Swagelok® DRP Series Ultrahigh-Purity Fluoropolymer 3-Way Diaphragm Valve Technical Report Abstracts

Scope

These abstracts summarize the testing conducted by an independent third party and Swagelok on the DRP series 3-way valve. The DRP 3-way valve has been designed primarily for use in semiconductor industry critical fluid management applications where purity is paramount. Reported data and test protocols are conducted in accordance with SEMI Standard F57-0301.

These abstracts cover:

- Surface roughness
- Particle contribution
- Metallic contamination
- Reliability testing

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. (0.64 µm) R_a for machined wetted surfaces.

Particle Contribution

The test, conducted by an independent, third-party laboratory, first measured particle release with a spool piece in place of the test valve Table 1). These system contributions were later subtracted out.

Next, particle release was monitored as the valves were flushed (Table 2) and alternately cycled (Table 3).

The data represent averages for five valves of each configuration. The results are better than industry expectations in each criterion.

Table 1—System Background Particle Contribution with Spool Piece

Valve Body Size	Particle Size			
	≥ 0.10 µm	≥ 0.15 µm	≥ 0.20 µm	≥ 0.30 µm
	Cumulative Particle Concentrations particles per milliliter			
Small	0.033	0.010	0.002	< 0.001
Medium	0.042	0.013	0.003	< 0.001

Table 2—Flush Volume Needed to Achieve Particle Contributions of < 0.1 Particles per Milliliter

Particle size ≥ 0.10 µm

Valve Configuration	Flush Volume, L
Small body, normally open	33
Small body, normally closed	4
Medium body, normally open	218
Medium body, normally closed	165
Industry expectation	*≤ 300*

Table 3—Cycles Needed to Achieve Industry Expectations for Actuated Valves

Particle size ≥ 0.10 µm

Valve Body Size	Particles Per Cycle	
	< 100	< 10
	Cycles Required	
Small	10	30
Medium	15	780
Industry expectation	*≤ 500*	*≤ 10 000*

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Surface Extractable Metallic Contamination

Results are for an aggressive dynamic metallic extraction test (DyconE$^{X\ SM}$) utilizing 37 % HCI. This testing was conducted by a third-party, independent laboratory on four medium-body valves.

Results for average surface contamination (Table 4) and rates of extraction (Table 5) are better than industry expectations.

Table 4—Average Surface Contamination

Industry expectation < 20 ng/cm^2 per element

Element	Normalized Mass Extracted ng/cm^2	Percentage of Total
Iron	2.15	85.3
Nickel	0.21	8.3
Others	0.16	6.4
Total	*2.52*	*100*

Table 5—Calculated Extraction Rate

Industry expectation < 0.5 ng/cm^2 per day at 7 days

Extraction Rate per Day ng/cm^2		
1 day	7 days	14 days
0.09	0.03	0.02

Reliability Testing

Reliability testing was performed in accordance with SEMASPEC 92010945B on a total of 61 Swagelok DRP series 3-way valves.

Valves (21 small body and 9 medium body) were installed in a continuous-flow loop containing 73°F (22°C) water at 80 psig (5.5 bar). Water was alternately cycled from the common port to normally closed and normally open ports with a cycle time of 3 seconds. Each valve was tested for seat and shell leak integrity at installation, 250 000, and 1 000 000 cycles.

Valves (15 small body and 16 medium body) were also cycled in a continuous flow loop containing 176°F (80°C) ethylene glycol at 40 psig (2.7 bar). Ethylene glycol was alternately cycled from the common port to normally closed and normally open ports with a cycle time of 3 seconds. Each valve was tested for seat and shell leak integrity at installation and 250 000 cycles.

All tested valves conformed to the requirements of SEMI E49.2 and E49.3 paragraph 9.2, “Hydrostatic Pressure Decay at Pre and Post Test Evaluations.”

Referenced Documents

SEMASPEC

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 E49.2 Guideline for the Qualification of Polymer Assemblies Used in Ultrapure Water and Liquid Chemical Systems in Semiconductor Process Equipment

SEMI Standard E49.3 Guide for Ultrahigh-Purity Deionized Water and Chemical Distribution Systems in Semiconductor Manufacturing Equipment.

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

Other Reference

Grant, D.C., T. Lemke, G. Duepner, D. Wilkes, and N. Powell (1996). “Measurement of Inorganic Contaminant Extraction from Fluid Handling Components by Dynamic Extraction.” *Journal of the Institute of Environmental Sciences* 39(2); 29-37.

The independent, third-party laboratory cited is CT Associates, Eden Prairie, Minnesota.

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

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