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Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE. WARRENDALE, PA. 15096

AEROSPACE RECOMMENDED PRACTICE

ARP 1321

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Revised

FLEXURE TESTING OF BENT HYDRAULIC TUBING

1. SCOPE

This recommended practice establishes a flexure test procedure for determining the fatigue strength of bent hydraulic tubing. The procedure is intended for conducting flexure fatigue testing of hydraulic and pneumatic tubing to determine the effects of tube fabrication methods, surface finishing, and other processing techniques on the fatigue performance of the tubing. A mean stress is applied by holding system pressure in the specimens and flexing in a rotary flexure test machine.

2. APPLICABLE DOCUMENTS

2.1 Military:

MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft and Ordnance
MS 33611	Tube Bend Radii

2.2 Society of Automotive Engineers:

ARP 1185	Flexure Testing of Hydraulic Tubing Joints and Fittings
ARP 1258	Qualification of Hydraulic Tube Joints to Specified Flexure Fatigue Requirements

3. REQUIREMENTS

3.1 Flexure Test Device: The test device should be capable of testing 120 deg (2.09 rad) bent test specimens. The rotary flexure test device should be similar to that shown in Figure 1 of ARP 1185, except for the tailstock and strain gage arrangement which shall be per Figure 1 of this document. Each rotary flexure test device should be capable of testing one specimen. The device should be capable of maintaining constant pressures of up to 5000 psi (34.47 MPa) in the test specimen. The hydraulic fluid may be a system fluid such as MIL-H-5606 or the phosphate ester fluids used in commercial jet airplanes. A typical pressurization and automatic shutdown system is shown in Figure 2 of ARP 1185. The shutdown should be automatic in the event of failure or pressure drop. The device should be capable of testing at controlled constant temperature, if specified by the procuring agency. The tailstock of the test device should be designed to permit alignment during initial installation and specimen mounting, and to serve as a pressure manifold. The rotating headstock should have a low-friction, self-aligning bearing and should be designed to permit total deflections of up to one inch (25.4mm), and a constant rotational frequency of 900 or 1550 rpm. When the axial movement of the specimen deflection pin in the self-aligning bearing (ref. Fig. 1) exceeds ±0.5 inch (12.7 mm), the test speed shall be 900 rpm. Otherwise the test speed shall be 1550 rpm.

3.2 Flexural Test Specimen: The test specimen shall consist of an adapter fitting (headstock end), section of 120 deg bent tubing, and a fitting at the tailstock end. A typical test specimen is shown in Figure 1. The tubing shall be of a size and wall thickness as specified by the user or procuring agency.

3.3 Strain Gaging: Test specimens shall be instrumented with strain gages per Figure 1. Suitable strain gages are recommended in ARP 1185. A minimum of one test specimen per size per deflection setting shall be strain gaged in any one group of test specimens.

3.4 Temperature: Test temperature shall be room temperature (68° - 78°F) (20° - 25.6°C), or as otherwise stated by the procuring activity.

3.5 Fatigue Performance: Tests shall be conducted per paragraph 4.0 of enough test specimens to obtain sufficient data for plotting an S/N curve using the method described in ARP 1258 (a minimum of eight specimens of a given size shall be tested). Fatigue performance of the bent tubing can then be observed. Minimum acceptable performances shall be all data points falling on or above the Base line - MS Flareless Fitting curve shown in ARP 1158.

3.6 Failure Analysis: Following the test, the location (degree of bend, neutral axis or inside of bend), origin (I.D., O.D.), mode (longitudinal, circumferential), and other pertinent factors shall be evaluated. The tube ovality shall be measured per MS 33611 in at least three points along the bend. Representative bends shall be sectioned to measure cross sectional changes in the tubing wall.

4. TEST PROCEDURE

4.1 Before installing test specimens in the rotary test machine, a proof pressure test shall be conducted at two times the system operating pressure using MIL-H-5606 hydraulic oil. No leakage and/or other failure shall occur.

4.2 The test specimen shall be positioned in the rotary flexure test machine per Figure 1 and the eccentric adjusted to produce the desired bending stress at the strain gage located on the inside of the tube bend. A strain gage indicator shall be used to establish the desired stress level with the machine rotated by hand or at 5^{+3}_{-0}RPM. The stress level should indicate the same within 15% when the machine is run at test speed.

4.3 After establishing the desired stress level, system operating pressure shall be applied to the specimen using MIL-H-5606 hydraulic oil.

4.4 Stress during test may be monitored using a recording oscillograph.

4.5 Failure is defined as loss of internal tube pressure due to fatigue cracking of the tubing. The failure mode (longitudinal, transverse) and location (inside bend, neutral axis, 3 o'clock, or such) shall be recorded.

PREPARED BY

SAE COMMITTEE G-3, AEROSPACE FITTINGS, HOSE, AND TUBING ASSEMBLIES