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Standard Test Method for Determination of Particle Contribution from Gas Distribution System Valves¹

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INTRODUCTION

Semiconductor clean rooms are serviced by high-purity gas distribution systems. This test method presents a procedure that may be applied for the evaluation of one or more components considered for use in such systems.

1. Scope

1.1 This test method covers gas distribution system components intended for installation into a high-purity gas distribution system.

1.1.1 This test method describes a procedure designed to draw statistically significant comparisons of particulate generation performance of valves tested under aggressive conditions.

1.1.2 This test method is not intended as a methodology for monitoring on-going particle performance once a particular valve has been tested.

1.2 This test method utilizes a condensation nucleus counter (CNC) applied to in-line gas valves typically used in semiconductor applications. It applies to automatic and manual valves of various types (such as diaphragms or bellows), 6.3 through 12.7-mm ($\frac{1}{4}$ through $\frac{1}{2}$ -in.) size. For applications of this test method to larger valves, see the table in the appendix.

1.2.1 Valves larger than 12.7 mm ($\frac{1}{2}$ in.) can be tested by this methodology. The test stand must be sized accordingly. Components larger than 12.7 mm ($\frac{1}{2}$ in.) should be tested while maintaining a Reynolds number of 20 000 to 21 000. This is the Reynolds number for 12.7-mm ($\frac{1}{2}$ -in.) components tested at a velocity of 30.5 m/s (100 ft/s).

1.3 Limitations:

1.3.1 This test method is applicable to total particle count greater than the minimum detection limit (MDL) of the condensation nucleus particle counter and does not consider classifying data into various size ranges.

1.3.1.1 It is questionable whether significant data can be generated from nondynamic components (such as fittings and

short lengths of tubing) to compare, with statistical significance, to the data generated from the spool piece. For this reason, this test method cannot reliably support comparisons between these types of components.

1.3.1.2 If detection or classification of particles, or both, in the size range of laser particle counter (LPC) technology is of interest, an LPC can be utilized for testing components. Flow rates, test times, sampling apparatus, and data analysis outlined in this test method do not apply for use with an LPC. Because of these variations, data from CNCs are not comparable to data from LPCs.

1.3.2 This test method specifies flow and mechanical stress conditions in excess of those considered typical. These conditions should not exceed those recommended by the manufacturer. Actual performance under normal operating conditions may vary.

1.3.3 The test method is limited to nitrogen or clean dry air. Performance with other gases may vary.

1.3.4 This test method is intended for use by operators who understand the use of the apparatus at a level equivalent to six months of experience.

1.3.5 The appropriate particle counter manufacturer's operating and maintenance manuals should be consulted when using this test method.

1.4 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use. Specific hazard statements are given in Section 6, Hazards.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the*

¹ This test method is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.10 on Contamination Control.

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Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 Federal Standard:

FED-STD-209D Federal Standard Clean Room and Work Station Requirements, Controlled Environment²

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

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

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

3.1.3 *control product*—sample component that gives consistent, stabilized counts at or below the expected counts from the test components. The product is run periodically in accordance with the test protocol to ensure that the system is not contributing particles significantly different from expected levels.

3.1.3.1 *Discussion*—The control product may have to be changed periodically if its performance degrades with testing. Between tests, the control product must be bagged in accordance with the original manufacturer's packaging and stored in a clean manner. The control product is used to allow the system to consider the disruption caused by the activation of any valve under test, such as significant fluctuations in flow, pressure, turbulence, and vibration.

3.1.4 *dynamic test*—test performed to determine particle contribution as a result of valve actuation.

3.1.5 *impact test*—test performed to determine particle contribution as a result of mechanical shock while the component is in the fully open position.

3.1.6 *sampling time*—the time increment over which counts are recorded.

3.1.7 *sample flow rate*—the volumetric flow rate drawn by the counter for particle detection. The counter may draw higher flow for other purposes (for example, sheath gas).

3.1.8 *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 baseline.

3.1.9 *standard conditions*—101.3 kPa, 20°C (14.73 psia, 68°F).

3.1.10 *static test*—a test performed on an as-received component in the fully open position. This test establishes particulate contribution by the valve to the counting system.

3.1.11 *test duration*—total time required to complete the test procedure.

3.1.12 *test flow rate*—volumetric flow at test pressure and temperature.

3.1.13 *test pressure*—pressure immediately downstream of the test component.

3.1.14 *test velocity*—the average velocity of the test gas in the outlet tube of the test valve (volumetric flow at ambient pressure and temperature divided by the internal cross-sectional area of the valve outlet). In this test method, the test velocity is specified to maintain a Reynolds number of 20 000 to 21 000 (see the table in the appendix).

3.2 Abbreviations:

3.2.1 *LPC*—laser particle counter.

4. Significance and Use

4.1 The purpose of this test method is to define a procedure for testing components intended for installation into a high-purity gas distribution system. Application of this test method is expected to yield comparable data among components tested for the purposes of qualification for this installation.

4.2 *Background Testing*—This test method uses background testing to ensure that the system is not contributing particles above a low, acceptable level. This ensures that counts seen are from the test device, not from a contaminated system. The techniques used to obtain background counts do not produce conditions identical to the conditions existing when a test device is in place. It is recommended that the control products be run periodically to see that they give consistent results. These control products should be the lowest particle release products. They will be additional proof that the system is not contributing excess particles during the static, dynamic, or impact portions of the test.

4.3 This test method can be used for testing lengths of tubing. The flow criteria will be identical to that indicated for valves. A tubing test would only include the static background, the impact background, and the static and impact portions of the method. A dynamic portion could be added by actuating the upstream pneumatic valve (PV1), thus creating a flow surge to the test length of tubing.

5. Apparatus

5.1 *Test Gas*—Clean, dry nitrogen or air is to be used (minimum dryness – 40°C (–40°F) dew point at 689 kPa gage pressure (100 psig) and <10 ppm total hydrocarbons).

5.2 *Filters*—Electronics grade filters are required to provide “particle-free” test gas. Each filter must be no more than 10 % penetration in accordance with manufacturer's specifications to 0.02 µm particles and have a pressure drop of less than 6.89 kPa at 0.00471 m³/s at 689 kPa gage pressure (1 psi at 10 standard ft³/min at 100 psig inlet). The filter must be capable of passing less than 70 particles ≥ 0.02 µm/m³ (2 particles ≥ 0.02 µm/ft³) of test gas under test conditions.

5.3 *Pressure Regulator*—A high-purity electronics grade pressure regulator is required to maintain system test pressure.

5.4 *Pressure Gage*—A high-purity electronics grade pressure transducer or gage is required to monitor system test pressure.

² Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.