Swagelok® DRP Series Ultrahigh-Purity Fluoropolymer Diaphragm Valve Technical Report Abstracts

Scope

These abstracts summarize the testing conducted by independent third parties and Swagelok on the DRP series valve. The DRP valve has been designed primarily for use in semiconductor industry critical fluid management applications where purity and reliability are paramount. Reported data and test protocols are conducted in accordance with SEMI Standard F57-0301.

These abstracts cover:

- Particle contribution
- Surface roughness
- Ionic contamination
- Metallic contamination
- Total organic carbon contamination
- Reliability testing with DI water, HCl, and slurry

Particle Contribution

Online particle measurements were recorded at zero, 10 000, and 20 000 cycles. The baseline measurement represents the background conditions of the water flowing through the test system without the valve installed. The zero cycle measurement was conducted in accordance with SEMI standard F40 prior to starting the valve actuation. Particle counts were generally low throughout the test. Test protocols were in accordance with SEMASPEC 92010949B and JIS K0554.

The results exceed industry expectations of fewer than 100 particles per cycle (particles less than or equal to 0.1 µm in size) within 500 cycles.

Table 1—Particle Contribution (Small Valve Size)

	Particle Size		
	0.10 µm	0.5 µm	1.0 µm
Cycles	Particles Per Milliliter		
Baseline	1	< 1	< 1
At 60 min rinse time	1	0	0
Zero	1	1	< 1
10 000	< 1	< 1	< 1
20 000	< 1	< 1	< 1

Table 2—Particle Contribution (Medium Valve Size)

	Particle Size		
	0.10 µm	0.5 µm	1.0 µm
Cycles	Particles Per Milliliter		
Baseline	1	< 1	< 1
At 60 min rinse time	3	0	0
Zero	< 1	< 1	< 1
10 000	< 1	< 1	< 1
20 000	< 1	< 1	< 1

Table 3—Particle Contribution (Large Valve Size)

	Particle Size		
	0.10 µm	0.15 µm	0.20 µm
Cycles	Particles Per Milliliter		
Baseline	2	2	1
At 60 min rinse time	14	5	4
Zero	1	1	2
10 000	1	1	0
20 000	1	0	1

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Surface Roughness

Consistent surface finishes are ensured by statistical process control (SPC). Test protocols were in accordance with SEMASPEC 92010950B. The wetted surface finishes measured were in compliance with SEMI Standard F57-0301, which calls for ≤ 25 µin. R_a for machined wetted surfaces.

Surface Extractable Ionic Contamination

Samples used for this analysis were prepared in accordance with SEMI Standard F40 and tested to ASTM D4779. All anions were below the detectable limit.

Table 4—Surface Extractable Ionic Contamination

Anion	Ionic Contamination, µg/m²	
	Detectable Limit	SEMI STD F57-0301
Bromide	0.06	≤ 100
Chloride	0.06	≤ 3000
Fluoride	0.3	≤ 60 000
Nitrate	0.06	≤ 100
Nitrite	0.06	≤ 100
Phosphate	0.06	≤ 300
Sulfate	0.06	≤ 300

Surface Extractable Metallic Contamination

Samples used for this analysis were prepared in accordance with SEMI Standard F40 and tested to SEMASPEC 92010936B. Also presented are the results of a more aggressive dynamic metallic extraction test (Dycon[EX SM]) utilizing 37 % HCl. All elements were below the detectable limit.

The primary contributors to surface contamination are shown in Table 6. Trace amounts of other elements accounted for the remainder of the surface contamination. The area-normalized surface contamination from 37 elements extracted was 9.36 ng/cm² which is below the industry expectation of < 20 ng/cm². Iron, aluminum, sodium, calcium, and potassium accounted for more than 80 % of the surface contamination measured. The area-normalized extraction rate was 0.06 ng/cm² per day at 7 days, which is below the industry expectation of < 0.5 ng/cm² per day at 7 days.

Table 5—Trace Metals with Ultra Pure Water

Element	Metallic Contamination, µg/m²	
	Detectable Limit	SEMI STD F57-0301
Aluminum	0.009	≤ 10
Barium	0.003	≤ 15
Boron	0.15	≤ 10
Calcium	0.6	≤ 30
Chromium	0.012	≤ 1
Copper	0.009	≤ 15
Iron	0.06	≤ 5
Lead	0.009	≤ 1
Lithium	0.006	≤ 2
Magnesium	0.006	≤ 5
Manganese	0.006	≤ 5
Nickel	0.012	≤ 1
Potassium	0.3	≤ 15
Sodium	0.021	≤ 15
Strontium	0.003	≤ 0.5
Zinc	0.015	≤ 10

Table 6—Trace Metals with 37 % HCl

Element	Normalized Mass Extracted ng/cm²
Aluminum	1.85
Calcium	1.15
Iron	2.12
Potassium	0.80
Sodium	1.66
Zirconium	0.80
Misc.	0.98
Total	9.36

Surface Extractable Total Organic Carbon (TOC) Contamination

The TOC measurements were essentially stable over the course of the test. Samples used for this analysis were prepared in accordance with SEMI Standard F40 and tested to ASTM D4779.

Table 7—Surface Extractable TOC Contamination

Cycles	TOC Contamination, µg/m²	
	UHP DRP	SEMI STD F57-0301
Baseline	< 30	≤ 60 000
Zero	< 30	≤ 60 000
10 000	< 30	≤ 60 000
20 000	< 30	≤ 60 000

Reliability Testing

Reliability testing was performed in accordance with SEMASPEC 92010945B with DI water, 37 % HCl, and Cabot SS-25 slurry on 174, 15, and 15, valves respectively.

DRP valves were installed in a continuous flow loop containing the test media at 40 ± 5 psig (2.7 ± 0.34 bar). Valves under test were cycled from open to closed in intervals of 3 s.

Each DRP valve was tested for shell and seat integrity at installation, 200 000, and 1 000 000 cycles. Leak integrity was tested at the valve rated pressure.

DRP valves have been tested for reliability to 1 000 000 cycles in DI water, 37 % HCl, and Cabot SS-25 slurry. No leaks were detected.

Referenced Documents

ASTM

ASTM D4779 Total, Organic, and Inorganic Carbon in High Purity Water by Ultraviolet (UV) or Persulfate Oxidation, or Both, and Infrared Detection.

JIS

JIS K0554 Testing Methods for Concentration of Fine Particles in Highly Purified Water.

SEMASPEC

SEMASPEC 92010949B Provisional Test Method for Determination of Particle Contribution and Retention by UPW Distribution System Components.

SEMASPEC 92010936B Provisional Test Method for Determining Leachable Trace Organics from UPW Distribution Systems.

SEMASPEC 92010945B Provisional Test Method for Verifying the Pressure Rating of Plastic Valves Used in UPW Distribution Systems.

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

SEMI

SEMI Standard F57-0301 Provisional Specification For Polymer Components Used in Ultrapure Water and Liquid Chemical Distribution Systems.

SEMI F40 Practice For Preparing Liquid Chemical Distribution Components for Chemical Testing.

The DyconE$^{X\ SM}$ procedure is patented by BOC Edwards Chemical Management Division (US patent No. 5,641,895).

December 2006, R2
MS-06-102-E