Scope

This technical report provides data on Swagelok® DP series diaphragm valves with PCTFE seats. The report covers:

- surface finish specifications
- inboard helium leak testing
- particle counting
- moisture analysis
- hydrocarbon analysis
- ionic cleanliness.

Moisture and hydrocarbon analysis data show test results from valves cleaned with deionized (DI) water in accordance with Swagelok Ultrahigh Purity Process Specification (SC-01), MS-06-61. Particle counting data contrast test results from valves cleaned in accordance with SC-01 and with Swagelok Photovoltaic Process Specification (SC-06), MS-06-64. Ionic cleanliness data for SC-01 and SC-06 processed valves are comparable.

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 DP series valves manufactured with a Swagelok P or P1 finish is 5 µin. (0.13 µm) $R_a$ on average.

Inboard Helium Leak Testing

SC-01 processed valves maintained a helium leak rate of less than $1 \times 10^{-9}$ std cm$^3$/s at the seat for an average of 200 s, which exceeds the required test time of 15 s, in accordance with SEMI F1-96. This result indicates that the PCTFE seat design has a high resistance to permeation.

The DP series valves were assembled in a class 100 environment and tested to ASTM E498, Method A, at the rated pressure of the valve.

Particle Counting

Static particle counts from SC-01 and SC-06 processed DP series valves are very low.

The DP series valves were tested in accordance with ASTM F1394:

- Class 100 cleanroom
- Class 100 laminar-flow bench
- 2.4 std ft$^3$/min flow rate
- Particles greater than 0.014 µm in size detected.
**Moisture Analysis**
SC-01 processed valves recover to background levels from a 2 ppm moisture spike within 30 min, much faster than the 4 h recommended by SEMI E49.8.

Three DP series valves were tested in accordance with SEMASPEC 90120397B-STD guidelines:
- The test gas was pure nitrogen.
- The flow rate was 1.28 std L/min at 30 psig (2 bar).

The lower graph shows the pattern of elevated temperatures that were applied to the valves during testing to enhance the moisture sensitivity of the system.

**Hydrocarbon Analysis**
Hydrocarbon residues in SC-01 processed valves fall within the background level produced by the test instrument.

Hydrocarbon analyses of SC-01 processed products are conducted in accordance with SEMASPEC 90120396B-STD guidelines.

The lower graph shows the pattern of elevated temperatures that were applied to the valves during testing to drive off any hydrocarbon residues in the system.
**Ionic Cleanliness**
Residual ionic contamination is very low (less than 1 µg/mL for SC-01 and SC-06 processed valves).

The DP series valves were tested in accordance with ASTM F1374:
- Each valve was filled with deionized (DI) water.
- After 24 h, the sample was extracted and analyzed.

### Test Data

<table>
<thead>
<tr>
<th>Model</th>
<th>High-Pressure</th>
<th>Low-Pressure</th>
<th>Low-Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mode of Actuation</strong></td>
<td>Normally closed pneumatically actuated</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Quantity</strong></td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td><strong>Gas</strong></td>
<td>Dry, filtered nitrogen</td>
<td>70 (20) ambient</td>
<td></td>
</tr>
<tr>
<td><strong>Temperature °F (°C)</strong></td>
<td>70 (20) ambient</td>
<td>70 (20) ambient</td>
<td></td>
</tr>
<tr>
<td><strong>Inlet Pressure psig (bar)</strong></td>
<td>3045 (210)</td>
<td>145 (9.9)</td>
<td>250 (17.2)</td>
</tr>
<tr>
<td><strong>Outlet Pressure psig (bar)</strong></td>
<td></td>
<td>70 (4.8)</td>
<td>70 (4.8)</td>
</tr>
<tr>
<td><strong>Actuator Pressure psig (bar)</strong></td>
<td>100 (6.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cycle Rate, cpm</strong></td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td><strong>Mean Time to Failure (MTTF)</strong></td>
<td>130 000 cycles</td>
<td>2 600 000 cycles</td>
<td>1 000 000 cycles</td>
</tr>
<tr>
<td><strong>Expected Cycle Life for 95% of Valves</strong></td>
<td>&gt; 50 000 cycles</td>
<td>&gt; 520 000 cycles</td>
<td>&gt; 290 000 cycles</td>
</tr>
</tbody>
</table>

### Lab Cycle Testing

The DP series diaphragm valve was tested to determine an estimated cycle life of the diaphragms under severe laboratory conditions (table at right).

Both high- and low-pressure DP series pneumatically actuated valves with cobalt-based superalloy (UNS R30003) diaphragms were tested. Valve cycle life was evaluated for leakage at regular intervals. Failure was defined as a helium leak rate greater than \(1 \times 10^{-9}\) std cm\(^3\)/s for envelope (inboard) or seat leakage.

The tests predict the mean time to failure (MTTF) and the expected cycle life for 95% of the valves.

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 endless variety of actual operating conditions and cannot promise that the same results will be realized in service.
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.