



AEROSPACE RECOMMENDED PRACTICE

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Recommended Design and Test Requirements for Hydraulic Flow Regulators

RATIONALE

There is a need for a document that provides recommended design and test requirements for hydraulic flow regulators. This document meets this need.

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1. SCOPE

This Aerospace Recommended Practice (ARP) provides recommendations for the design and test requirements for hydraulic flow regulators (also known as flow control valves).

The hydraulic flow regulator is intended for use in a civil or a military aircraft hydraulic system with a rated system pressure up to 5000 psi (34500 kPa).

1.1 Purpose

The recommended requirements contained in this document are compiled for inclusion in a Procurement Specification for a hydraulic flow regulator.

NOTE: The recommended requirements in this ARP should be reviewed by the Purchaser or the Contractor and only those requirements that are applicable for a specific application should be incorporated in the Procurement Specification.

1.2 Classification

The hydraulic flow regulator types covered by this ARP are:

- The line-mounted type - a valve with standard fitting ends
- The cartridge type - a cylindrical valve with O-ring glands for mounting in a manifold, for example
- The insert type - a cylindrical valve with an expansion pin to seal and lock in a cylindrical cavity

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 a 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.

ARP24	Determination of Hydraulic Pressure Drop
ARP1185	Flexure Testing of Hydraulic Tubing Joints and Fittings
ARP1383	Aerospace - Impulse Testing of Hydraulic Components
ARP4386	Terminology and Definitions for Aerospace Fluid Power, Actuation and Control Technologies
AS478	Identification Marking Methods
AS683	Installation Procedure and Torques for Fluid Connections
AS4059	Aerospace Fluid Power - Contamination Classification for Hydraulic Fluids
AS4941	Aerospace - General Requirements for Commercial Aircraft Hydraulic Components
AS5148	Assembly, Installation and Torque for Flareless and Straight Thread Fluid Fittings and Tube Assemblies

AS5440 Hydraulic Systems, Military Aircraft, Design and Installation Requirements for

AS8775 Hydraulic System Components, Aircraft and Missiles, General Specification For

2.1.2 Military Publications

Available from DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: (215) 697-6396, <http://quicksearch.dla.mil/>.

MIL-STD-130 Identification Marking of U.S. Military Property

MIL-STD-810 Environmental Engineering Considerations and Laboratory Tests

2.2 Definitions

Refer to ARP4386 for the fluid power terms that are used in this ARP.

HYDRAULIC FLOW REGULATOR: This is a valve that provides a constant flow rate through it with varying differential pressure across the inlet and outlet ports.

RATED SYSTEM PRESSURE: This is the steady-state pressure that has been generated by the hydraulic system power generation system or the pressure of a hydraulic sub-circuit that has been reduced by a pressure reducer valve (for example, a brake control system).

NOTE: The Rated System Pressure is equivalent to the Design Operating Pressure (DOP) for commercial aircraft and Working Pressure (P_w) for military aircraft.

CONSTANT FLOW or REGULATED FLOW: This is the flow that is regulated by the hydraulic flow regulator.

NOTE: This is the nominal flow rate of the regulator and all the recommended requirements are based on this flow rate.

INLET PORT: This is the port where the high-pressure side of the hydraulic system supplies fluid to the hydraulic flow regulator.

OUTLET PORT: This is the port where the regulated hydraulic flow is supplied to a component or a hydraulic sub-system.

ENDURANCE TEST: This is the test that is intended to determine if the hydraulic flow regulator will operate satisfactorily throughout its design lifetime.

PRESSURE IMPULSE TEST: This is the test that is intended to determine the fatigue characteristics of the hydraulic flow regulator pressure vessel to determine if it will maintain its strength throughout its operational lifetime.

PURCHASER or CONTRACTOR: This is the organization that is responsible for producing the Procurement Specification for the hydraulic flow regulator.

NOTE: The Purchaser or Contractor is typically an aircraft manufacturer, a modification center, a system supplier (for hydraulic or braking systems, for example), or an equipment supplier (for use in a manifold or an actuator, for example).

SUPPLIER: This is the manufacturer of the hydraulic flow regulator who is responsible for its design, production, and qualification.

PROCUREMENT SPECIFICATION: This is the document that includes the following:

- a. Specific performance and technical criteria
- b. Acceptance and qualification test requirements
- c. Reliability requirements
- d. Quality requirements
- e. Packaging requirements

3. RECOMMENDED REQUIREMENTS

3.1 General

The hydraulic flow regulator that is intended to be used in commercial aircraft hydraulic systems should conform to the general hydraulic components requirements of AS4941 as applicable.

The hydraulic flow regulator that is intended to be used in military aircraft hydraulic systems should conform to the general hydraulic components requirements of AS8775 as applicable.

The hydraulic flow regulator should meet all the requirements when it is installed or operated as defined by the applicable Procurement Specification.

The hydraulic flow regulator should not be sensitive to spatial orientation.

If the hydraulic flow regulator contains nonmetallic parts other than static seals, it should conform to all the functional and performance requirements specified hereinafter being immersed in the applicable hydraulic fluid (see 3.5.5) for 72 hours at the lower of the specified ambient or the hydraulic fluid survival minimum temperatures and the maximum operating hydraulic fluid temperature specified in 3.4.1 and 3.4.2. If the hydraulic flow regulator contains no nonmetallic parts other than static seals, then the required period for being immersed in the applicable hydraulic fluid should be reduced to 24 hours for each temperature case.

3.2 Functional Requirements

The hydraulic flow regulator should deliver a constant flow rate at:

- Any increment of pressure at the inlet port up to the rated system pressure
- Any increment of pressure at the outlet port up to the rated system pressure minus 200 psi (1380 kPa) or the specified pressure loss
- Any combination of the pressures across the inlet and outlet ports provided that the pressure is greater than the pressure at the outlet port plus the maximum allowable pressure drop.

3.3 Performance Requirements

3.3.1 Constant Flow Rate

The Procurement Specification should state the constant flow rate of the flow regulator.

3.3.1.1 Flow Rate Tolerances

The tolerances of the constant flow rate should be independent of the type of flow regulator. Unless otherwise specified in the Procurement Specification, they should be as follows for normal and high ambient and fluid temperatures:

- Constant flow rate below 0.49 gpm (1.86 l/m): $\pm 20\%$
- Constant flow rate between 0.50 to 1.50 gpm (1.9 to 5.7 l/m): $+10\%$, -15%
- Constant flow rate above 1.50 gpm (5.7 l/m): $\pm 10\%$

The tolerances at low ambient and fluid temperatures (for example, below -5°F (-20°C)) should be agreed upon between the Purchaser or the Contractor and the Supplier.

3.3.2 Damping

The hydraulic flow regulator should be designed such that it is not affected by any normally encountered back pressures or pressure surges.

The hydraulic flow regulator should be designed such that when it opens or closes, it does not create any pressure surges.

3.3.2.1 Pressure Differential Compensation

NOTE: The percentage and time values quoted in the sub-sections below for the momentary overshoot and the momentary reduction of regulated flow are typical values. It is recommended that a dynamic analysis of the application is conducted to either confirm these values or if more or less stringent values are required.

3.3.2.1.1 Sudden Increase in Inlet Pressure

The hydraulic flow regulator should be designed such that it will react to any sudden increase in the inlet pressure such that:

- The momentary overshoot of the regulated flow should not exceed 20% of the constant flow plus the applicable tolerance defined in 3.3.1.1.
- The duration of the momentary overshoot should not exceed 0.5 seconds.

3.3.2.1.2 Sudden Increase in Outlet Pressure

The hydraulic flow regulator should be designed such that it will react to any sudden increase in the outlet pressure such that:

- The momentary reduction of the regulated flow should not exceed 25% of the constant flow plus the applicable tolerance defined in 3.3.1.1.
- The duration of the momentary overshoot should not exceed 0.5 seconds.

3.3.3 Pressure Drop

The Procurement Specification should state the minimum pressure drop across the flow regulator at the point where the device must begin regulating the nominal flow within the applicable tolerance defined in 3.3.1.1.

3.3.4 External Leakage

There should be no external leakage allowed under any combination of environments specified herein.

NOTE: Any evidence of wetness sufficient to form a drop should be considered leakage.

3.4 Operating Temperature

3.4.1 Ambient Temperature

The Procurement Specification should specify the ambient temperature range, including the minimum and maximum operating and survival (non-operating) temperatures.

3.4.2 Hydraulic Fluid Temperature

The Procurement Specification should specify the hydraulic fluid temperature range, including the minimum and maximum operating and survival (non-operating) temperatures.

3.5 Construction

3.5.1 Materials

AS4941 or AS8775, as applicable, should be used for guidance in the selection of the hydraulic flow regulator materials. The Procurement Specification should list any prohibited materials.

3.5.2 Corrosion Resistance

The corrosion protection features of the hydraulic flow regulator should be per AS4941 or AS8775, as applicable.

3.5.3 Electro-Conductive Bonding

If there is a requirement for electro-conductive bonding, the Procurement Specification should state the electrical resistance requirement between any point on the mounting facilities and specified points on the hydraulic flow regulator.

NOTE: Refer to AS4941 for specific bonding requirements.

3.5.4 Seals

AS4941 or AS5440, as applicable, should be used for guidance in the design of the seal glands and the seal materials.

3.5.5 Hydraulic Fluid

The Procurement Specification should specify the hydraulic fluid(s) to be used for the hydraulic flow regulator application.

3.5.5.1 Hydraulic Fluid Contamination

The Procurement Specification should state the hydraulic fluid contamination limits per AS4059 for:

- a. Aircraft at new build
- b. In-service (typical and maximum)

3.6 Physical Requirements

3.6.1 Mounting Requirements

3.6.1.1 Line-Mounted Hydraulic Flow Regulator

The Procurement Specification should define the type and size of the hydraulic fluid ports fittings and the overall space envelope.

NOTES:

1. It is recommended that the inlet port and the outlet port fittings be different sizes or be male/female to prevent the hydraulic flow regulator from being installed incorrectly.