



AEROSPACE RECOMMENDED PRACTICE

ARP4378™**REV. C**

Issued 2009-08
Reaffirmed 2002-07
Revised 2017-01

Superseding ARP4378B

(R) Accumulator, Hydraulic, Welded Bellows, Factory Pre-Charged

RATIONALE

ARP4378 has been updated to Revision C for the following reasons:

- To introduce new and revised technical and test requirements
- To update the references

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1. SCOPE

This SAE Aerospace Recommended Practice (ARP) provides design and test requirements for high pressure, factory pre-charged, welded bellows hydraulic accumulators.

1.1 Purpose

The requirements contained in this ARP are compiled for inclusion in a Procurement Specification for this type of accumulator.

NOTES:

1. As there are many uses for this type of accumulator in aircraft hydraulic systems, the requirements in this ARP should be reviewed by the procuring activity and only those requirements that are applicable for a specific application should be incorporated in the Procurement Specification.
2. In the event of a conflict between the requirements in this ARP and the Procurement Specification, the Procurement Specification will take precedence.

1.2 Field of Application

The accumulator is intended for use in commercial and military aircraft hydraulic systems with rated pressures up to 5000 psi (34474 kPa).

NOTE: As this ARP is for high pressure accumulators, it should not be used for hydraulic reservoirs in Electrohydrostatic Actuator Applications (EHAs). This is because EHA reservoirs are essentially low pressure accumulators and have different technical and qualification requirements.

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 +1 724-776-4970 (outside USA), www.sae.org.

AS478	Identification Marking Methods
ARP1383	Aerospace - Impulse Testing of Hydraulic Components
AS4059	Aerospace Fluid Power - Contamination Classification for Hydraulic Fluids
ARP4386	Terminology and Definitions for Aerospace Fluid Power, Actuation and Control Technologies
AS4941	Aerospace - General Requirements for Commercial Aircraft Hydraulic Components
AS8775	Hydraulic System Components, Aircraft and Missiles, General Specification for

2.1.2 Code of Federal Regulations (CFR)

Available from the U.S. Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-1800, www.gpo.gov.

49 CFR.173.306 Code of Federal Regulations – Transportation – Shippers – General Requirements for Shipments and Packagings - Gases; Preparation and Packaging – Limited Quantities of Compressed Gases

2.1.3 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

RTCA/DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

2.1.4 U.S. Government Publications

Copies of these documents are available online at <http://quicksearch.dla.mil>.

A-A-59503 Nitrogen, Technical

MIL-DTL-5498 Accumulators, Hydraulic, Cylindrical, 3000 PSI, Aircraft

MIL-PRF-27401 Propellant Pressurizing Agent, Nitrogen

MIL-PRF-27407 Propellant Pressurizing Agent, Helium

MIL-PRF-27415 Propellant Pressurizing Agent, Argon

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

MIL-STD-810 Environmental Engineering Constraints and Laboratory Tests

2.2 Related Publications

The following publications are provided for information purposes only, and are not a required part of this SAE Aerospace document.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

ARP4379 Aerospace - Accumulator, Hydraulic, Cylindrical, Piston Separated

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

ARP4553 Aerospace - Accumulator, Hydraulic, Self-Displacing

ARP4752 Aerospace - Design and Installation of Commercial Transport Aircraft Hydraulic Systems

ARP4925 Aerospace Design and Installation of Commercial Transport Helicopter Hydraulic Systems

2.3 Definitions

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

PURCHASER: This is the organization that is responsible for providing the Procurement Specification for the accumulator. The Purchaser is typically an aircraft manufacturer, a modification center, or a system supplier (hydraulic or braking, for example).

SUPPLIER: This is the manufacturer of the accumulator 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

RATED SYSTEM PRESSURE: This is the nominal steady state pressure that is achieved:

- a. From the output pressure of the hydraulic system pumps - for an accumulator used in the power generation system, or
- b. Due to thermal effects at the point of the actuation of a thermal relief valve - for an accumulator used to provide stored energy (for example, a brake accumulator)

NOTES:

1. Rated System Pressure is equivalent to the Design Operating Pressure (DOP).
2. All pressures referred to in this document are gauge pressures

PRE-CHARGE: This is the factory sealed gas charge within the accumulator with the separator bottomed at the fluid end prior to installation and in non-operational service (specified as a pressure at a specific temperature).

SEPARATOR: This is the part of the accumulator that separates the gas and the hydraulic system fluid. The separator comprises a welded bellows assembly, a sweeper and other devices to permit the separator to smoothly move within the accumulator body as hydraulic fluid enters or is expelled from the accumulator.

PRESSURE VESSEL: This is the portion of the accumulator that contains the pressurized hydraulic fluid and gas and separates both from the atmosphere.

DISPLACED FLUID VOLUME: This is the fluid that is expelled from the accumulator fluid port when the accumulator separator is moved from the position where the fluid stored in the accumulator is at the rated system pressure and at a prescribed temperature to either zero pressure or a designated return pressure.

MAXIMUM DISPLACED FLUID VOLUME: This is the maximum volume of hydraulic fluid that can be stored in the accumulator at either proof pressure or the system relief pressure at cold temperature, for example -40 °F (-40 °C). To determine the maximum displaced volume, the volume at both conditions must be calculated. The difference in gas volume between the pre-charge volume and the smaller of the proof pressure volume and the cold temperature relief pressure volume is the maximum displaced fluid volume. Real gas laws, including compressibility, should be used to calculate these volumes.

ENDURANCE TEST: This is the test or series of tests that is intended to determine the wear and fatigue characteristics of the accumulator separator in order to determine if it will operate satisfactorily throughout its design lifetime. The endurance test comprises the realistic simulation of the accumulator in the specific application on the aircraft over the lifetime that has been declared for it. The test comprises the repeated application of hydraulic pressure cycles using an appropriate test rig.

PRESSURE IMPULSE TEST: This is the test or series of tests that is intended to determine the fatigue characteristics of the accumulator pressure vessel in order to determine if it will maintain its strength throughout its operational lifetime. The pressure impulse test comprises the realistic simulation of the operation of the accumulator in the specific application on the aircraft over the life that has been declared for it. The test comprises the repeated application of pressure impulses using an appropriate test rig.

3. REQUIREMENTS

3.1 General

The accumulator should be designed to meet the requirements of Federal Regulation 49 CFR.173.306 (f) (3).

Factory pre-charged, welded bellows hydraulic accumulators that are intended to be used in military flight vehicle hydraulic systems should conform to the general hydraulic components' requirements of AS8775 as applicable.

Factory pre-charged, welded bellows hydraulic accumulators that are intended to be used in commercial aircraft or helicopter hydraulic systems should conform to the general hydraulic components' requirements of AS4941 as applicable.

3.2 Functional Requirements

3.2.1 Dynamic Performance Requirements

3.2.1.1 General

The Purchaser should identify if there are any important accumulator dynamic behavior requirements depending on the accumulator design and the hydraulic system characteristics, such as the:

- a. Response rate for filling the accumulator
- b. Response rate for discharging the accumulator
- c. Optimization of charge pressure/accumulator volumes, including whether the gas pressure changes are considered to be adiabatic or isothermal, etc.
- d. Performance at operating temperature extremes

The Purchaser and the Supplier should work together to ensure that the accumulator will meet these requirements.

If required, the Supplier should provide the necessary data to the Purchaser to enable a detailed hydraulic model to be generated in a hydraulic simulation program to ensure that the accumulator is compatible with the dynamic operation of the hydraulic system.

3.2.1.2 Extreme Pressure Rise or Decay Rates

The Supplier and the Purchaser should determine if there are any necessary application-specific detail requirements related to extreme pressure rise or decay rates at the interface between the system and the accumulator, considering for example:

- a. High pressure within the accumulator due to inertia of the welded bellows and resistance within any fluid passages
- b. The responsiveness of the accumulator during a rapid pressure decay at the pressure port

3.2.2 Pre-Charge Gas Requirements

The Procurement Specification should specify the required pre-charge volume, pressure and temperature, and their associated tolerance ranges.

3.2.3 Displaced (Expelled) Fluid Volume

The Procurement Specification should specify the displaced (expelled) fluid volume and the corresponding pressures and temperatures.

NOTE: Careful consideration should be given to the start and finish pressures, temperatures and fluid flow rates since these are significant factors that affect accumulator design and sizing.

3.2.4 Maximum Displaced Fluid Volume

The Procurement Specification should state the relief valve pressure (either the system relief valve or the dedicated thermal relief valve pressure) and the corresponding temperature in order to enable the maximum displaced fluid volume to be determined.

3.2.5 Separator Friction

The hydraulic fluid pressure at which the separator begins to move should not be greater than 25 psi (172 kPa) above the pre-charge pressure. This requirement should be met over the total stroke of the accumulator, and over the specified temperature range. This value should be independent of the pre-charge pressure and the rated system pressure. If this is not the case, then the Supplier and the Purchaser should agree where the requirement can be exceeded.

NOTE: This requirement is not applicable if there are no dynamic seals incorporated between the separator bellows assembly and the inside surface of the pressure vessel (i.e., only guides are incorporated in the bellows assembly).

3.2.6 Leakage Requirements

3.2.6.1 Gas Leakage

A new pre-charged accumulator should have a total gas leakage, internal and external, not greater than 1×10^{-7} standard cubic centimeters of helium per second at atmospheric pressure. The pre-charge pressure should not reduce more than 3% in ten years with any combination of storage or operation.

3.2.6.2 Fluid Leakage

There should be no evidence of external fluid leakage over the lifetime of the accumulator while in use or while capped for storage.

3.2.7 Operating Temperature

3.2.7.1 Ambient Temperature

The ambient temperature range should be specified in the Procurement Specification, including the operating and survival (non-operating) temperatures.

3.2.7.2 Hydraulic Fluid Temperature

The hydraulic fluid temperature range should be specified in the Procurement Specification, including the operating and survival (non-operating) temperatures. The maximum survival fluid temperature should not exceed the rated fluid temperature.