



Product Test Report

Swagelok Company
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PTR-5017
Ver 01
August 2023
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TITLE

Rotary Flexure Test of Stainless Steel Swagelok® Medium-Pressure Tube Fittings (FK Series) and Other Brand Medium-Pressure Cone and Thread Fittings (both with and without anti-vibration glands)

PRODUCT TESTED

The following fittings were tested to observe rotary flex performance.

Swagelok FK Series Medium-Pressure Tube Fittings		
Fitting Description	Tubing Size	Tubing Material
	Outside Diameter × Wall Thickness (in.)	
SS-12FK0-1-16	0.750 × 0.134	Alloy 2507

Other Brand Cone and Thread Fittings		
Fitting Description	Tubing Size	Tubing Material
	Outside Diameter × Inside Diameter (in.)	
3/4 in. Straight Union	0.745 × 0.438	316SS

Other Brand Cone and Thread Fittings (with Anti-Vibration Gland)		
Fitting Description	Tubing Size	Tubing Material
	Outside Diameter × Inside Diameter (in.)	
3/4 in. Straight Union with Anti-Vibration Glands	0.745 × 0.438	316SS

PURPOSE

The assemblies were tested to observe the fatigue performance of Swagelok FK series stainless steel medium-pressure tube fittings compared to another brand of cone and thread fittings (both with and without anti-vibration glands) under laboratory conditions at various levels of applied alternating bending stress of the tube.

TEST CONDITIONS

Original test date: December 2019

- Each sample tested consisted of one tube length and one test fitting. Each fitting was assembled according to the manufacturer's installation instructions.
- Test conducted at room temperature.

TEST METHOD

Rotary flexure testing procedures were derived from SAE-ARP-1185. This method applies a completely reversed bending stress on the fitting connection while it is pressurized with hydraulic oil at the tubing working pressure. 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 $\mu\text{in./in.}$ peak-to-peak strain level results in frequent piping system failures. For stainless steel, the 200 $\mu\text{in./in.}$ strain level calculates to an alternating stress of 2800 lb/in.^2 (19.2 MPa). ASME PVP-62 also reports that measured field data for piping systems suggest that if a 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, for 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, that are 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:

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

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 flex test stand. Refer to figure 1.

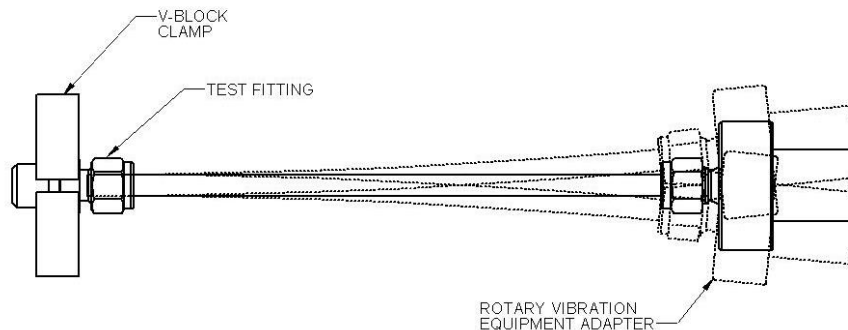


Figure 1

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.



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

Nominal Alternating Bending Stress^① lb/in. ² (MPa)	Swagelok FK Series Medium Pressure Tube Fitting (Samples Tested)	Other brand Cone and Thread Fitting (Samples Tested)	Other Brand Cone and Thread Fitting with Anti-Vibration Gland (Samples Tested)
15 000 (103.3)	2	2	2
10 000 (68.9)	2	2	2
7 500 (51.6)	2	2	2
Total	6	6	6

① Zero to Peak stress

- Test samples were pressurized to 8000 psig (551 bar) with hydraulic oil.
- 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.
- A bending stress versus number of cycles graph (S/N) was created from the data and the results were compared to the ASME based data outlined earlier.
- Test samples passed the rotary flex test if all samples remained leak-tight for 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 $i = 1.3$.

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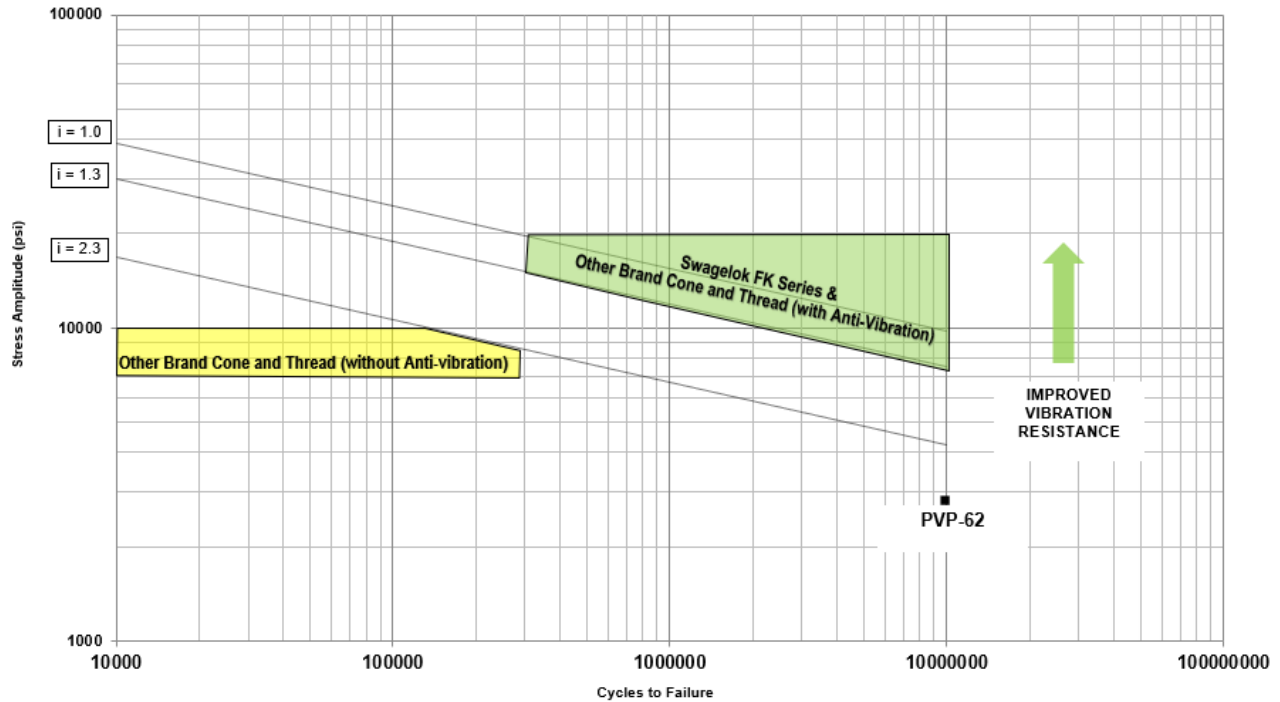
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TEST RESULTS

- The shaded area of the following S/N graph shows the test results of the fitting rotary flex 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 AMSE PVP-62 on the graph is the intersection of 2800 lb/in.² (19.2 MPa) and 10 million cycles.

Swagelok FK Series - versus - Other Brand Cone and Thread



These 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.



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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, ASME *Boiler and Pressure Vessel (BPV) Code, Section III*, 2019, ASME International, Three Park Avenue, New York, NY 10016-5990, www.asme.org

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