

AEROSPACE RECOMMENDED PRACTICE

ARP1383™

REV. C

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Superseding ARP1383B

(R) Aerospace - Impulse Testing of Hydraulic Components

RATIONALE

ARP1383 has been updated to Revision C for the following reasons:

- Technical changes have been made including adding a section on scatter factors and an appendix that is associated with this topic, and deleting the original Appendix A.
- The references in the document have been updated.
- Editorial changes have been made to improve the readability of the document.

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1. SCOPE

This SAE Aerospace Recommended Practice (ARP) defines impulse test procedures that are recommended for hydraulic components.

1.1 Scope and Field of Application

This ARP is applicable to actuators, valves, pressure containers, and other similar fluid system components.

ARP1383 is not applied to the following hydraulic elements, as these are covered as follows:

- a. Military hydraulic pumps - refer to AS19692
- b. Hydraulic motors - refer to AS7997
- c. Hydraulic hose assemblies - refer to AS603
- d. Tubing and fittings - refer to AS603 and AS4265

In addition, ARP1383 is not to be applied for elements that are not directly connected to the hydraulic system, such as brake master cylinders.

This ARP is intended to cover the fatigue testing of a component as a pressure vessel - it does not cover the testing of mechanical elements of hydraulic components including levers, actuator rods and end fittings, etc.

1.2 Requirements When Invoking This Recommended Practice

When this document is referenced in a design specification as part of the requirements, additional requirements as identified in 3.3 should be specified.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AS603	Impulse Testing of Hydraulic Hose, Tubing, and Fitting Assemblies
AIR1228	Standard Impulse Machine Equipment and Operation
AS4265	Impulse Testing of Hydraulic Tubing and Fittings, S-N Curve
AIR4298	Impulse Test Machine, Sine Wave, Equipment and Operation of

AS7997 Motors, Aircraft Hydraulic, Constant Displacement, General Specification For

AS19692 Pumps, Hydraulic, Variable Flow, General Specification For

2.1.2 U.S. Government Publications

Available from National Technical Information Service, 5301 Shawnee Road, Alexandria, VA 22312, Tel: 1-888-584-8332 or 703-605-6050, www.ntis.gov.

DOT/FAA/AR-MMPDS-01 Metallic Materials Properties Development and Standardization

2.2 Definitions

MINER'S RULE: This is the Palmgren-Miner cycle-ratio summation theory, also known as Miner's rule, which may be expressed as a method that is used to approximate the cumulative fatigue damage at a point in a metallic part from the repeated exposure to cycles of various stress levels. For given maximum and minimum stress levels, the fatigue life in terms of the number of cycles is found from an S-N curve. The damage fraction is the applied number of cycles divided by the fatigue life. The fractional damage amounts for each stress level are added together to calculate the total fatigue damage. Cumulative fatigue damage greater than or equal to 1 indicates that the part will fail.

RATE OF RISE: This is the slope of the pressure-time curve in the straight portion of the initial pressure increase portion between 10% of the total rise above return pressure and 10% of the total rise below peak pressure. (Note: The rate of rise is the steepest part of the slope and is dependent on volume of pressurized cavity.)

CYCLE: This is the time from minimum pressure to maximum pressure and back to minimum pressure.

DWELL TIME (TIME AT PRESSURE): This is the time for which the pressure exceeds the lower tolerance for P_{Max} .

S-N CURVE: This is a graph of the magnitude of a cyclic stress (S) against the logarithmic scale of cycles to failure (N), which characterizes materials performance with respect to high-cycle fatigue.

PRESSURE CAVITY: This is the part of the hydraulic component that is either directly connected to the high pressure side of the aircraft hydraulic system, or is downstream of a selector valve or servo valve.

RETURN CAVITY: This is the part of a hydraulic component that is directly connected to the low pressure side (return or reservoir) of the aircraft hydraulic system.

TEST LAYER: This is the process of conducting pressure impulse testing into sections which is the alternative to conducting a complete pressure impulse test on a component without stopping. The use of Test Layers permits the component to be inspected for fatigue induced damage and to replace seals, etc., before the commencement of the next test layer.

CENTER DAM: This is the gland assembly that separates the two hydraulic systems in a dual tandem actuator.

2.3 Abbreviations

n = cycles in one operational life

N = stress life cycle expectancy for each flight segment

P_{Min} = minimum return pressure experienced in normal operation

P_{Max} = maximum supply cavity test pressure

$$P_{\text{Mean}} = (P_{\text{Max}} + P_{\text{Min}})/2$$

P_{Oper} = nominal system design operating pressure

P_R = nominal return line design pressure

$P_{R_{\text{Max}}}$ = maximum return cavity test pressure

3. REQUIREMENTS

The pressure-impulse test is basically an accelerated fatigue test. There are two categories of test:

- a. Category I - Generically Derived Test Requirements
- b. Category II - Specifically Derived Test Requirements

3.1 Category I - Generically Derived Test Requirements

This category is applicable to generic aerospace hydraulic equipment impulse testing, with recommended pressure levels and test cycle requirements being provided. The pressure and return cavities of the component should be tested, as a minimum, to the number of pressure impulse cycles defined below for the applicable aircraft classification.

3.1.1 Fixed Wing Aircraft

- a. Flight control actuators/valves/components: 200 000 cycles, $P_{\text{Max}} = 1.5 \times P_{\text{Oper}}$
- b. Utility actuators/valves/components: 100 000 cycles, $P_{\text{Max}} = 1.5 \times P_{\text{Oper}}$
- c. Return ports/passages and components subjected to return pressure only: 100 000 cycles, $P_{R_{\text{Max}}} = P_R \times 1.5$, with P_R taken as $0.5 \times P_{\text{Oper}}$

3.1.2 Rotary Wing Aircraft

- a. Primary flight control actuators: 1 000 000 cycles, $P_{\text{Max}} = 1.5 \times P_{\text{Oper}}$
- b. Secondary flight control actuators: 1 000 000 cycles, $P_{\text{Max}} = 1.5 \times P_{\text{Oper}}$
- c. Utility actuators: 300 000 cycles, $P_{\text{Max}} = 1.5 \times P_{\text{Oper}}$
- d. Flight control system hydraulic components: 1 000 000 cycles, $P_{\text{Max}} = 1.5 \times P_{\text{Oper}}$
- e. Utility system hydraulic components: 300 000 cycles, $P_{\text{Max}} = 1.5 \times P_{\text{Oper}}$
- f. Return ports/passages and components subjected to return pressure only: 300 000 cycles, $P_{R_{\text{Max}}} = 1.5 \times P_R$ with P_R taken as $0.5 \times P_{\text{Oper}}$

3.2 Category II - Specifically Derived Test Requirements

Category II is applicable to all aircraft configurations (including helicopters), both military and commercial, where the test requirements are derived from specifically related system values. The number of test cycles are to produce equivalent fatigue damage, when the component is tested at the design operating pressure, using the selected waveform (see 4.1) to create the damage that the component is expected to receive during the lifetime of the applicable aircraft. The determination of the number of test cycles must consider both mean and alternating stresses for inservice, ground, and test operations of the aircraft during its expected life. The cycles at various stress levels are combined by Miner's Rule to determine the number of equivalent cycles at the design operating pressure.

Appendix A provides details of the method to be used to determine the test cycles by means of an example.

3.3 Test Conditions

Unless otherwise specified, the following general requirements are applicable to test categories I and II.

When this document is referenced in a design specification as part of the requirements, the following additional requirements must be specified:

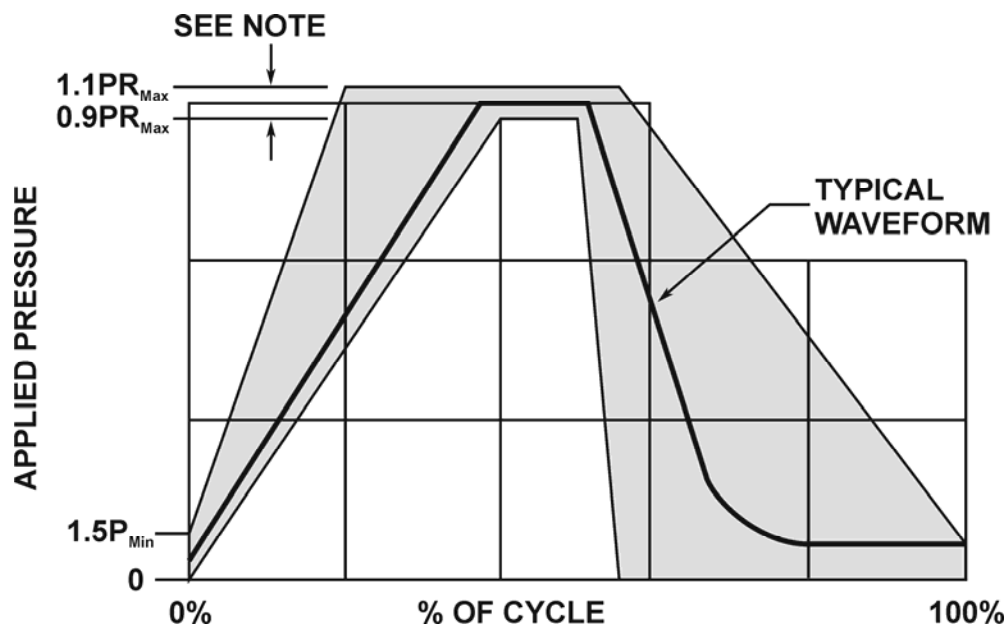
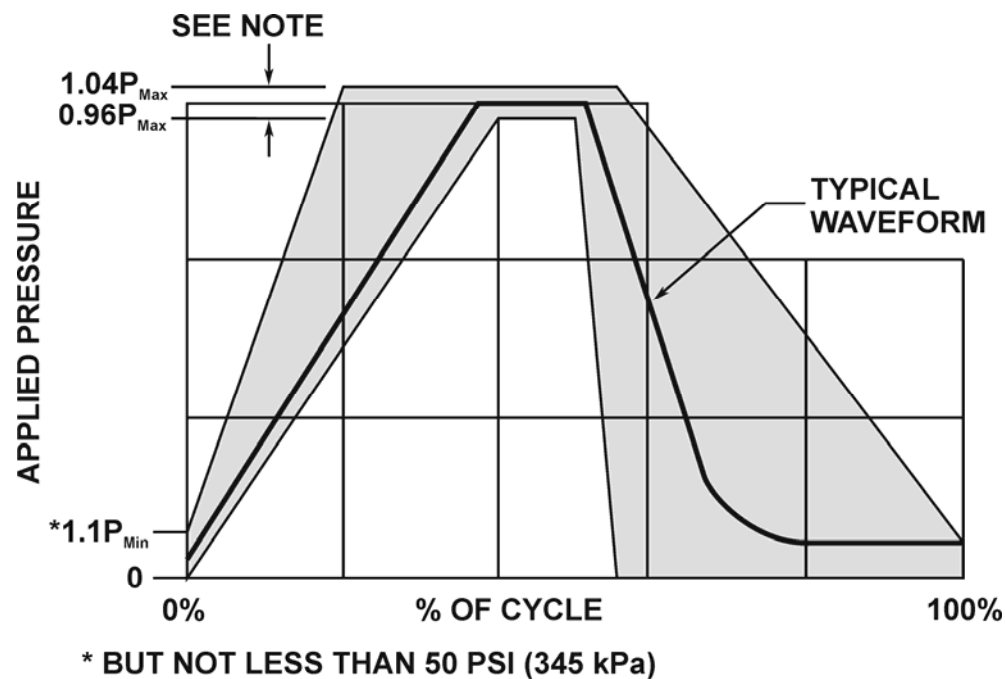
- a. Number of test cycles (for Category I testing, see 3.1; for Category II testing, see 3.2)
- b. Test pressures for all cavities
- c. Operating temperature(s) (see 4.4)
- d. Fluid (see 4.5)
- e. Waveform (see 4.1)
- f. Component/valve position (see 6.3.1)
- g. Minimum return line pressure and return line design pressure (for Category I testing, see 3.1; for Category II testing, see 3.2)
- h. Number of actuator cycles extended and retracted and position, if applicable (see 6.3.2)
- i. Cycling rate and tolerance (see 4.2)
- j. Layering requirements (sequential test condition(s) groupings) (see 6.4.1)
- k. Pressure transients/surges (pressure and return if known) (see 4.1)
- l. When an S-N curve is to be developed and if less than six specimens are permitted (see Appendix B)
- m. Any performance tests/inspections that must be satisfactorily completed following the completion of the impulse test (see 7.1)

4. GENERAL TEST REQUIREMENTS

4.1 Shape of the Impulse Cycle

The limits shown in Figures 1, 2, and 3 define the pressure-time cycle when observed on an oscilloscope or pressure trace and instrumented in accordance with AIR1228.

NOTE: If testing with elevated P_{Min} (for example, testing between 2000 - 6000 - 2000 psig (13.8 - 41.3 - 13.8 MPa)), then the tolerance on P_{Min} should be $1.1 P_{Min}$ to $0.9 P_{Min}$.



NOTE: The applied pressure shall be within this pressure band for not less than 10% and not more than 37% of the cycle time

FIGURE 1 - SUPPLY CAVITY AND RETURN CAVITY WAVEFORM