Swagelok® PTU Series Pressure Transducer Technical Report Summary

Scope

This technical report provides data on Swagelok PTU series pressure transducers.

The report covers:

- Accuracy
- Temperature coefficient
- Long-term stability
- Ionic cleanliness
- Helium leak testing
- Hydrocarbon analysis
- Moisture analysis
- Oxygen analysis
- Particle counting
- Material specifications
- Manufacturing and surface finish
- Electropolishing and passivation
- Cleaning and drying
- Assembly and testing
- Referenced documents

Accuracy

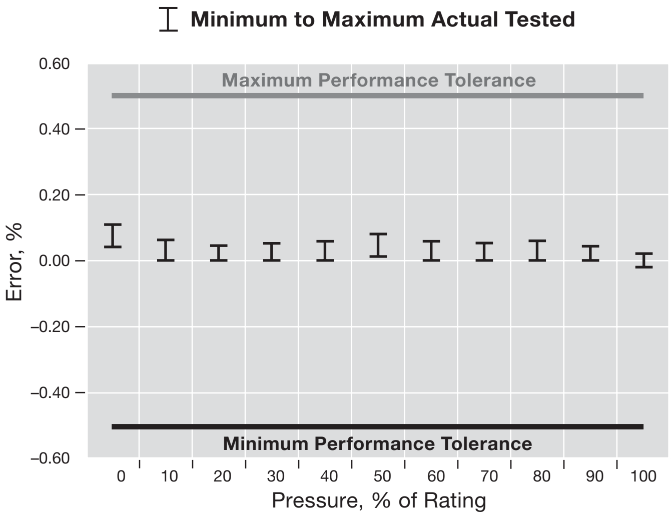
Eight PTU series pressure transducers were tested in accordance with ISA 37.3:

- Pressure was increased from zero to maximum pressure in ten equal steps; measurement of reference pressure and output signal was performed 2 s after adjusting pressure.
- Pressure was decreased from maximum pressure to zero in two equal steps; measurement of reference pressure and output signal was performed 2 s after adjusting pressure at each valve.
- This procedure was repeated three times.

The table represents an average of all eight pressure transducers. The graph shows the actual result from a typical pressure transducer.

Performance Characteristic	Test Results % of Span	Product Specification Limits % of span
Accuracy	0.144	≤ 0.5 for ≥ 0 psig (0 bar)
Linearity	0.040	≤ 0.2
Hysteresis	0.028	≤ 0.03
Repeatability	0.022	≤ 0.05
Reproducibility	0.031	≤ 0.15

Sample Accuracy Performance for a Single Pressure Transducer



Temperature Coefficient

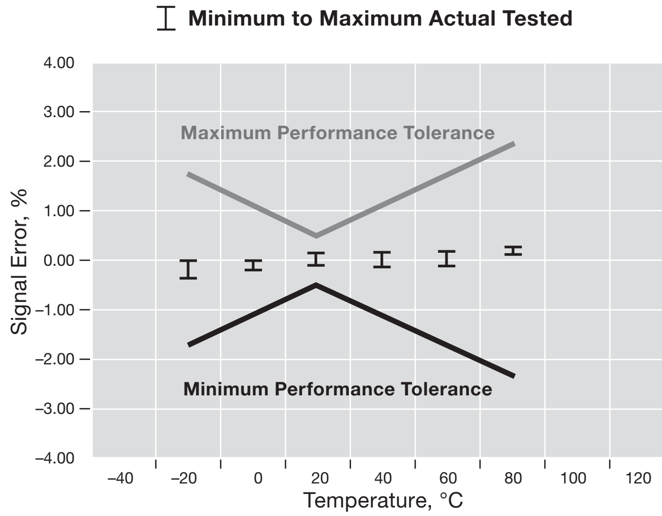
Seven PTU series pressure transducers were tested in accordance with ISA 37.3:

- Starting at 20°C, the temperature was increased in steps of 20°C up to 80°C.
- Next, the temperature was decreased in steps of 20°C down to the minimum rated temperature, –20°C.
- The temperature was then returned to 20°C.
- At each temperature increment, the output signal was measured at zero and at the maximum pressure after a hold time of 1 h to allow the temperature to stabilize.

The table represents an average of all seven pressure transducers. The graph shows the actual result from a typical pressure transducer.

Performance Characteristic	**Test Results** % of span per 10 K (10°C)	**Product Specification Limits** % of span per 10 K (10°C)
Temperature coefficient offset	0.143	0.3
Temperature coefficient span	0.025	0.15

Sample Temperature Coefficient Performance for a Single Pressure Transducer



Long-Term Stability

Three transducers were tested in accordance with ISA 37.3:

- Measure output signal at zero pressure.
- Apply maximum pressure and keep constant for 30 days.
- Release pressure.
- Measure output signal at zero pressure.

The data represent an average of all three transducers.

Performance Characteristic	**Test Results** % of span per year	**Product Specification Limits** % of span per year
Stability	0.060	0.2

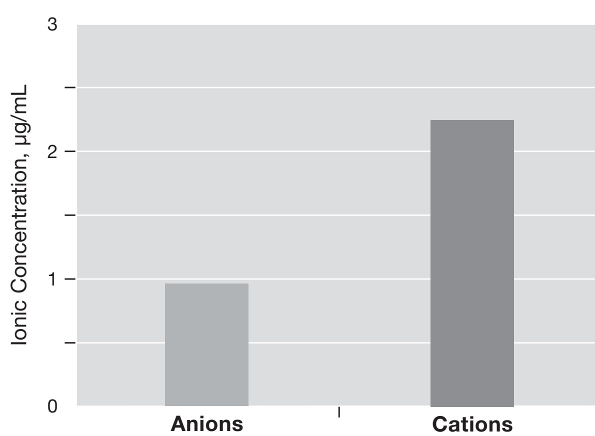
Ionic Cleanliness

Six transducers were tested in accordance with SEMASPEC 90120399B-STD:

- Each transducer was tested three times for anions and three times for cations.

The data represent an average of the three tests for all six transducers.

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



Helium Leak Testing

Six transducers with 1/4 in. rotatable male VCR® metal gasket face seal fittings were outboard helium leak tested in accordance with SEMASPEC 90120391B-STD.

- No measurable leak above background was detected after 1 min.

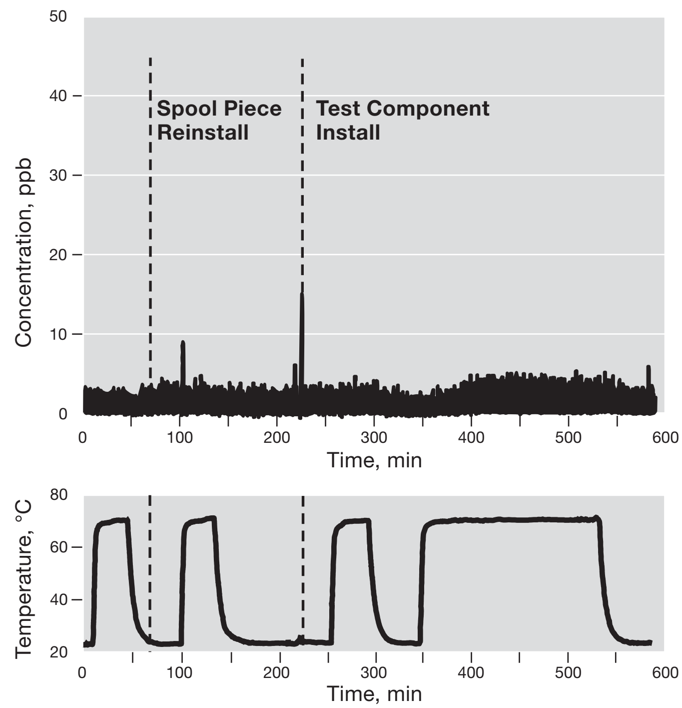
Sample Number	Background Helium Level std cm^3/s	Helium Pressure psig (bar)
1	5×10^{-10}	100 (6.9)
2	5×10^{-10}	100 (6.9)
3	6×10^{-10}	100 (6.9)
4	6×10^{-10}	3000 (206)
5	6×10^{-10}	3000 (206)
6	5×10^{-10}	3000 (206)

Hydrocarbon Analysis

Six PTU series pressure transducers were tested in accordance with SEMASPEC 90120396B-STD. Hydrocarbon residue in all six test samples remained below 10 ppb.

- The test gas was high-purity nitrogen.
- The flow rate was 1.28 std L/min.

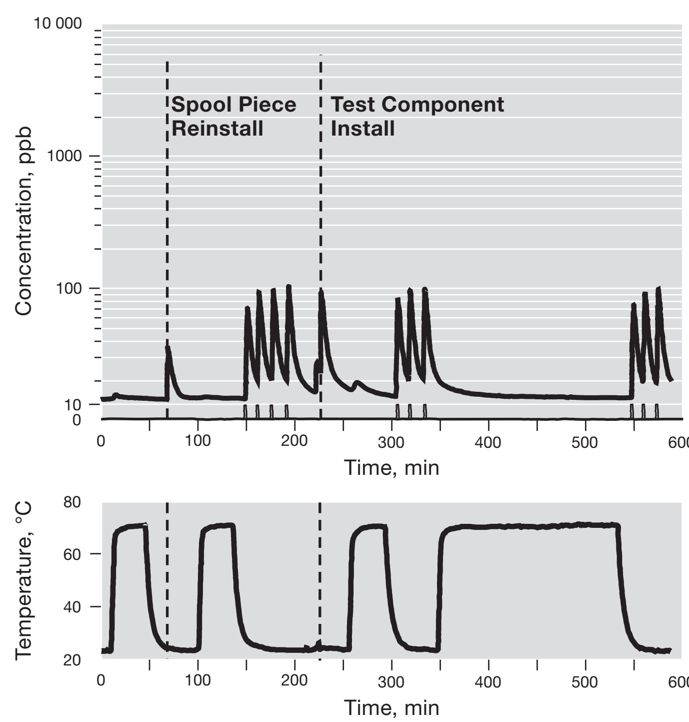
The upper graph represents the actual result from a typical transducer. The lower graph shows the pattern of elevated temperatures that was applied to the transducers during testing to release hydrocarbon residues.



Moisture Analysis

Six PTU transducers were exposed to a nominal 2000 ppb moisture pulse for 1.5 min. All six test samples recovered to levels below 20 ppb within 30 min. There was little residual moisture detected in the 3 h bakeout period. Testing was conducted in accordance with SEMASPEC 90120397B-STD. Moisture pulses are indicated on the moisture concentration graph between 0 and 10 ppb. These are indications of the times and duration of the moisture pulse and not the concentration of the moisture pulse.

The upper graph represents the actual result from a typical transducer. The lower graph shows the pattern of elevated temperatures that were applied to the transducers during testing to enhance the moisture sensitivity of the system.

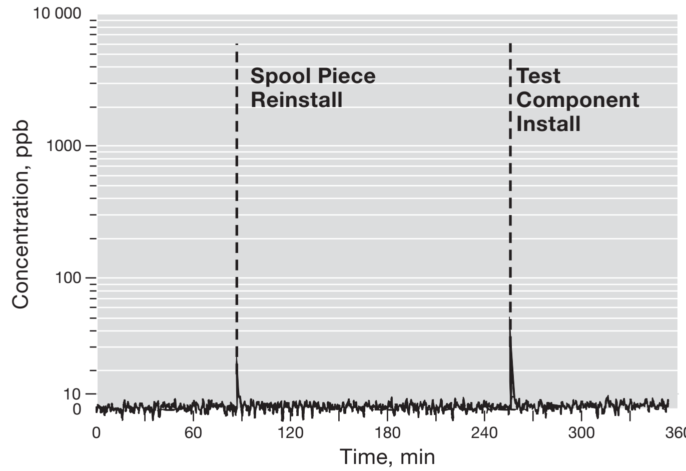


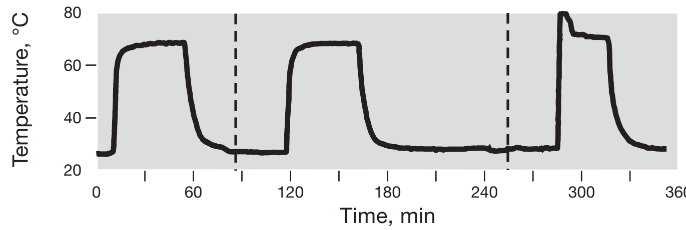
Oxygen Analysis

Six PTU series pressure transducers were tested in accordance with SEMASPEC 90120398B-STD. Oxygen residues in all six test samples recovered to within 10 ppb within 20 min.

- The test gas was pure, particle-free, dry nitrogen.
- The flow rate was 1.28 std L/min.

The upper graph represents the actual result from a typical transducer. The lower graph shows the pattern of elevated temperatures that was applied to the transducers during testing to drive off any oxygen residues in the system.

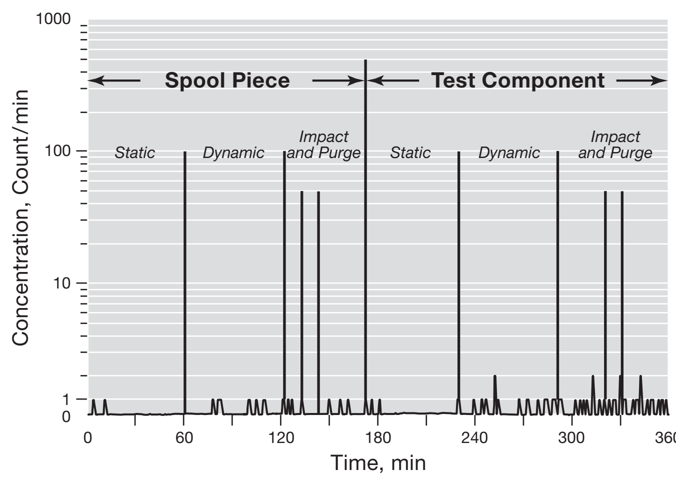




Particle Counting

Six PTU series pressure transducers were tested in accordance with SEMASPEC 92071226B-STD. The graph shows emissions for static, dynamic, and impact phases of the test.

- The test gas was pure, particle-free, dry nitrogen.
- The flow rate was 2.4 ft^3/min (67 L/min).



Material Specifications

316L VIM-VAR

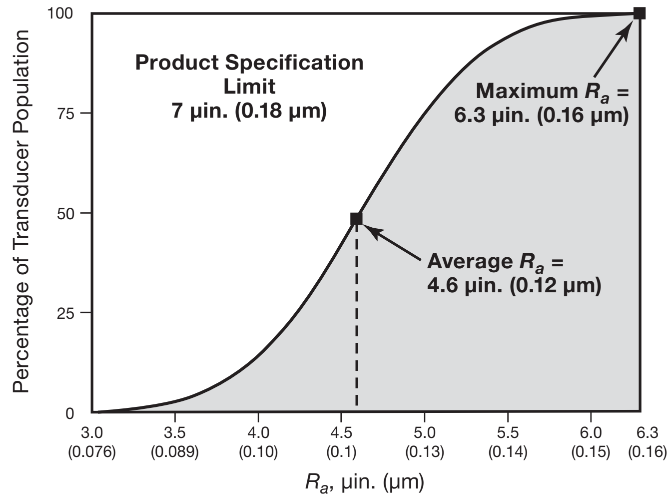
Element	**Composition,** wt. %
C (carbon)	0.030 max
S (sulfur)	0.001 to 0.012
Mn (manganese)	2.0 max

Manufacturing and Surface Finish

During manufacturing, dimensions and surface finishes are monitored closely. Each machined component has extremely fine surface finishes, smooth transitions, and square weld ends to minimize the number of entrapped or generated particles.

- Surface finish and roughness of wetted surfaces of electropolished 316L SS are manufactured in accordance with SEMI F19.
- Verification of surface roughness is done in accordance with SEMI F37.

Statistical process control (SPC) allows Swagelok to provide consistent surface finishes. This surface distribution illustrates the roughness average (R_a) for a typical production lot.



Electropolishing and Passivation

The wetted surfaces are electropolished to improve surface conditions and to form a corrosion-resistant surface layer of chromium oxide. After electropolishing, all surfaces are passivated to remove free iron.

Test Results from Six Randomly Selected PTU Series Pressure Transducers

Parameter	Test Results	Test Method
Chromium-to-iron (Cr/Fe)	Average ratio = 2.1	ESCA (electron spectroscopy for chemical analysis); based on SEMASPEC 90120403B
Chromium oxide-to-iron oxide (CrO/FeO)	Average ratio = 2.9	
Oxide thickness	Average 35 Å	AES (Auger electron spectroscopy); based on SEMASPEC 90120573B
Surface finish	Average R_a = 3.5 µin. (0.089 µm) Maximum R_a = 6.8 µin. (0.017 µm)	SEMASPEC 90120573B
Defect analysis	Average of 4 defects per area with a maximum of 11 defects per area	SEM (scanning electron microscopy); based on ASTM F1372

Cleaning and Drying

The DI water cleaning system is closed to the outside environment and thereby limits particle contamination. Products move through a series of ultrasonic washing and multistage DI water rinse tanks to a drying chamber. The DI water characteristics are based on the guidelines of SEMI E49.6, “Guide for Subsystem Assembly and Testing Procedures—Stainless Steel Systems.”

DI Water Characteristics

Characteristic	Swagelok Capabilities
Resistivity	≥ 18 MΩ·cm at 25°C (77°F)
Total organic carbon (TOC)	< 20 ppm
Silica	< 5 ppm
Particles	< 1 particle per milliliter, ≥ 0.1 µm in size
Bacteria	< 10 colonies per 100 milliliter
Hot DI water temperature	80°C (176°F), minimum

Assembly and Testing

To protect parts from airborne contamination, parts are protected and transported directly from the established cleaning system to a clean environment for assembly and testing. Packaging of PTU series pressure transducers is done in accordance with SEMI E49.6.

- End connections are protected by end caps, labeled, purged, and double-bagged in a class 100 clean room.

Referenced Documents

*ISA Standards*①

ISA 37.3, Specifications and Tests for Strain Gauge Pressure Transducers

*SEMATECH SEMASPECS*②

90120391B—STD, Standard Test Method for Helium Leak Rate by Gas Distribution Systems Components

90120396B—STD, Standard Test Method for Determination of Total Hydrocarbon Contribution by Gas Distribution System Components

90120397B—STD, Standard Test Method for Determination of Moisture Contribution by Gas Distribution Systems Components

90120398B—STD, Standard Test Method for Oxygen Contribution by Gas Distribution Systems Components

90120399B—STD, Standard Test Method for Ionic/Organic Extractables by Gas Distribution Systems Components

90120400B—STD, Test Method for Determination of Surface Roughness by Contact Profilometry for Gas Distribution System Components

90120401B—STD, Test Method for SEM Analysis of Metallic Surface Condition for Gas Distribution System Components

90120403B—STD, Test Method for XPS Analysis of Surface Composition and Chemistry of Electropolished Stainless Steel Tubing for Gas Distribution System Components

91060573B—STD, Test Method for Auger Electron Spectroscopy (AES) Analysis of Surface and Oxide Composition of Electropolished Stainless Steel Tubing for Gas Distribution System Components

92071226B—STD, Standard Test Method for Particle Contribution by Mass Flow Controllers

*SEMI Standards*③

SEMI E49.6-95, Guide for Subsystem Assembly and Testing Procedures—Stainless Steel Systems

SEMI F37-0299, Method for Determination of Surface Roughness Parameters for Gas Distribution System Components

SEMI F19-95, Specification for the Finish of the Wetted Surfaces of Electropolished 316L Stainless Steel Components

① ISA, Alexander Dr., PO Box 12277, Research Triangle Park, NC 27709

② SEMATECH, Inc. 2706 Montopolis Dr., Austin, TX 78741

③ Semiconductor Equipment and Materials International, 3801 Zanker Rd., San Jose, CA 95134

⚠ **These test results 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. See the product catalog for technical data.**

April 2007, R1
MS-06-105-E