Swagelok

ALD7 Diaphragm Valve Technical Report

Scope

This technical report provides data on Swagelok® ALD7 normally closed ultrahigh-purity diaphragm valves. The report covers:

- valve flow consistency
- vacuum flow
- flow at temperature
- pneumatic actuation speed
- lab cycle testing
- helium seat leak testing
- particle counting
- moisture analysis
- ionic cleanliness
- hydrocarbon analysis

Hydrocarbon analysis and moisture analysis data show test results from valves cleaned with deionized (DI) water according to the techniques described in Swagelok *Ultrahigh-Purity Process Specification (SC-01),* MS-06-61.

Valve Flow Consistency

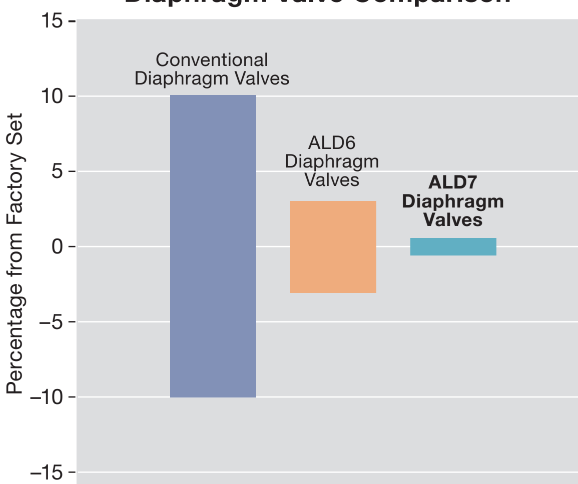
Swagelok ALD7 valves are factory set to provide a consistent flow performance.

A quantity of 32 ALD7 valves was tested in accordance with SEMI F32 following standard production assembly processes. The measured difference in flow output among the 32 valves was less than ±1%.

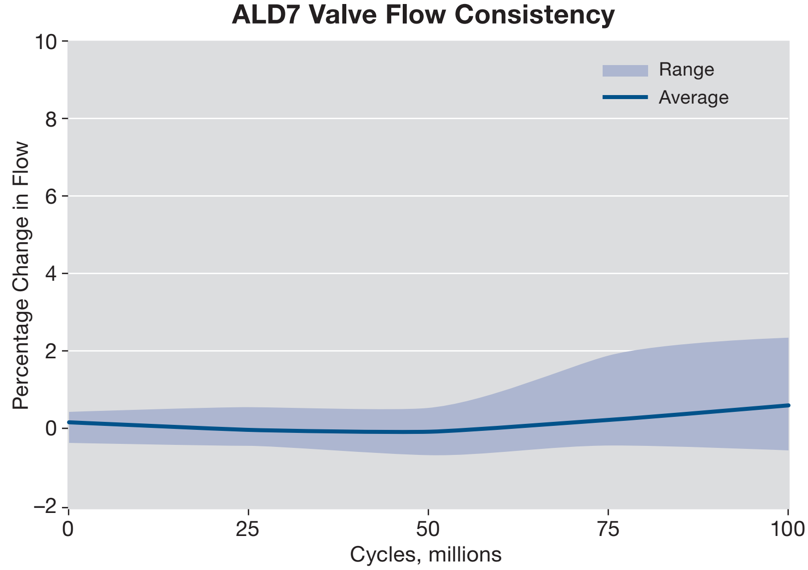
- 5 psig (0.34 bar) inlet pressure
- 5 psi (0.34 bar) differential pressure
- 70°F (20°C)

A total quantity of 32 valves was tested in accordance with SEMI F32 for 100 million cycles at ambient temperature 70°F (20°C). Flow variation up to 50 million cycles was within a measured 1% range.

Diaphragm Valve Comparison

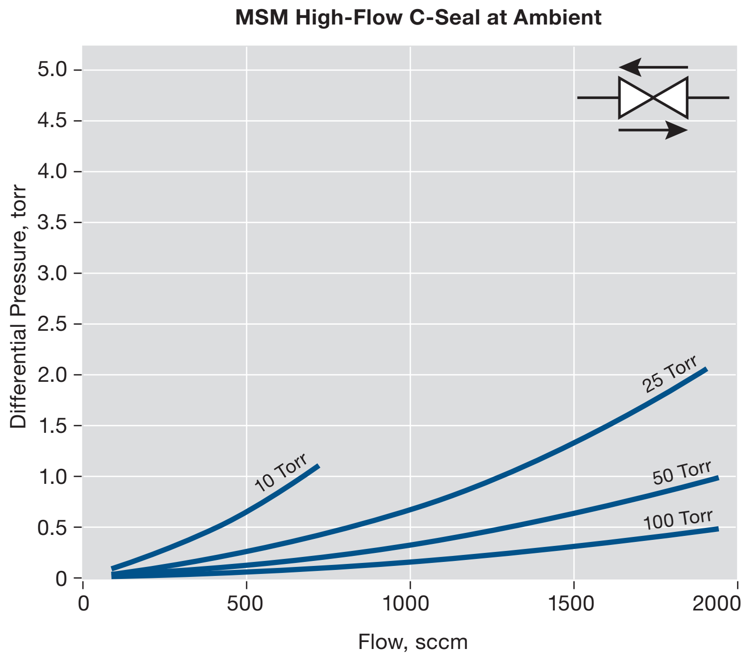


ALD7 Valve Flow Consistency



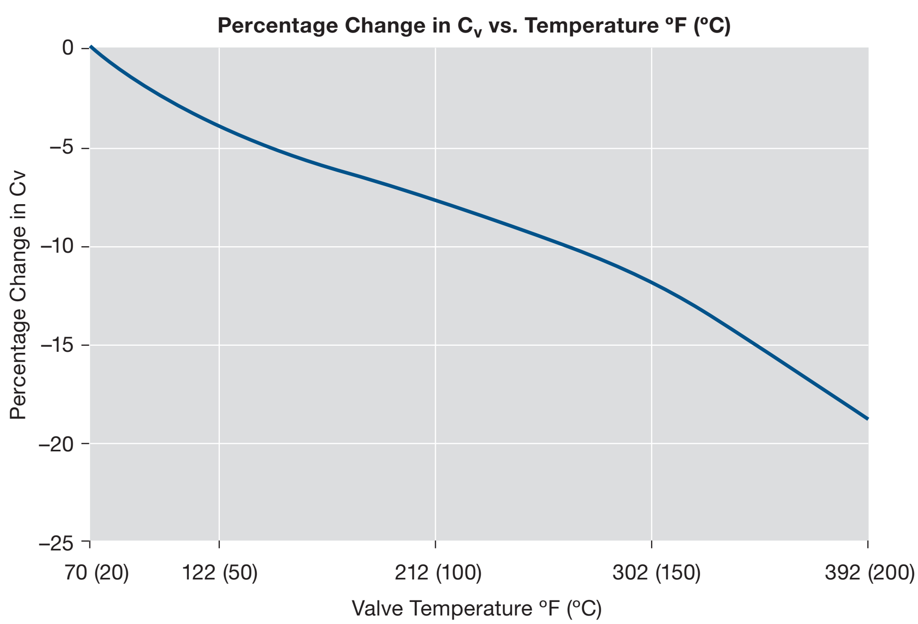
Vacuum Flow

Swagelok ALD7 valve conductance was laboratory tested at various inlet pressures, from 10 to 100 torr, and differential pressure drops. The flow response of ALD7 valves at these conditions is independent of flow direction.



Flow at Temperature

Swagelok ALD7 valves were tested in accordance with SEMI F32 at various temperatures from 70°F (20°C) up to 392°F (200°C). The percent change in C_v is represented by the graph below.

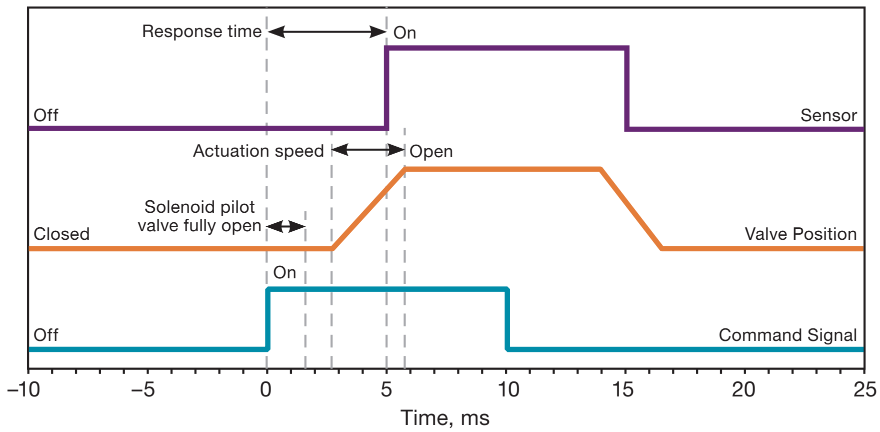


Pneumatic Actuation Speed

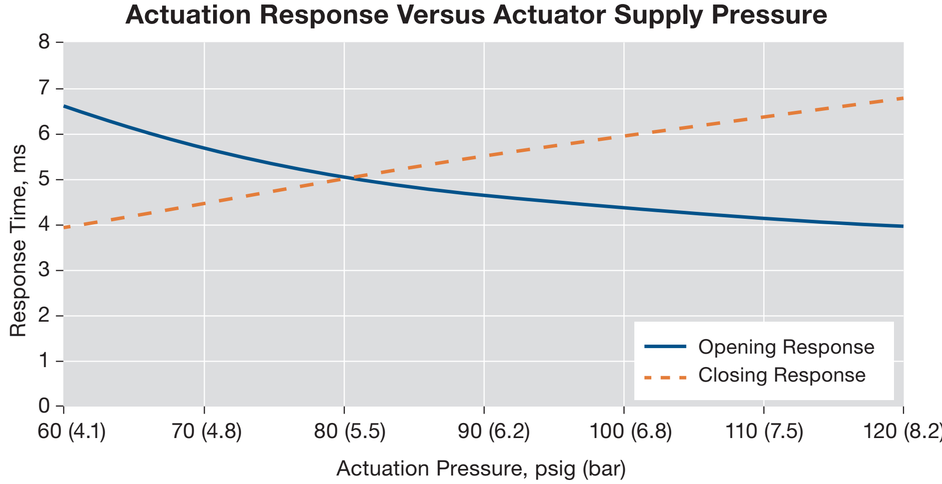
The actuation speed of Swagelok ALD7 valves was electronically evaluated using an oscilloscope, inductive sensor on the actuator piston, and an optical sensor on the valve diaphragm. The measured valve opening profile is compared to the control signal and the signal from an optional electronic position indicator. As shown in the charts below, the ALD7 valve is capable of an actuation speed of less than 5 ms and a response time of less than 7 ms.

- Festo® MHE2-MS1H 3/2G-M7 solenoid pilot valve
- 60 to 120 psig (4.1 to 8.3 bar)
- Tubing from solenoid pilot valve to ALD7 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
- 70°F (20°C)

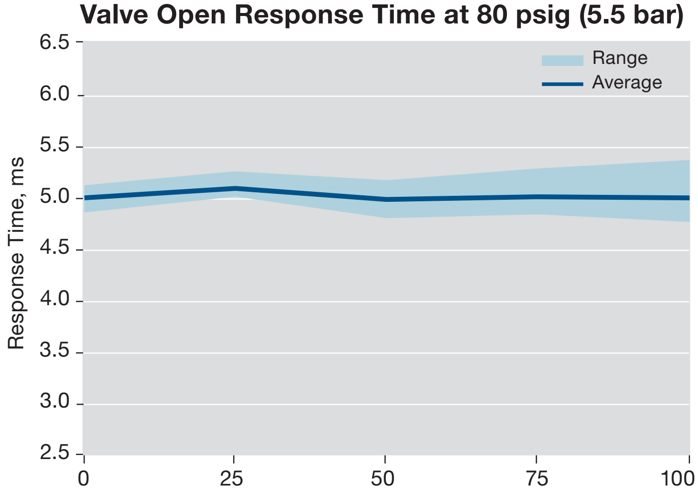
Actuation Speed Test Diagram at 80 psig (5.5 bar)



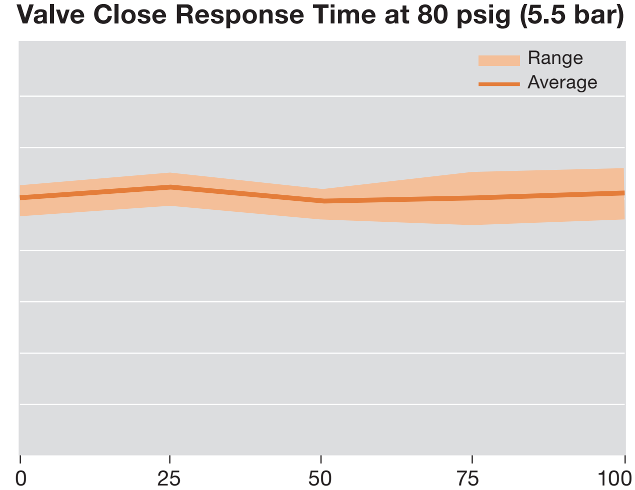
Actuation Response Versus Actuator Supply Pressure



Valve Open Response Time at 80 psig (5.5 bar)



Valve Close Response Time at 80 psig (5.5 bar)



Cycles, millions

Lab Cycle Testing

The Swagelok ALD7 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 48 valves were cycled to a minimum of 50 million cycles with no 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.

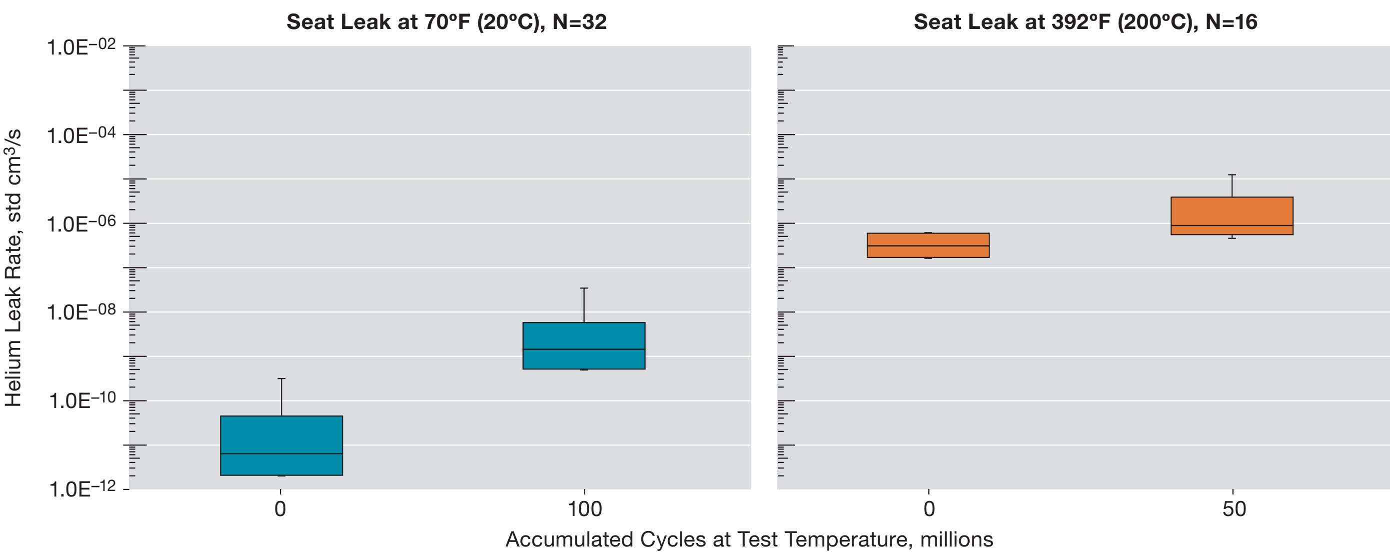
Quantity	32	16
Gas	Dry, filtered nitrogen	
External Temperature	70°F (20°C)	302°F (150°C)
Valve Temperature	70°F (20°C)	392°F (200°C)
Valve Pressure (quantity)	Vacuum	Vacuum
Cycle Rate	24 cycles per second, 50% actuation duty cycle	
Cycles Accumulated (millions)	100 suspended	50 suspended
< 2% Flow Change at 70°F (20°C)	31①	13②
Envelope Leakage > 1 × 10^{-9} std cm^3/s He	NONE③	NONE③
Actuator Air Leakage > 1 L/min	NONE③	NONE③

① At 100 million, one valve had a flow change of 2.4%.
② At 25 million, 15 of 16 valves had < 2% flow change at 70°F (20°C). At 50 million, 3 valves had < 6% flow change at 70°F (20°C).
③ NONE – None of the valves in the population exhibited detectable leakage or leakage greater than the defined limit.

Helium Seat Leak Testing

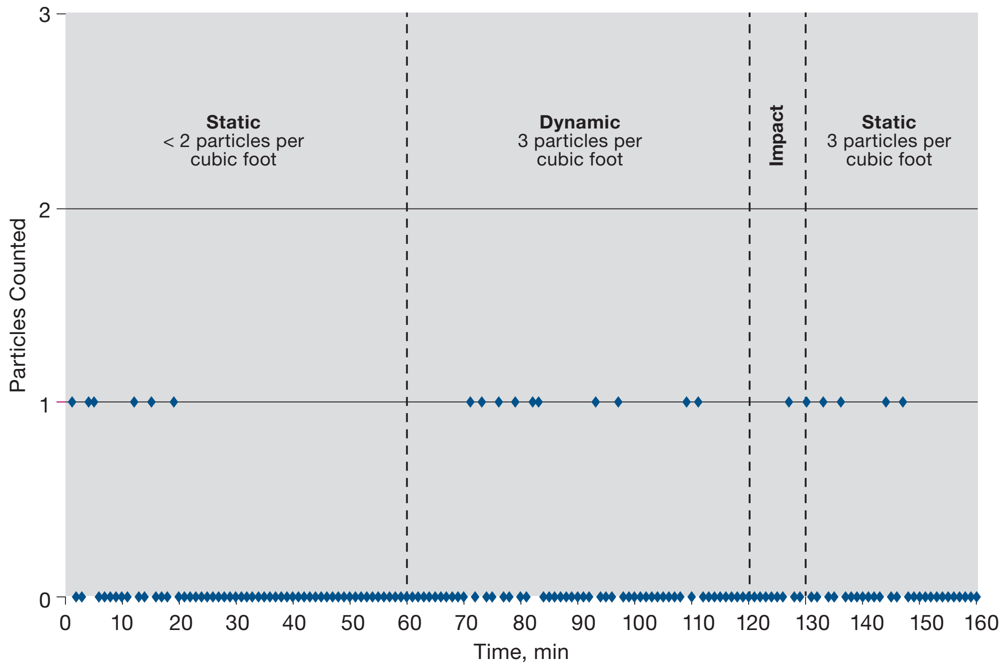
Swagelok ALD7 valves processed to meet Swagelok Ultrahigh-Purity Process Specification (SC-01), MS-06-61, were evaluated for internal helium leak integrity of the valve seat in accordance with SEMI F1. Valves were cycled at the test temperature, and seat testing was performed at regular intervals throughout 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.



Particle Counting

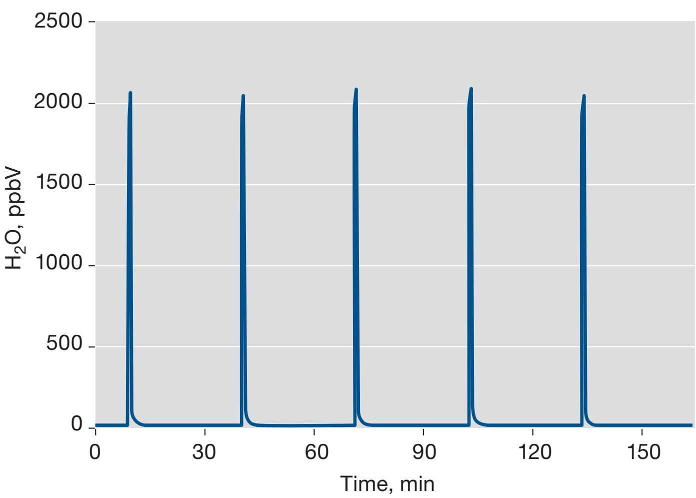
Testing was performed in accordance with ASTM F1394, measuring particles greater than 5nm in size. Static particle emissions from a Swagelok ALD7 valve met the recommended performance of fewer than 20 particles per cubic foot, in accordance with SEMI E49.8.



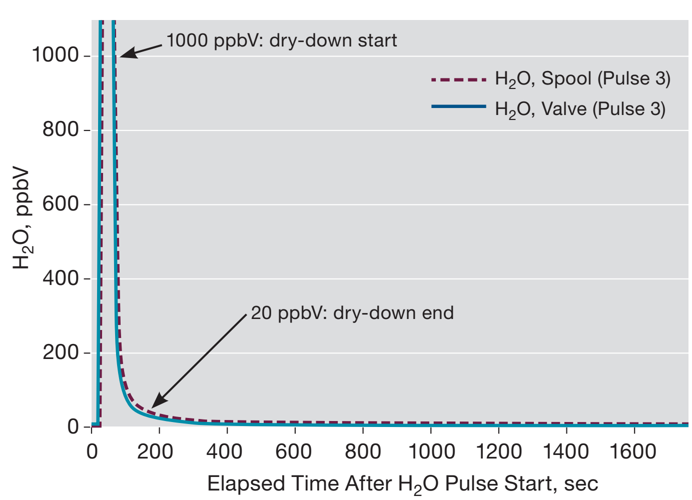
Moisture Analysis

Moisture analysis of Swagelok SC-01 processed products was performed in accordance with ASTM F1397 guidelines. A Swagelok ALD7 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



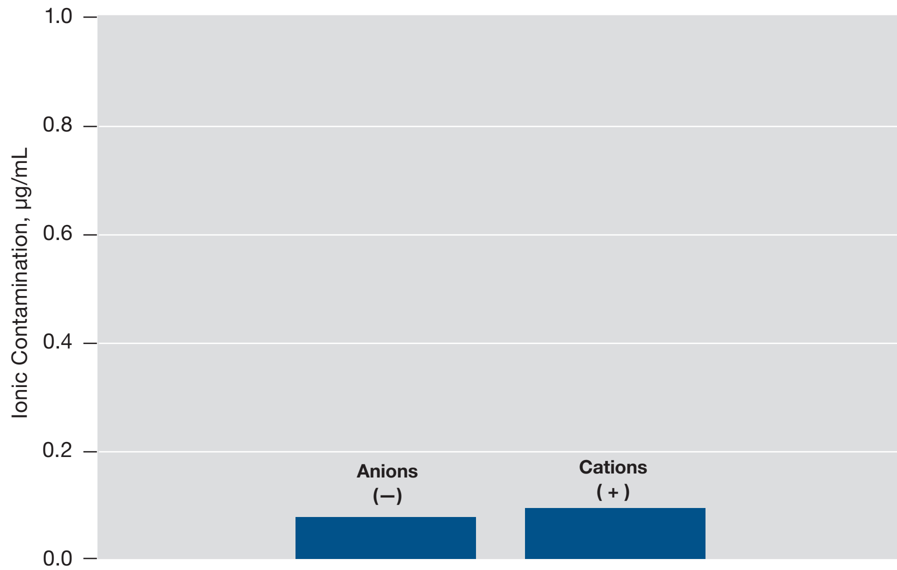
Ionic Cleanliness

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

A Swagelok ALD7 valve was 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 ALD7 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

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

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.