II Gas Distribution System Technical Report

Scope

This technical report provides data on Swagelok IGC II gas distribution systems. The report covers:

- particle emissions
- oxygen contribution
- moisture analysis
- hydrocarbon analysis
- ionic cleanliness
- pressure drop
- pressure cycling
- surface finish specifications
- weld corrosion resistance.

Particle emissions, oxygen contribution, moisture and hydrocarbon analysis, and ionic cleanliness data show test results from components cleaned with deionized (DI) water according to the techniques described in Swagelok *Ultrahigh-Purity Surface Finish and Cleanliness (SC-01),* MS-06-61.

Test Panel

The IGC II test panel contained 22 components and 49 seal locations (22 × 2 surface-mount seals plus 5 × 1 manifold seals) configured in:

- three stick lines—a nine-component process in-and-out line, an eight-component process line, and a five-component purge line
- two manifold lines.

The purge line and each process line were constructed with a separate regulator, pressure transducer, and filter. In addition, each process line was equipped with a mass flow controller. A three-position manifold connected the two process lines and the purge line, and a second manifold joined the two process lines to a common outlet.

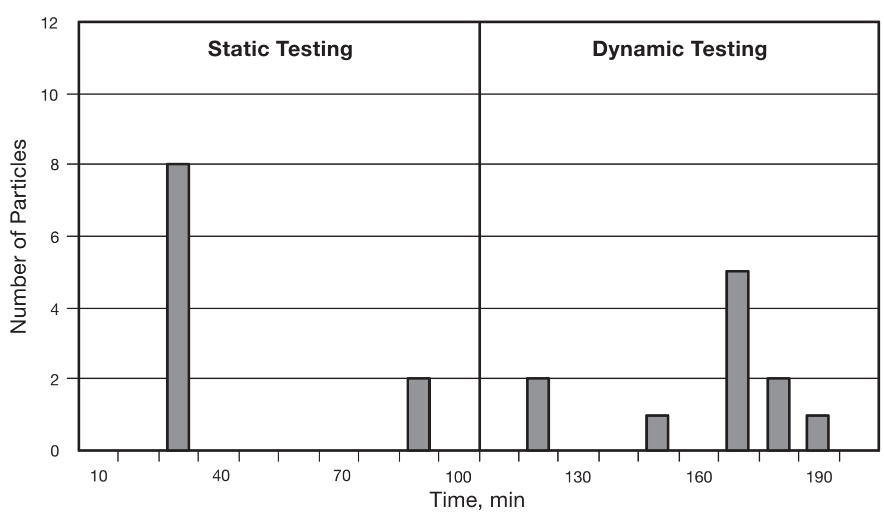
The system contained a total of 14 valves. Except for the manually operated inlet valve on each line, valves were pneumatically actuated.

Particle Emissions

The particle emissions test method was based on SEMI F28-0997. The test gas was nitrogen with a flow rate of 2.8 std L/min. Testing included a static phase and a dynamic phase, with a test interval of 10 min.

The test panel had a total of:

- 10 particles during static testing (0.11 particles per standard cubic foot)
- 11 particles during dynamic testing (0.12 particles per standard cubic foot).



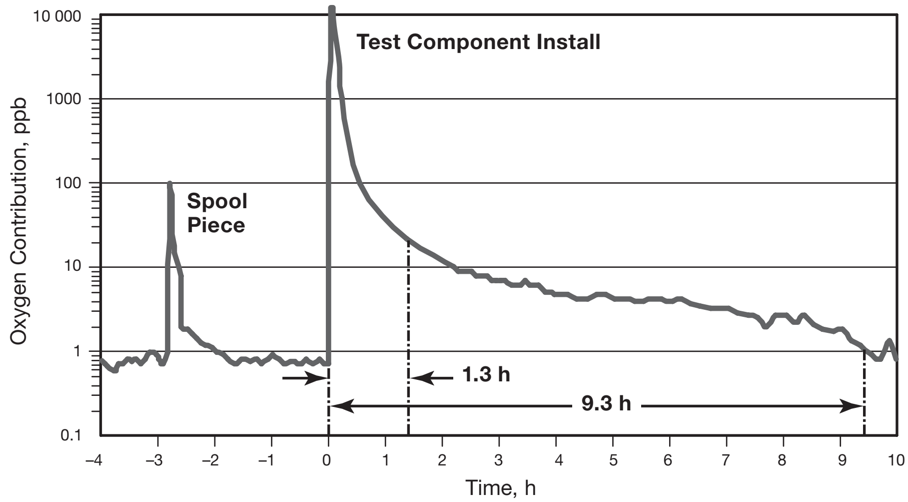
Oxygen Contribution

The oxygen displacement test method was based on SEMASPEC 90120398B-STD. The test gas was nitrogen with a flow rate of 1.2 std L/min.

The test panel was installed following purging of the spool calibration piece.

The test panel reached:

- 100 ppb oxygen in 30 min
- 20 ppb oxygen in 1.3 h
- 1 ppb oxygen in 9.3 h.

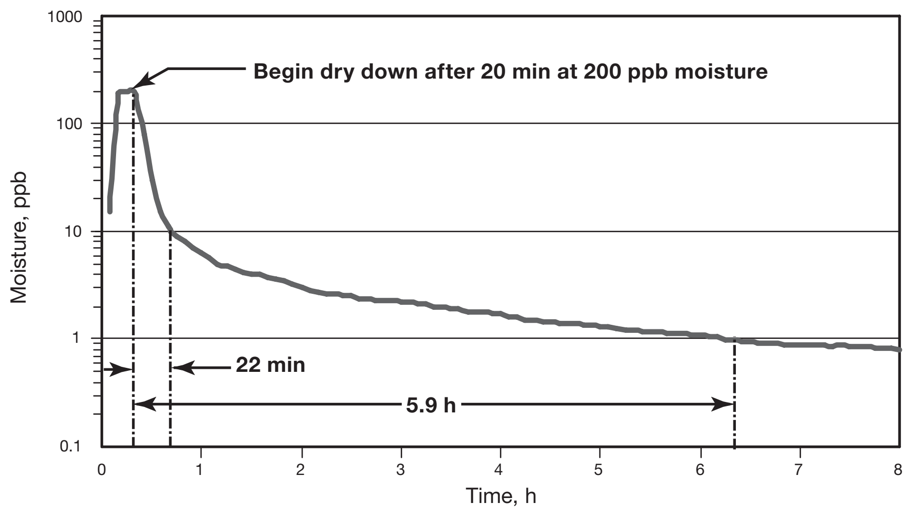


Moisture Analysis

The moisture dry down test method was based on SEMI F58-1000. The test gas was nitrogen with a flow rate of 1.2 std L/min. The tests included application of a 20-min pulse of nominal 200 ppb moisture.

The test panel reached:

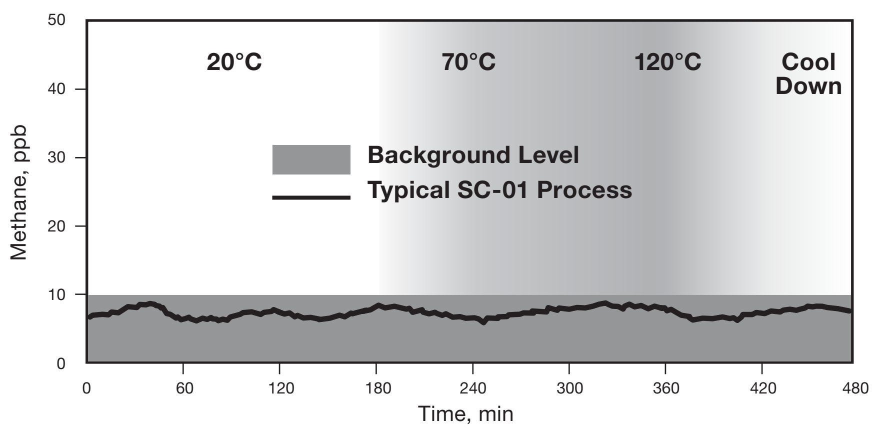
- 10 ppb moisture in 22 min
- 1 ppb moisture in 5.9 h.



Hydrocarbon Analysis

Hydrocarbon residues in SC-01 processed flow components fall entirely within the background level produced by the test instrument.

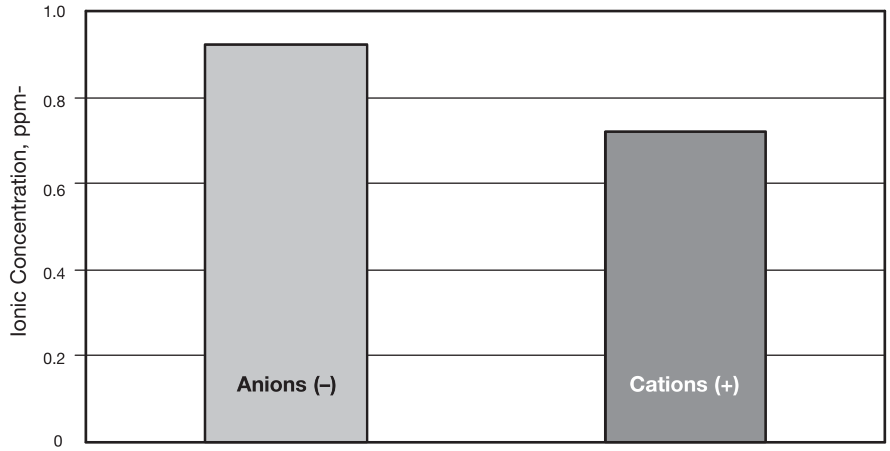
Hydrocarbon analyses of SC-01 processed products are conducted in accordance with ASTM F1398 guidelines.



Ionic Cleanliness

The flow components in the test panel were tested in accordance with ASTM F1374. Each component was filled with deionized water. After 20 h, the sample was extracted and analyzed.

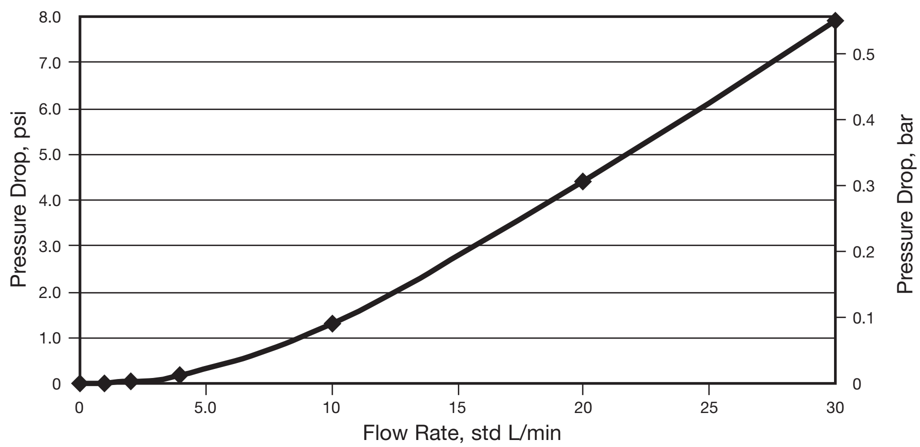
Anions (–)	Cations (+)
Fluoride	Lithium
Chloride	Sodium
Nitrate	Ammonium
Phosphate	Potassium
Sulfate	Magnesium
	Calcium



Pressure Drop

The pressure drop test method was based on SEMASPEC 90120393B-STD. Spools were installed in place of the regulator, filter, and mass flow controller. The inlet pressure was set to 30 psig (2.0 bar). Pressure drop was measured across one gas stick at flow rates of 1, 2, 4, 10, 20, and 30 std L/min.

- The pressure drop was less than 0.2 psi (0.01 bar) for flow rates of less than 4 std L/min.



Pressure Cycling

The pressure cycling test was performed in accordance with SEMI Draft Standard 3063. Five separate gas panels were pressurized between 9.8 and 100 psig (0.67 and 6.8 bar) for 250 000 total cycles. Stainless steel and nickel C-seals from two major suppliers were tested.

- The acceptance criterion for each test iteration was a system helium leak rate of less than 1×10^{-9} std cm^3/s.
- Following the cycles, the gas panels sealed below the 1×10^{-9} std cm^3/s range in all cases.

Surface Finish

Statistical process control (SPC) allows Swagelok to provide consistent surface finishes, as described in Specification SC-01. The roughness average (R_a) specification we have established for the wetted surfaces of IGC II components is 5 µin. (0.13 µm) R_a on average.

Weld Corrosion Resistance

Tubing samples 0.25 in. (6.4 mm) in diameter with 0.035 in. (0.89 mm) wall thickness were machined from bar stock of the moderately controlled-chemistry VIM/VAR stainless steel specified for IGC II wetted components (heat KZM). Tube sections were electropolished and passivated, then SC-01 cleaned and dried.

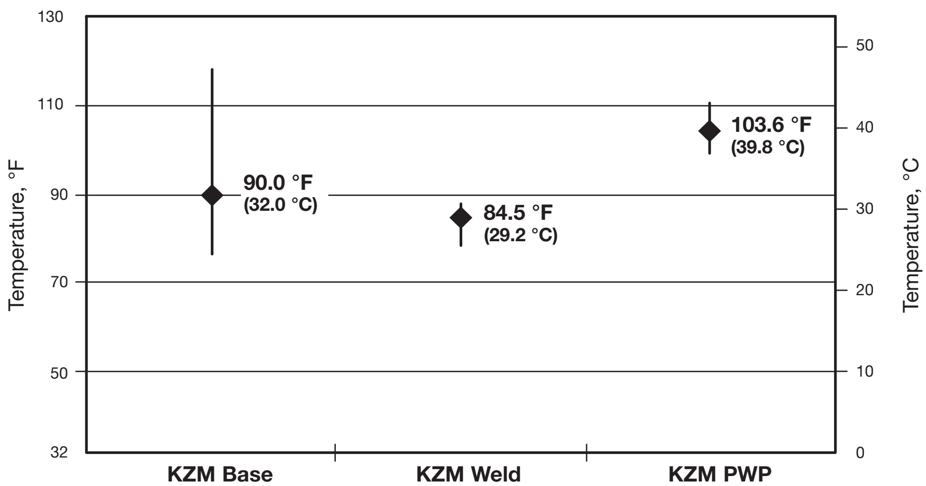
Welded samples were produced in an atmosphere of 96 % Ar and 4 % H_2 with an O_2 content of 4 ppm.

The corrosion resistance of the material was compared at each stage of processing:

- before welding—KZM Base
- after welding—KZM Weld
- after welding and post-weld passivation—KZM PWP.

Critical Pitting Temperature

Electrochemical critical pitting temperature testing based on ASTM G150 was performed to determine resistance to localized corrosion. The electrolyte was 3.56 % NaCl made from reagent-grade chemicals and DI water. The critical pitting temperature increased following post-weld passivation.



Moist Hydrogen Chloride Gas Testing

A gas bench based on the "mixed flowing gas" system described in ASTM B827 was used to create a corrosive atmosphere of 1500 to 2000 ppm moisture in anhydrous hydrogen chloride.

Welded tube samples were exposed for 8 hours at ambient temperature and this moisture level to simulate extended use at 30 ppb moisture, typical of semiconductor applications.

Scanning electron microscope images of the weld and the heat affected zones showed that the KZM material was not attacked in any of the sample groups.

Referenced Documents

ASTM Standards[1]

B827 Standard Practice for Conducting Mixed Flowing Gas (MFG) Environmental Tests

F1374 Standard Test Method for Determination of Ionic/Organic Extractables of Internal Surfaces—IC/GC/FTIR for Gas Distribution Systems Components

F1398 Standard Test Method for Determination of Total Hydrocarbon Contribution by Gas Distribution Systems Components

G150 Standard Test Method for Electrochemical Critical Pitting Temperature Testing of Stainless Steels

SEMATECH SEMASPECS[2]

90120393B-STD Pressure Drop Testing of Gas Distribution Systems Components

90120398B-STD Oxygen Contribution Testing of Gas Distribution Systems Components

SEMI Standards[3]

3063 Draft Guide for Performance and Evaluation of Metal Seals Used in Gas Delivery Systems

F28-0997 Test Method for Measure Particle Generation from Process Panels

F58-1000 Test Method for Determination of Moisture Dry-down Characteristics of Surface-Mounted and Conventional Gas Delivery Systems

Swagelok Specification

Ultrahigh-Purity Process Specification (SC-01), MS-06-61

1. American Society for Testing and Materials, 100 Barr Harbor Dr., West Conshohocken, PA 19428.
2. SEMATECH, Inc., 2706 Montopolis Dr., Austin, TX 78741.
3. Semiconductor Equipment and Materials International, 3801 Zanker Rd., San Jose, CA 95134.

Safe Product Selection
When selecting products, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Panel design and testing for particle emissions, moisture analysis, and pressure drop performed by Ultra Clean Technology (UCT), Menlo Park, California.

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