



## Product Test Report

**PTR-5007**

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### TITLE

Chloride Stress Corrosion Cracking (CSCC) Test of 316 Stainless Steel Swagelok® Tube Fittings and Eight Other Brands of 316 Stainless Steel Tube Fittings

### SWAGELOK PRODUCT TESTED

Ordering Number	Tubing Material	Number of Fittings Tested	Test Pressure psig (MPa)	Tubing Size and Wall in.	Tubing Hardness HRB
SS-600-6	Alloy 254	4	7500 (51.6)	3/8 × 0.065	87
SS-600-9		4			
SS-600-6	Alloy 825	4	7500 (51.6)	3/8 × 0.065	87
SS-600-9		4			
SS-600-6	Tungum	4	7500 (51.6)	3/8 × 0.065	40
SS-600-9		4			
SS-600-6	Alloy 316	4	7500 (51.6)	3/8 × 0.083	88
SS-600-9		4			
SS-810-6	Alloy 254	4	6700 (46.1)	1/2 × 0.083	80
SS-810-9		4			
SS-810-6	Alloy 825	4	6700 (46.1)	1/2 × 0.065	76
SS-810-9		4			
SS-810-6	Tungum	4	6700 (46.1)	1/2 × 0.065	42
SS-810-9		4			
SS-810-6	Alloy 316	8	6700 (46.1)	1/2 × 0.083	82
SS-810-9		8			

### EIGHT OTHER BRANDS PRODUCT TESTED

Tube Fitting Configuration	Tubing Material	Number of Fittings Tested	Test Pressure psig (MPa)	Tubing Size and Wall	Tubing Hardness HRB
3/8 in. Straight	Alloy 316	24	7500 (51.6)	3/8 × 0.083 in.	88
3/8 in. Elbow		24			
1/2 in. Straight	Alloy 316	23	6700 (46.1)	1/2 × 0.083 in.	82
1/2 in. Elbow		23			
10 mm Straight	Alloy 316	4	7500 (51.6)	10 × 2.0 mm	72
10 mm Elbow		4			
12 mm Straight	Alloy 316	4	6700 (46.1)	12 × 2.0 mm	73
12 mm Elbow		4			

## PURPOSE

Assemblies of 316 stainless steel Swagelok tube fittings with stainless steel tubing, along with various tubing materials described in Swagelok's *Tubing Data—Engineered Combinations* (MS-06-117), and eight other brands of 316 stainless steel tube fittings were tested under laboratory conditions to observe the effects of an environment that promotes Chloride Stress Corrosion Cracking (CSCC) of 316 stainless steel.

## TEST CONDITIONS

Original test date: October 2017

The assemblies were exposed at 65°C (149°F) for 720h to alternate cycles of (a) salt spray (substitute ocean water per ASTM D1141) and (b) controlled humidity (60 to 70 %) to encourage concentrating chlorides in surface pits and crevices to particularly accelerate CSCC of 316 SS. Assemblies of one and seven-eighths turns past finger tight (TPFT) were included to increase tensile stress in the tube fitting components to further increase the risk of CSCC.

## TEST METHOD

1. Sample groups were prepared for each size. Each tubing assembly was comprised of two fittings, one barstock, and one forging, assembled to a 64 mm (2 1/2 in.) length of tubing.
2. Additional Swagelok sample fitting components and tubing of each size were set aside to comprise a control group for comparing surface structures before and after the CSCC test.
3. Half of each of 3/8 inch, 1/2 inch, 10 mm and 12 mm size sample tube fittings were assembled one and one-quarter turns past finger-tight (TPFT). The other half of each size was assembled one and seven-eighths TPFT.
4. Each sample was pressurized with nitrogen to the test pressure and monitored for leakage for 10 minutes prior to the CSCC test.
5. Samples were placed into a salt spray chamber that utilized substitute ocean water per ASTM D1141.
6. Samples were pressurized with water to the test pressure and held at that pressure throughout the CSCC test.
7. The chamber temperature was elevated to 65°C (149°F) and the following salt spray schedule, derived from SAE J2334 and ASTM B117, was initiated:
  - a. continuous salt spray maintained at 65°C for 24 hours
  - b. salt spray turned off, 60 % to 70 % relative humidity maintained at 65°C for 48 hours
  - c. repeat step a for 48 hours
  - d. repeat step b for 96 hours
  - e. repeat step a for 168 hours
  - f. repeat step b for 336 hours, for a schedule total of 720 hours (see **Figure 1**)
8. Upon completion of the 720 hours, the samples were removed and rinsed in de-ionized water.
9. Each sample was again pressurized with nitrogen to its test pressure and monitored for leakage for 10 minutes.
10. Swagelok samples were then disassembled. The Swagelok components (nut, body, and ferrules) swaged on the tubing were then liquid penetrant examined per ASTM E165 to reveal any cracks.
11. Sample components were then sectioned and metallurgically examined by 100× optical microscope for signs of CSCC.

### SWAGELOK TEST RESULTS

- All samples (72 ends total) successfully passed 720 hours in the salt spray chamber without loss of pressure.
- All samples successfully passed the pre- and post-salt spray nitrogen gas pressure tests without leakage.
- Liquid penetrant evaluation of the sample components found no evidence of crack formation.
- No evidence of CSCC crack initiation and propagation beyond surface structures of the sample components was observed.

### EIGHT OTHER BRANDS TEST RESULT

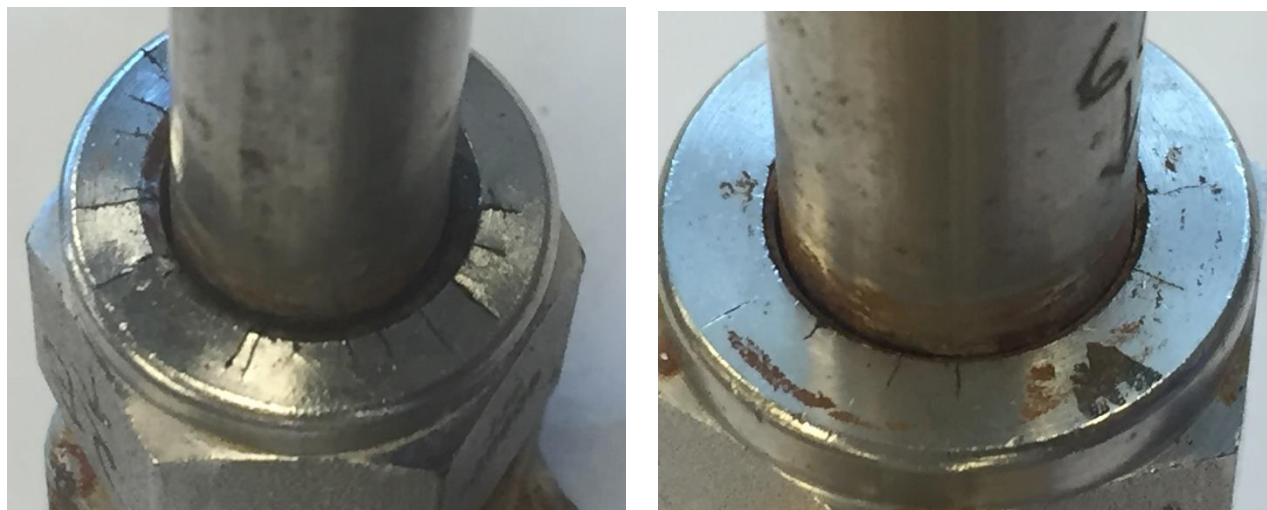
- Three of 48 of the 3/8 inch fittings lost pressure during 720 hours in the salt spray chamber.
- All samples successfully passed the pre-salt spray nitrogen gas pressure tests without leakage. The above three fittings did not pass post-salt spray nitrogen gas pressure tests.
- Visual evidence of CSCC formation was found in each of the other 8 brands (see **Figure 2**):
  - 18 of 48 of the 3/8 inch nuts
  - 16 of 46 of the 1/2 inch nuts
  - 5 of 8 of the 10 mm nuts
  - 4 of 8 of the 12 mm nuts

**Figure 1:** Cyclic humidity corrosion salt spray schedule

### Dual Cycle Humidity Test – at 65°C



**Figure 2:** Example CSCC formations in other brand nuts 3/8 inch & 1/2 inch



This test was performed to consider a specific set of conditions and should not be considered valid outside those conditions. Swagelok Company makes no representation or warranties regarding these selected conditions or the results attained. Laboratory tests cannot duplicate the variety of actual operating conditions. Test results are not offered as statistically significant. See the product catalog for technical data.

### **SAFE PRODUCT SELECTION**

When selecting a product, 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.

### **Referenced Documents**

ASTM D1141: *Standard Practice for the Preparation of Substitute Ocean Water*, ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428

ASTM E165-95: *Standard Test Method for Liquid Penetrant Examination*, ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428

ASTM B117-95: *Practice for Operating Salt Spray (Fog) Apparatus*, ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428

SAEJ2334: *Cosmetic Corrosion Lab Test*, SAE International, 400 Commonwealth Drive, Warrendale, PA 15096

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### APPENDIX

Auto Technology Cyclic Corrosion Chamber



Assembled and Pressurized Tube Fittings Installed in Cyclic Salt Spray Chamber

