ALD7C Diaphragm Valve Technical Report

Scope

This technical report provides data on Swagelok® ALD7C normally closed ultrahigh-purity diaphragm valves.

The report covers:

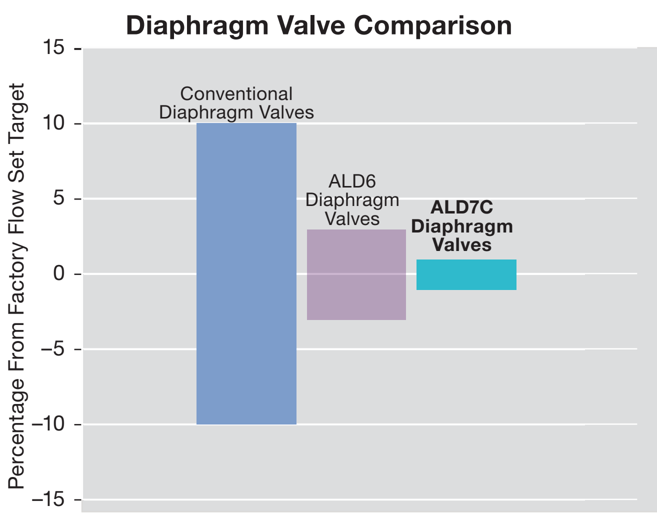
- Factory Flow Set Consistency
- Standard Cartridge Flow Consistency
- Standard Cartridge Flow at Temperature
- Pneumatic Actuation Time
- Lab Cycle Testing
- Helium Seat Leak Testing
- Flow Adjustability
- Cartridge Servicability
- Additive Alloy 22 Material
- Surface Finish
- Moisture Analysis
- Ionic Cleanliness
- Hydrocarbon Analysis
- Referenced Documents

Factory Flow Set Consistency

Swagelok ALD7C valves are factory set to provide a consistent flow performance.

A quantity of 32 ALD7C valves were tested in accordance with SEMI F32 following standard production assembly processes. The difference in flow capacity among the 32 valves was less than ±1%.

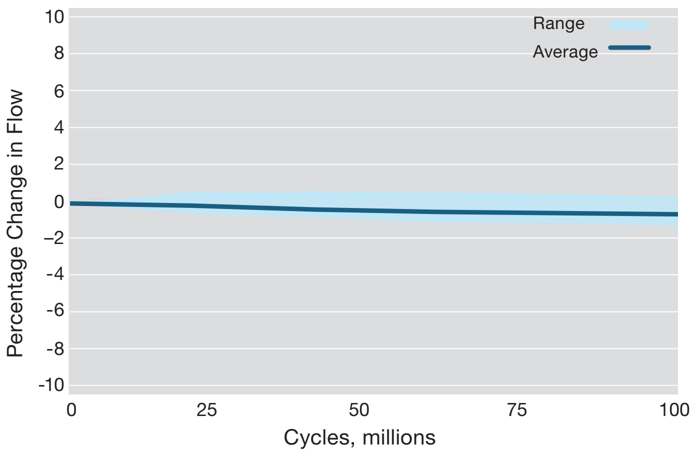
- 5 psig (0.34 bar) inlet pressure
- 5 psi (0.34 bar) differential pressure
- 70°F (20°C)



Standard Cartridge Flow Consistency

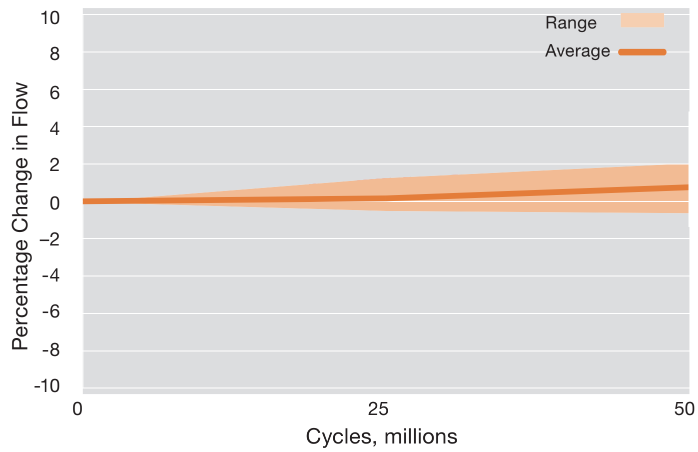
Valves were tested in accordance with SEMI F32. Flow variation up to 100 million cycles was within a measured 1% range at ambient. The change in the flow capacity of each valve, shown below as a percentage, is compared to initial flow at test without flow adjustments.

ALD7C Valve Flow Consistency at Ambient 70°F (20°C)①



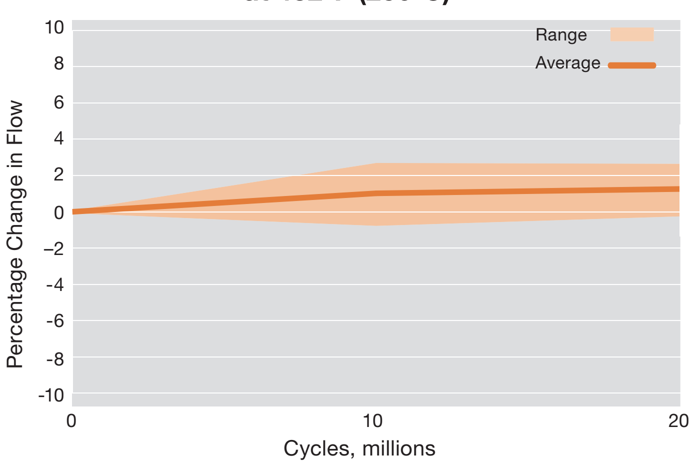
① Valve Quantities Tested: (16)

ALD7C Valve Flow Consistency at 392°F (200°C)①



① Valve Quantities Tested: (16)

ALD7C Valve Flow Consistency at 482°F (250°C)①

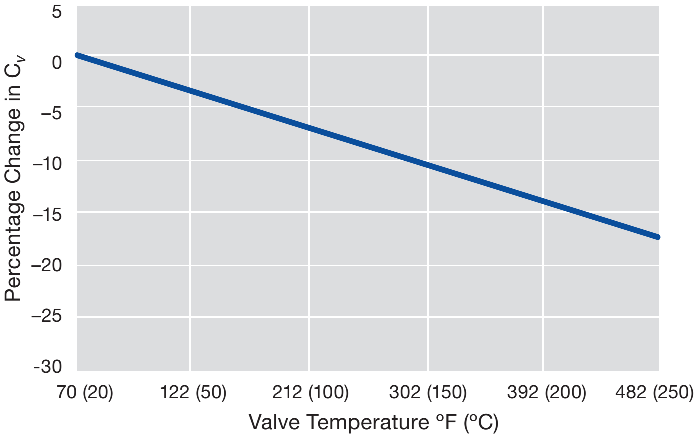


① Valve Quantities Tested: (16)

Standard Cartridge Flow at Temperature

Swagelok ALD7C valves were tested in accordance with SEMI F32 at various temperature from 70°F (20°C) up to 482°F (250°C). The percentage change in C_v is represented by the graph below.

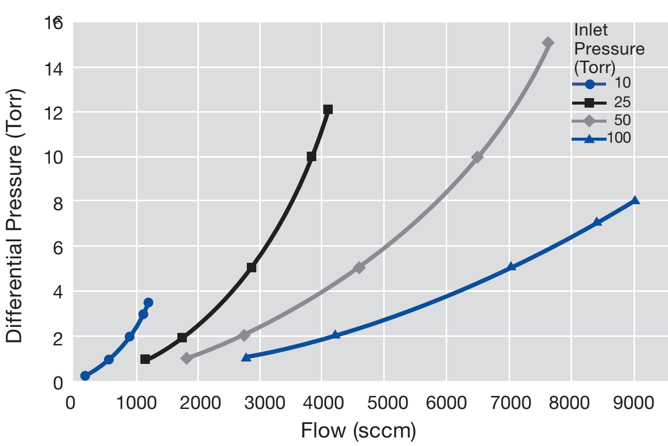
Percentage Change in C_v vs. Temperature °F (°C)



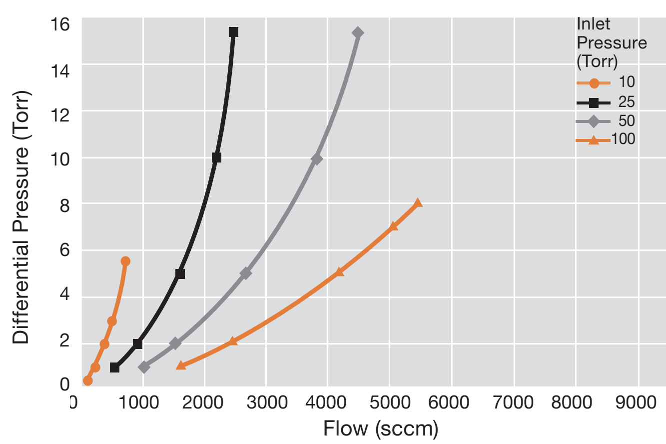
Vacuum Flow

Swagelok ALD7C valve conductance was laboratory tested at various inlet pressures, from 10 to 100 torr, and differential pressure drops. The flow response of ALD7C valves at these conditions is independent of flow direction.

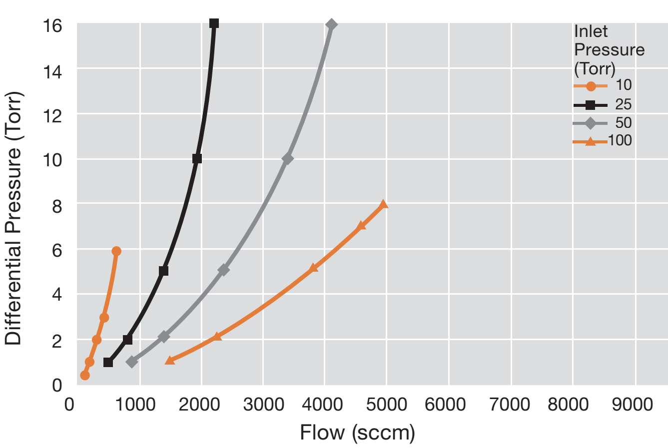
ALD7C Standard Cartridge at 70°F (20°C)



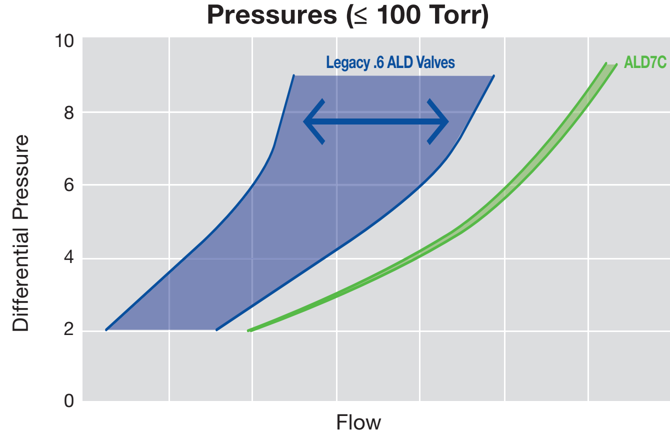
ALD7C Standard Cartridge at 392°F (200°C)



ALD7C Standard Cartridge at 482°F (250°C)



Elevated Temperature ≥ 302°F (150°C) Valve Flow Comparison Under Extreme Vacuum Pressures (≤ 100 Torr)



Note: Swagelok ALD7C design has been optimized for consistent high flow at low vacuum and elevated temperatures

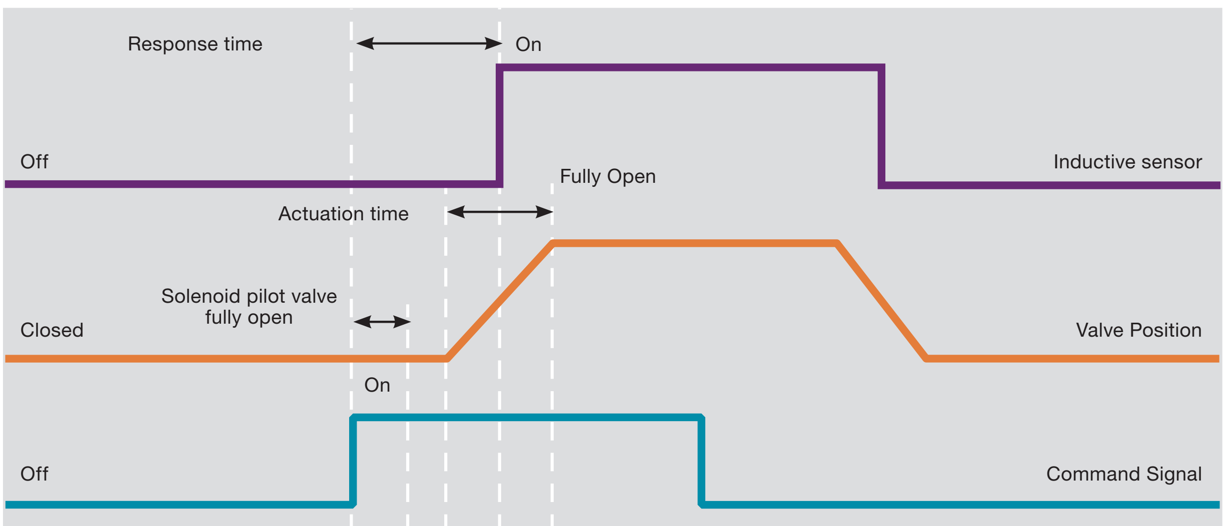
Pneumatic Actuation Time

The actuation time of Swagelok ALD7C valves was electronically evaluated using an oscilloscope, inductive sensor on the actuator piston, and an optical sensor on the valve diaphragm. The measured valve opening profile is compared to the control signal and the signal from an optional inductive sensor. As shown in the charts below, the ALD7C valve is capable of an actuation response time of less than 4 ms and a response time of less than 5 ms.

Actuator response time is dependent on pneumatic circuit and temperature.

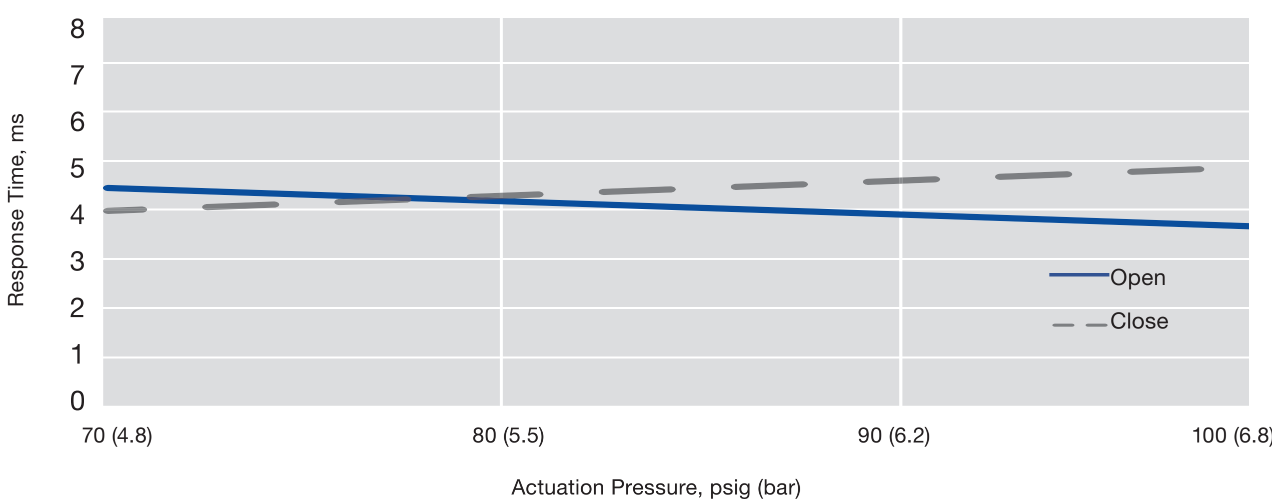
- Festo® MHE2-MS1 H 3/2G-M7 solenoid pilot valve
- 70 to 100 psig (4.8 to 6.8 bar)
- Tubing from solenoid pilot valve to ALD7C actuator: 5/32 × 3/32 × 1.100 in.
- Tubing to solenoid pilot valve inlet: 1/4 in. × 0.065 in.
- Unrestricted solenoid pilot valve exhaust port

Actuation Time Test Diagram



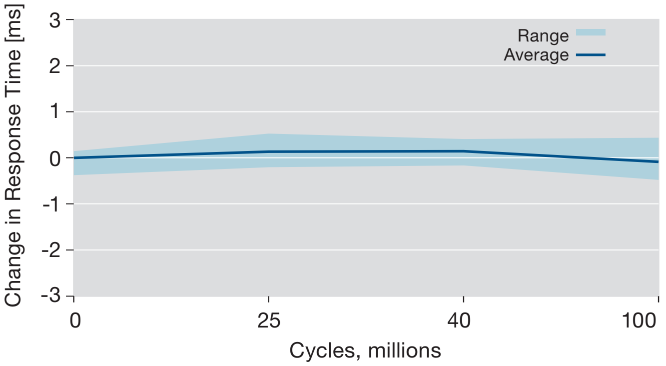
Time

Actuation Time Versus Actuator Supply Pressure at Ambient 70°F (20°C)

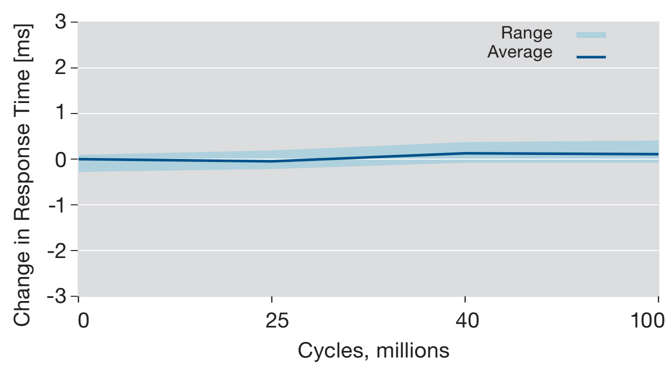


Pneumatic Actuation Time

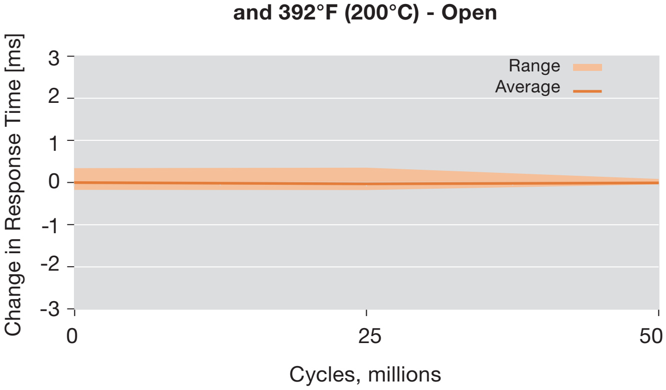
Actuator Response Time at 60 psig (4.1 bar) and Ambient 70°F (20°C) - Open



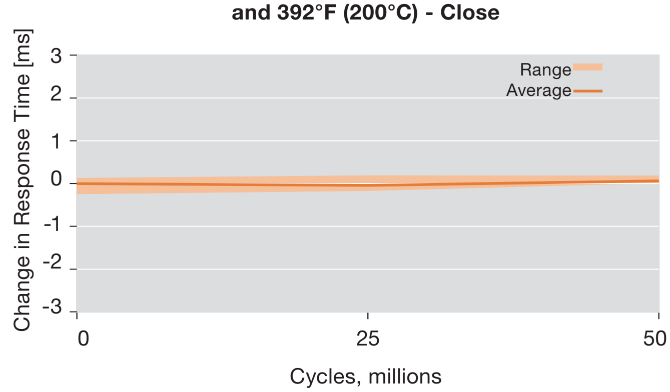
Actuator Response Time at 60 psig (4.1 bar) and Ambient 70°F (20°C) - Close



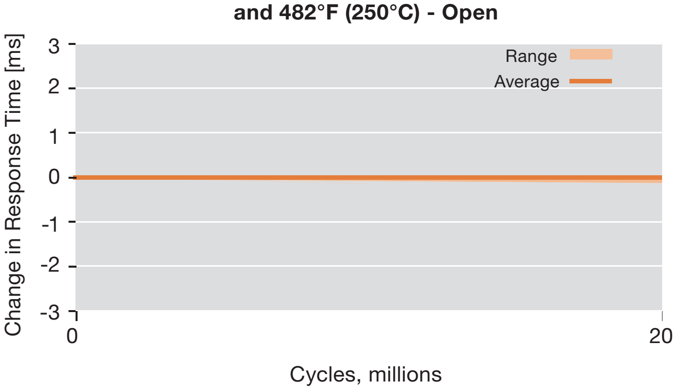
Actuator Response Time at 60 psig (4.1 bar) and 392°F (200°C) - Open



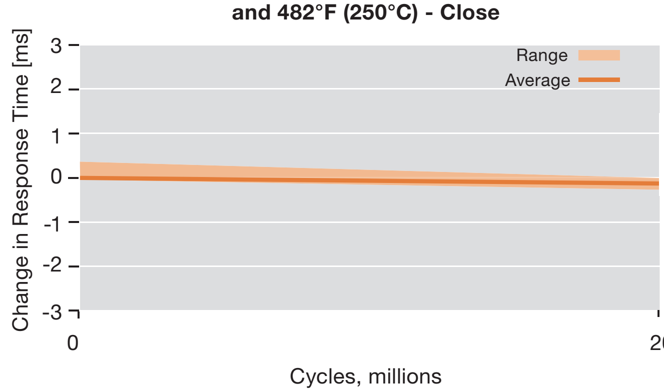
Actuator Response Time at 60 psig (4.1 bar) and 392°F (200°C) - Close



Actuator Response Time at 60 psig (4.1 bar) and 482°F (250°C) - Open



Actuator Response Time at 60 psig (4.1 bar) and 482°F (250°C) - Close



Lab Cycle Testing

The Swagelok ALD7C valve was evaluated to determine an estimated cycle life under controlled laboratory conditions. All valves were electronically monitored during testing for envelope seal integrity. At regular intervals, the valves were removed and evaluated for seat seal integrity, envelope seal integrity, and actuator seal performance. **A total of 72 valves were cycled to a minimum of 20 million cycles with no envelope seal or seat failures.**

These tests are not a guarantee of a minimum number of cycles in service. They indicate that in tests under these laboratory conditions, the probability of early failure is low. Laboratory tests cannot duplicate the variety of actual operating conditions, and therefore we cannot promise that the same results will be realized in service.

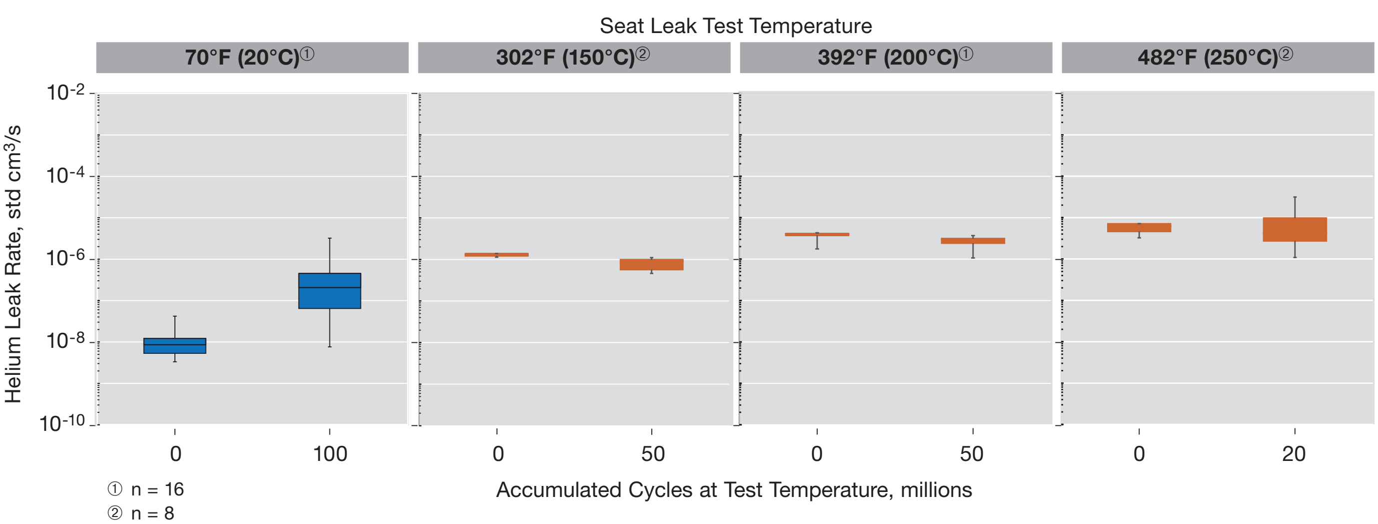
Quantity		40	24	16	16	8
Gas		Dry, filtered nitrogen				
Immersion Temperature		482°F (250°C)	392°F (200°C)	302°F (150°C)	70°F (20°C)	70°F (20°C)
Valve Pressure		Vacuum	Vacuum/ Atmosphere②	Vacuum/ Atmosphere③	Vacuum	35 psig (2.4 bar)
Cycle Rate		24 cycles per second				
Cycles Accumulated		20 million (suspended)	50 million (suspended)	50 million (suspended)	100 million (suspended)	40 million (suspended)
Envelope Leakage > 1 × 10^{-9} std cm^3/s He		NONE①	NONE①	NONE①	NONE①	NONE①
Actuator Air Leakage > 1 L/min at 80 psig input	**Room Temperature 70°F (20°C)**	2	NONE①	NONE①	NONE①	NONE①
	At Immersion Temperature	NONE①	NONE①	NONE①	N/A	N/A

① NONE – None of the valves in the population exhibited detectable leakage or leakage greater than the defined limit.
② Valve quantities tested: Quantity 16 - Atmosphere, Quantity 8 - Vacuum.
③ Valve quantities tested: Quantity 8 - Atmosphere, Quantity 8 - Vacuum.

Helium Seat Leak Testing

Swagelok ALD7C valves processed to meet Swagelok Ultrahigh-Purity Process Specification (SC-01), MS-06-61, were evaluated for internal helium leak integrity of the valve seat in accordance with SEMI F1. Valves were cycled at the test temperature, and seat testing was performed at regular intervals throughout cycling.

The increasing valve seat seal response shown at elevated test temperatures is predominantly a function of the helium permeation through the plastic seat material. Room temperature seat seal leak rates will also increase after cycling at elevated temperatures.



Flow Adjustability

Swagelok ALD7C flow adjustment sensitivity and range will depend on flow path configuration and customer process parameters. Typically, the C_v will adjust approximately 3% for every 10 degrees of actuator rotation and may provide at least 35% reduction of C_v from Factory Flow Set.

Refer to *ALD7C Service Instructions*, MS-CRD-0279 for flow adjustment instructions.

Cartridge Servicability

Six Swagelok ALD7C valves were evaluated for envelope and seat seal integrity after new cartridge remakes, refer to *ALD7C Service Instructions*, MS-CRD-0279. All valves passed envelope (< 1 x 10-9 Std cm^3 /s He) and seat (<1 x 10-7 Std cm^3 /s He) leak rate requirements up to 9 remakes, where the test was suspended.

These tests are not a guarantee of a minimum number of remakes in service. They indicate that in tests under laboratory conditions, the probability of seal degradation is low. Laboratory tests cannot duplicate the variety of actual operating conditions, and therefore we cannot promise that the same results will be realized in service.

Additive Alloy 22 Material

Swagelok ALD7C additive manufactured manifolds meets Alloy 22 (UNS N06022) chemical composition, density, and mechanical properties specified in ASTM B574, Table 5 Mechanical Property Requirements for Hot or Cold Finished, Solution Annealed Rods and Bars.

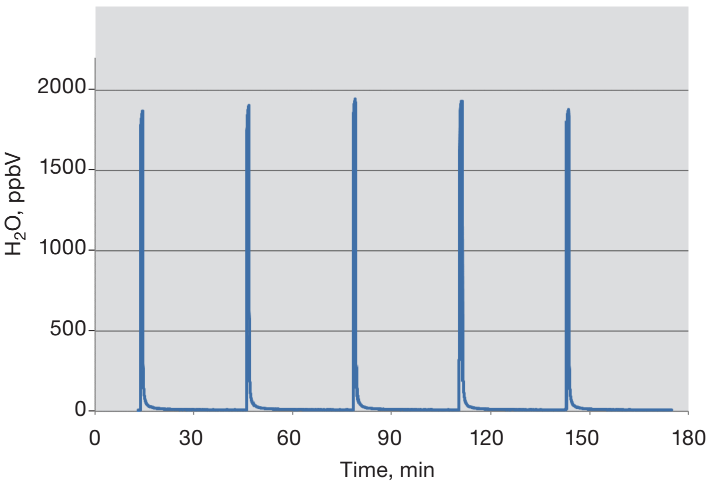
Surface Finish

Swagelok ALD7C manufacturing process controls, applied to both machined wrought bar and additively manufactured components, allow Swagelok to provide consistent surface finishes, refer to *Ultrahigh-Purity Process Specification (SC-01)*, MS-06-61. The surface roughness established for the wetted surfaces of Swagelok ALD7C valves is of <5 µin (0.13 µm) R_a.

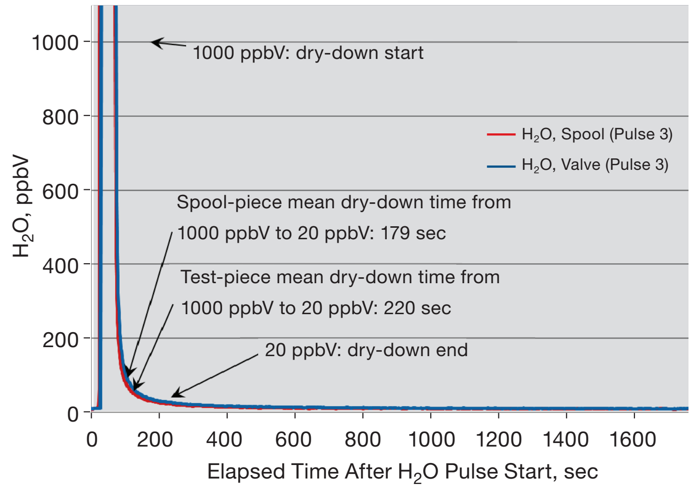
Moisture Analysis

Moisture analysis of Swagelok SC-01 processed products was performed in accordance with ASTM F1397 guidelines. A Swagelok ALD7C valve had 2 ppm moisture pulses introduced every 30 minutes and recovered from each pulse in less than 4 minutes. This is much faster than the 1-hour guideline of SEMI E49.8.

Moisture Concentration vs. Time—Valve



Dry-Down Performance: Valve vs. Spool Piece



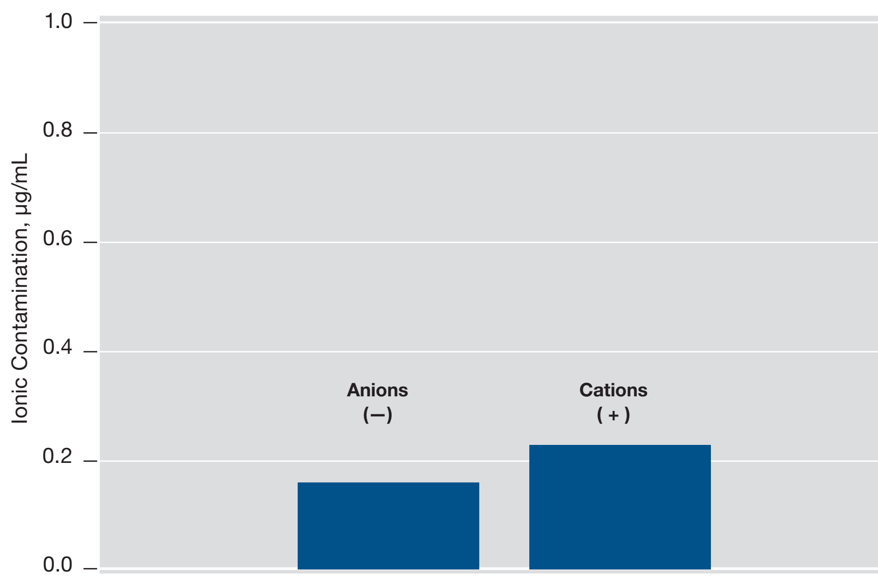
Ionic Cleanliness

Residual ionic contamination is very low (less than 1 µg/ml) for Swagelok SC-01 processed valves.

A Swagelok ALD7C valve tested in accordance with ASTM F1374:

- Valve was filled with deionized (DI) water
- After 24 hours, the sample was extracted and analyzed

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



Hydrocarbon Analysis

An analysis of hydrocarbon residues in a Swagelok ALD7C SC-01 processed valve was conducted as referenced in ASTM G93. Residue levels were less than 0.13 mg/ft^2 (1.4 mg/m^2).

Referenced Documents

ASTM Standards[1]

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

F1397 Standard Test Method for Determination of Moisture Contribution by Gas Distribution System Components

G93 Standard Guide for Cleanliness Levels and Cleaning Methods for Materials and Equipment Used in Oxygen-Enriched Environments

B574 Standard Specification for Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Molybdenum-Chromium, Low-Carbon Nickel-Molybdenum-Chromium-Tantalum, Low-Carbon Nickel-Chromium-Molybdenum-Copper, and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten

SEMI Standards[2]

F1 Specification for Leak Integrity of High-Purity Gas Piping Systems and Components

E49.8 Guide for High-Purity and Ultrahigh-Purity Gas Distribution Systems in Semiconductor Manufacturing Equipment

F32 Test Method for Determination of Flow Coefficient for High-Purity Shutoff Valves

Swagelok Specification

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

ALD7C Service Instructions, MS-CRD-0279

① American Society for Testing and Materials, 100 Barr Harbor Dr., West Conshohocken, PA 19428, U.S.A.

② Semiconductor Equipment and Materials International, 3081 Zanker Road, San Jose, CA 95134, U.S.A.

These tests do not simulate any specific application and are not a guarantee of performance in actual service. Laboratory tests cannot duplicate the variety of actual operating conditions. The results are not offered as statistically significant. See the product catalog for technical data.

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.

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Festo—TM Festo SE & Co. KG
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