Product Test Report

Swagelok Company
29500 Solon Road
Solon, Ohio 44139 U.S.A.

TITLE
Rotary Flexure Test of Alloy 2507 Swagelok® Medium-Pressure Tube Fittings

PRODUCT TESTED
The following alloy 2507 Swagelok medium-pressure tube fittings were tested with the identified alloy 2507 super duplex seamless tubing.

Ordering Number	Quantity Tested	Tubing Size in.	Tubing Hardness
2507-4FK0-1-4-SG2	12	1/4 × 0.035	HRC 22 to 26
2507-6FK0-1-4-SG2	12	3/8 × 0.049	HRC 20 to 28
2507-8FK0-1-4-SG2	12	1/2 × 0.065	HRC 25
2507-12FK0-1-4-SG2	18	1/2 × 0.095	HRC 29

PURPOSE
The assemblies were tested to observe the fatigue endurance of alloy 2507 Swagelok medium-pressure tube fittings under laboratory conditions at various levels of applied alternating bending stress of the tube.

TEST CONDITIONS
Original test report date: October 2019

Each sample tested consisted of one tube length and one test fitting. Each fitting was assembled according to the Swagelok medium-pressure tube fitting installation instructions. Testing was conducted at room temperature.

TEST METHOD
Rotary flexure testing procedures have been derived from SAE-ARP-1185. This method applies a completely reversed bending stress on the fitting connection while the assembly is pressurized with hydraulic oil. The test samples were flexed until either the fitting leaked, the tube fractured, or at least 10 million cycles were achieved, whichever occurred first.

ASME Pressure Vessel and Piping, volume 62 (ASME PVP-62) reports that vibration at or above an alternating stress of 200 µin./in. peak-to-peak strain level results in frequent piping system failures. For alloy 2507, the 200 µin./in. strain level calculates to an alternating stress of 2900 lb/in.^{2} (20 MPa). ASME PVP-62 also reports that measured field data for piping systems suggest that if the system lasts beyond 10 million cycles, it will have infinite life.

The ASME BPV Code, Section III NC-3673, lists stress intensification factors for various types of fittings. For example: certain butt welds i = 1.0, socket welds i = 1.3 to 1.9, brazed joints i = 2.1, and pipe joints i = 2.3. The stress intensity lines i = 1.0, 1.3, and 2.3 shown on the graph are based on fatigue bend testing of mild carbon steel fittings. The lines allow visual comparison to other fitting types and are defined by the following equation from the ASME BPV Code, Section III, NC-3673:

$$i \times S = 245\,000 \times N^{-0.2}$$

where

S = amplitude of the applied bending stress at the point of failure, (lb/in.^{2})

N = number of cycles to failure

i = stress intensification factor

The following procedure was followed:

1. Each test sample was attached to a rotary flexure test stand. Refer to Figure 1.

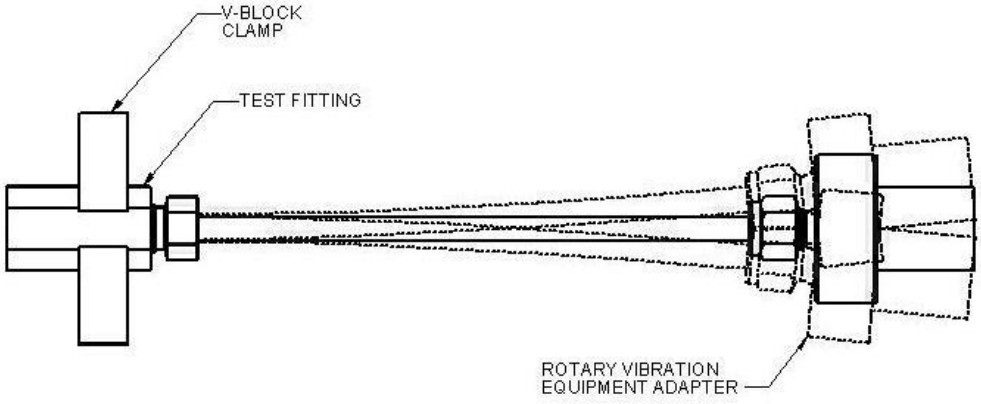


Figure 1

2. A bending stress was applied to each sample by a gimbaled rotary offset. The bending stresses were selected to generate a stress versus number of cycles (S/N) graph. The stress levels support a highly accelerated life test protocol and are not indicative of any specific application.

3. The alternating bending stress was computed from the actual measured flexure strain in the tubing (1/2 of alternating peak-to-peak flexure range).

Table 1

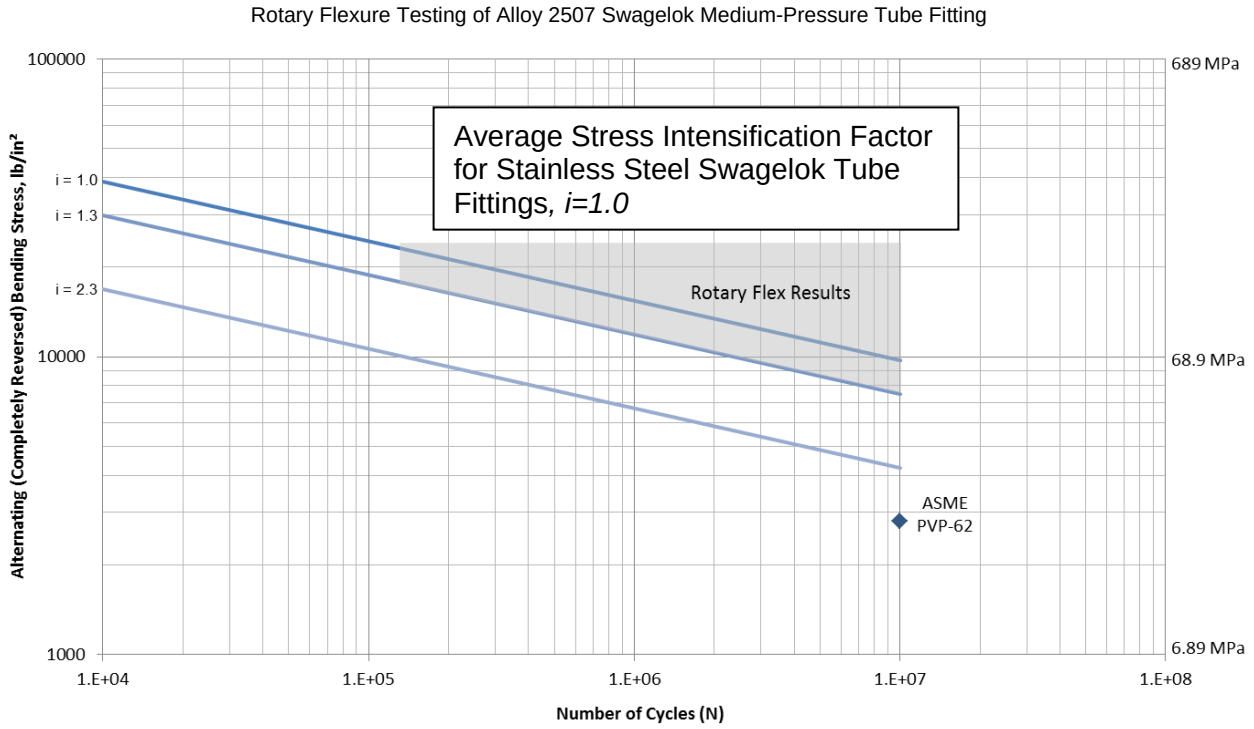
Nominal Alternating Bending Stress① lb/in.^{2} (MPa)	Samples Tested
20 000 (137.8)	18
15 000 (103.4)	18
10 000 (68.9)	18
TOTAL	**54**

① Zero-to-peak stress

4. Test samples were pressurized to a minimum of 10 000 psig (689 bar) with hydraulic oil.
5. The test samples were flexed until either the fitting leaked, the tube fractured, or 10 million cycles were achieved, whichever occurred first. An inline pressure transducer stopped the test if fitting leakage or tube fatigue fracture occurred.
6. A bending stress versus number of cycles graph (S/N) was made from the data and the results were compared to the ASME-based data described earlier.
7. Test samples passed the rotary flexure test if all samples remained leak-tight over the duration of the test and demonstrated, for a given bending stress, the number of cycles that met or exceeded the predicted number of cycles for fittings having a stress intensification factor of i = 1.3.

TEST RESULTS

- No fitting leakage was detected throughout the testing criteria. The test was stopped when the tube fractured or the test sample exceeded 10 million cycles.
- The shaded area of the following S/N graph envelopes the test results of the alloy 2507 Swagelok medium-pressure tube fitting rotary flexure test. The shaded area is truncated at 10 million cycles to indicate testing was suspended without leakage at 10 million cycles in accordance with the test method.
- Point ASME PVP-62 on the graph is the intersection of 2900 lb/in.^{2} (39.6 MPa) and 10 million cycles.
- The alloy 2507 Swagelok medium-pressure tube fitting remained leak-tight while protecting the tubing from premature fracture at alternating stresses greatly exceeding the ASME PVP-62 recommended upper limit. The fitting's performance also resulted in a calculated endurance stress at ten million cycles which exceeds a stress intensification factor of i = 1.3 as defined in ASME BPV Code Section III, NC-3673, therefore passing the rotary flexure test.
- ASME B31J, *Standard Test Method for Determining Stress Intensification Factors (i-Factors) for Metallic Piping Components*, recommends reporting the average stress intensification, i, factor from several tests. The average stress intensification factor for the stainless steel Swagelok medium-pressure tube fitting is i = 1.0.



The tests were conducted beyond the product's recommended operating parameters and do not modify the published product ratings.

These tests were 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

SAE-ARP-1185, *Flexure Testing of Hydraulic Tubing Joints and Fittings,* SAE International, 400 Commonwealth Drive, Warrendale, PA 15096

ASME *Pressure Vessel and Piping (PVP),* Vol. 62, 1982, and ASME *Boiler and Pressure Vessel (BPV) Code, Section III*, 2007, ASME International, Three Park Avenue, New York, NY 10016-5990, www.asme.org

ASME B31J, *Standard Test Method for Determining Stress Intensification Factors (i-Factors) for Metallic Piping Components*, ASME International, Three Park Avenue, New York, NY 10016-5990, www.asme.org