## TITLE

Chloride Stress Corrosion Cracking (CSCC) Test of 316 Stainless Steel Swagelok® Tube Fitting Engineered Combinations Using 65°C Cyclic Salt Spray with Substitute Ocean Water

## 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 (46.6) | 1/2 × 0.083 | 80 |
| SS-810-9 | | 4 | | | |
| SS-810-6 | Alloy 825 | 4 | 6700 (46.6) | 1/2 × 0.065 | 76 |
| SS-810-9 | | 4 | | | |
| SS-810-6 | Tungum | 4 | 6700 (46.6) | 1/2 × 0.065 | 42 |
| SS-810-9 | | 4 | | | |
| SS-810-6 | Alloy 316 | 4 | 6700 (46.6) | 1/2 × 0.083 | 82 |
| SS-810-9 | | 4 | | | |

## PURPOSE

Assemblies of 316 stainless steel Swagelok tube fittings with stainless steel tubing and with various tubing materials described in Swagelok's Engineered Combinations catalog MS-06-117 were tested under laboratory conditions to observe the effects of an environment that promotes CSCC of 316 stainless steel.

The assemblies were exposed at 65ºC (149ºF) 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.

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## TEST METHOD

Original test date: September 2016

1. Eight samples 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 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. Four each of 3/8 inch and 1/2 inch size sample fittings were assembled according to Swagelok tube fitting installation instructions: one and one-quarter turns past finger-tight (TPFT). The other four of each size were 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. Samples were then disassembled. The 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.

## TEST RESULTS

- All samples (64 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.

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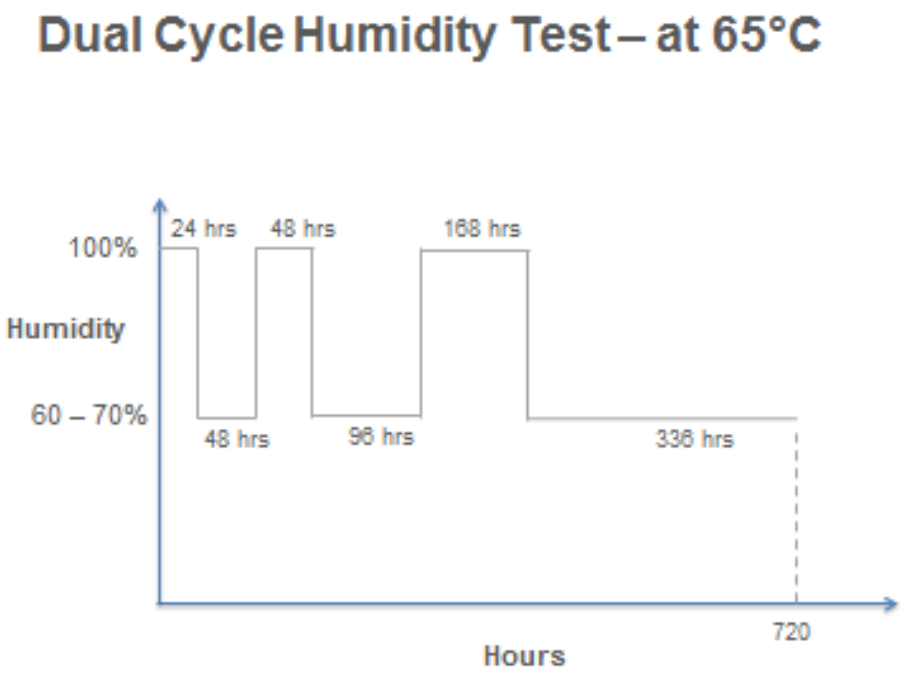
**Figure 1**: Cyclic humidity corrosion salt spray schedule




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 there from. 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

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