

SEMI E66-0611 (Reapproved 0517) TEST METHOD FOR DETERMINING PARTICLE CONTRIBUTION BY MASS FLOW CONTROLLERS

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1 Purpose

1.1 The purpose of this Test Method is to measure particle contribution by mass flow controllers (MFCs) intended for use 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.

2.2 This Test Method defines a procedure for testing MFCs intended for installation into a high-purity gas systems. It is intended for use by manufacturers and end users.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents 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 or argon. 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 and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI E29 — 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 ASME Standards¹

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

¹ American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990, USA; Telephone: +1.973.882.1170, Fax: +1.973.882.1717, <https://www.asme.org>

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

5.1.11 *psig* — pounds per square inch gauge

5.1.12 *Ra* — roughness average [ASME B46.1]

5.1.13 *RH* — relative humidity [ASME B46.1]

5.1.14 *Rmax* — roughness maximum

5.1.15 *scfm* — standard cubic feet per minute

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 *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.

5.2.3 *impact or vibration test* — a test performed to determine particle contribution as a result of an impact to the DUT or Vibration of the DUT within the normal range of MFC operation.

5.2.4 *isokinetic sampling* — sampling of particles in a moving aerosol or fluid by matching the sample probe inlet velocity (flow speed and direction) to the velocity of the moving aerosol or fluid.

5.2.5 *normal statistical distribution* — standard normal distribution with a mean of zero and standard deviation of one.

² International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland; Telephone: +41.22.749.01.11, Fax: +41.22.733.34.30, <http://www.iso.org>

5.2.6 *observation* — a 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 electro polished 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.

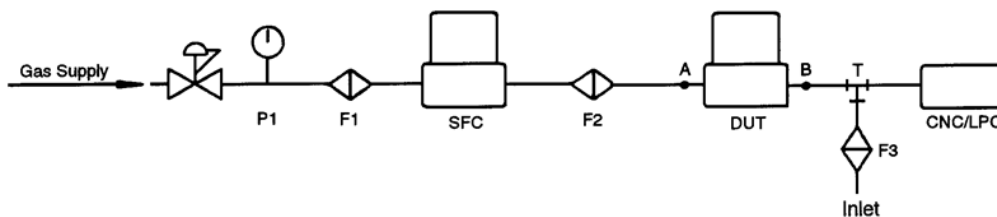
5.2.12 *standard reference conditions* — 101.32 kPa, 0.0°C (14.7 psia, 32°F). (See SEMI E29.)

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.

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

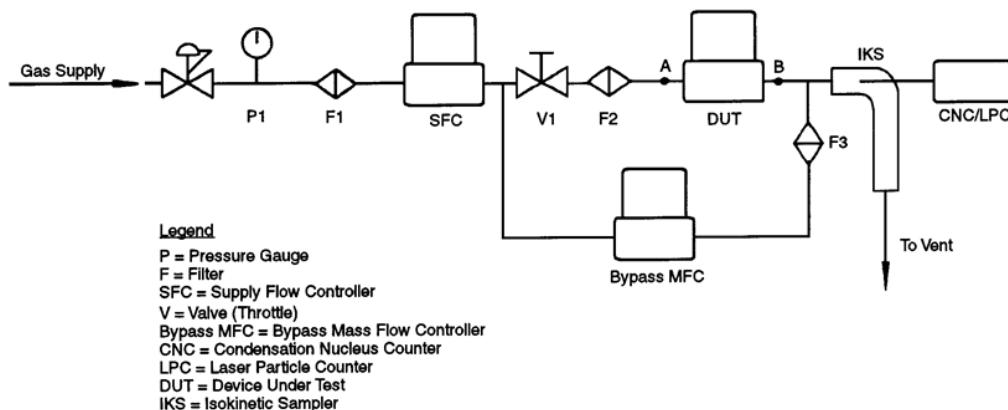
#1 Inlet F3 facing down.

#2 Distance between DUT and center of tee to be kept at a minimum.

#3 All tubing to be 6.35 mm (¼ in.) OD.

#4 A, B are connection points.

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



#1 12.7 mm (½ in.) outside diameter tubing except IKS.

#2 IKS, see Table 1 and Figure 1.

#3 A, B are connection points.

#4 Id for ½ in. tubing wall thickness of the tubing to be 1.25 mm (0.49 in.).

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

6 Summary of 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 Apparatus

7.1 *Test Gas* — Nitrogen, with a dew point $\leq -40^{\circ}\text{C}$ (-40°F) at 790.57 kPa (100 psig) and with <10 ppm of total hydrocarbons.

7.2 *Membrane Filters* — To provide filtered test gas, nine-log retentive to larger than 0.01 μm 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 particle 0.01 μm per cubic foot of test gas under test conditions.

7.3 *Pressure Regulator* — Made of electro polished 316L stainless steel, with an internal surface finish of 0.18 μm (7 $\mu\text{in.}$) Ra and 0.25 μm (10 $\mu\text{in.}$) Rmax, to maintain system test pressure.

7.4 *Pressure Gauge or Transducer* — Made of electro polished 316L stainless steel, with an internal surface finish of 0.18 μm (7 $\mu\text{in.}$) Ra and 0.25 μm (10 $\mu\text{in.}$) Rmax, to monitor system test pressure.

7.5 *Throttle Valve* — Made of electro polished 316L stainless steel, with an internal surface finish of 0.18 μm (7 $\mu\text{in.}$) Ra and 0.25 μm (10 $\mu\text{in.}$) Rmax, to proportion flow in test system.

7.6 *Tubing* — Made of electro polished 316L stainless steel, with an internal surface finish of 0.18 μm (7 $\mu\text{in.}$) Ra and 0.25 μm (10 $\mu\text{in.}$) Rmax.

7.7 *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.

7.8 *Upstream Adapter* — To connect 12.7 mm (½ in.) tubing to the test device. For 12.7 mm (½ in.) test devices, the adapter is a simple face-seal connector. For 6.35 mm (¼ in.) test devices, the adapter is a tapered cone between 6.35 mm and 12.7 mm (¼ in. and ½ in.) face-seal connections.

7.9 *Downstream Adapter* — To connect 12.7 mm (½ in.) sampler tubing to the test device. For 12.7 mm (½ in.) test devices, the adapter is a simple face-seal connector. For 6.35 mm (¼ in.) test devices, the adapter is a tapered cone between 6.35 mm and 12.7 mm (¼ in. and ½ in.) face-seal connections.

7.10 *Spool Pieces* — Of the same inside diameter as the inside diameter of the 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.

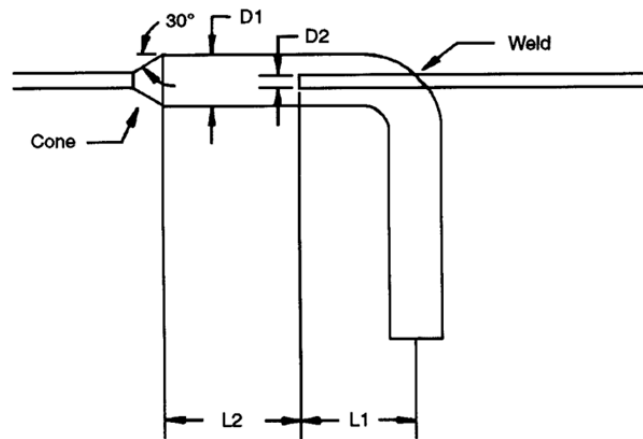
7.11 *Fittings* — Face seal connectors or compression fittings, depending on test component end connections. The end connection fittings of each DUT being compared must be of the same type.

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

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

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

7.15 *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.



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

#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° 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 Isokinetic Sampler Conditions

Maximum IKS Inlet Flow (liters/min.)	ID Probe D ₂ (note) mm (in.)	ID Sampler D ₁ - mm (in.)	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