 in.) tubing to the test device. For 12.7 mm (1/2 in.) test devices, the adapter is a simple face-seal connector. For 6.35 mm (1/4 in.) test devices, the adapter is a tapered

cone between 6.35 mm and 12.7 mm (1/4 in. and 1/2 in.) face-seal connections.



D1 = Sampler Diameter
D2 = Probe Diameter
L1 = Length of Sampling Tube (minimum 15 x D1)
L2 = Length of Straight Section (minimum 15 x D1)

Notes

1. Transition cone to be 30°.
2. Material: Electropolished 316L, (0.25 mm) Ra, (0.375 mm) Rmax.
3. The volume of tubing downstream of the 90 degrees bend in the IKS must be large enough to contain the volume of gas drawn by the CNC/LPC when a DUT with a full scale equal to the IKS maximum is at 10% command to prevent ambient air from being sampled.

Figure 3
Isokinetic Sampler Design

Table 1

Maximum IKS Inlet Flow (liters/min.)	ID Probe D ₂ (note)mm (inches)	ID Sampler D ₁ - mm (inches)	Worst-Case Dilution
300	4.62 (0.180)	68.58 (2.700)	3:1
100	4.62 (0.180)	39.62 (1.560)	3:1
30	4.62 (0.180)	21.44 (0.844)	3:1
10	4.62 (0.180)	11.99 (0.472)	3:1
3	7.75 (0.305)	12.57 (0.495)	2:1

NOTE 1: For 300,000 to 10,000 cc/min. test flow:

- Constant sample velocity = 132 cm/sec.
- D₂ = 4.57 mm (0.180 in.) ID standard 6.35 mm (1/4 in.) tubing (see Figure 3)
- For 1.41 l/min. CNC

NOTE 2: For 3,000 cc/min. test flow:

- Constant sample velocity = 49.9 cm/sec.
- D₂ = 7.75 mm (0.305 in.) ID standard 9.53 mm (3/8 in.) tubing (see Figure 3)
- For 1.41 l/min. CNC

8.10 Downstream Adapter — To connect 12.7 mm (1/2 in.) sampler tubing to the test device. For 12.7 mm (1/2 in.) test devices, the adapter is a simple face-seal connector. For 6.35 mm (1/4 in.) test devices, the adapter is a tapered cone between 6.35 mm and 12.7 mm (1/4 in. and 1/2 in.) face-seal connections.

8.11 Spool Pieces — Of the same inside diameter as the inside diameter fittings on the test piece and of a length representative of the DUT, to be installed in the system in place of the test device while obtaining background counts for the system.

8.12 *Fittings* — Face seal connectors or compression fittings, depending on test component end connections. The end connection fittings of each DUT being compared must be of the same type.

8.13 *Metal Gaskets* — New gaskets should be used for each new connection.

8.14 *Mechanical Shock Device* — To provide mechanical shock by impact to the test device. (See Figure 4.)

8.15 *Instrumentation* — Condensation nucleus counter (CNC) or laser particle counter (LPC) to collect particle count data.

8.16 *Isokinetic Sampler (IKS)* — A static device used to collect a representative sample that is not influenced by flow characteristics and/or particle size (see Figure 3). Other designs of isokinetic samplers are permitted as long as they collect a representative sample of the flow.

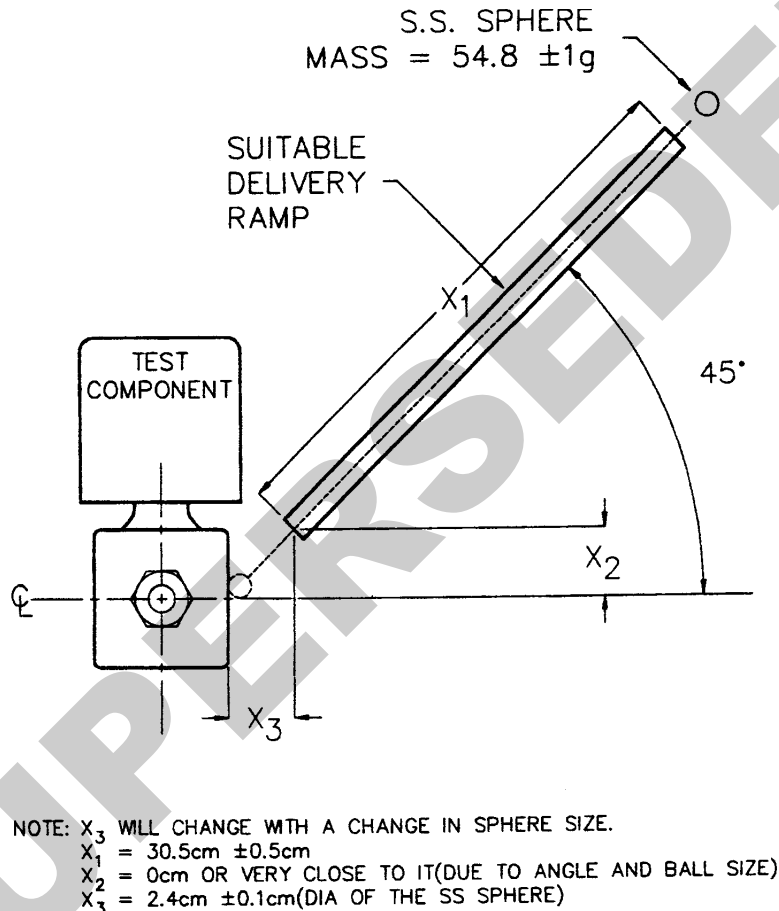


Figure 4
Mechanical Shock Test Device

NOTE: Position the delivery ramp so that the position of impact is at the midpoint of the axial centerline of the device under test.

9 Sampling, Test Specimens, and Test Units

9.1 MFCs regulate flows greater than or less than the flow requirements of particle counters; therefore, two different sampling techniques have been defined, isokinetic sampling and direct sampling.

9.1.1 *Direct Sampling* — The direct sampling method is used when the test flow is less than or equal to the sample flow. (See Figure 1.)

9.1.1.1 In this case, gas exiting the DUT is introduced directly into the CNC. A tee, equipped with a filtered branch, is inserted between the DUT and the CNC to provide make-up flow to the CNC. The volume and overall length of the tubing connecting the DUT to the tee assembly should be minimized.