SAE Aerospace
An SAE International Group

AEROSPACE RECOMMENDED PRACTICE

SAE ARP4379 | REV. A

Issued 1991-06
Revised 2007-11

Superseding ARP4379

(R) Aerospace - Accumulator, Hydraulic, Cylindrical, Piston Separated

RATIONALE

ARP4379 has been revised to issue A for the following reasons:

- Major editorial changes
- Document restructured and reformatted in its entirety to reflect latest industry practice and standards
- Vessel Proof and Burst factors changed for commercial to comply with new regulations
- Updated references
- New and revised technical and test requirements have been incorporated

TABLE OF CONTENTS

1. SCOPE 3
2. REFERENCES 3
2.1 Applicable Documents 3
2.1.1 SAE Publications 3
2.1.2 Department of Defense Publications 4
2.1.3 NAS Publications 4
2.1.4 RTCA Publications 4
2.2 Definitions 5
3. REQUIREMENTS 6
3.1 General 6
3.2 Qualification Testing 6
3.3 Design and Construction 6
3.3.1 Construction 6
3.3.2 Dimensions and Mounting Provisions 6
3.3.3 Ports 6
3.3.4 Weight 7
3.3.5 Hydraulic Fluid 7
3.3.6 Seals 7
3.3.7 Corrosion Protection 7
3.3.8 Storage 7
3.3.9 Marking 7
3.3.10 Fluid Cleanliness 8
3.4 Structural Requirements 8
3.4.1 Design Operating Pressure (DOP) 8
3.4.2 Vessel Proof Pressure 8

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3.4.3 Vessel Burst Pressure 8
3.4.4 Separator 8
3.4.5 Pressure Impulse Cycling 8
3.5 Performance Requirements 9
3.5.1 Precharge Pressure 9
3.5.2 Separator Friction 9
3.5.3 Leakage 9
3.5.4 Swept (expelled) Oil Volume 9
3.5.5 Volumetric Efficiency 9
3.6 Operational Requirements 10
3.6.1 Endurance Cycling 10
3.6.2 Immersion 10
3.6.3 Operating Temperature 10
3.6.4 Vibration 10
3.6.5 Additional Testing 10
3.6.6 Reliability 10
4. QUALITY ASSURANCE PROVISIONS 10
4.1 Responsibility of Inspection 10
4.2 Classification of Tests 11
4.3 General Testing Requirements 11
4.4 Qualification Tests 11
4.5 Acceptance Tests 11
4.6 Examinations 12
4.6.1 Examination of Product 12
4.7 Test Methods 12
4.7.1 Temperature 12
4.7.2 Fluid Cleanliness 12
4.8 Tests 12
4.8.1 Proof Pressure 12
4.8.2 Cycling 12
4.8.3 Leakage Test 13
4.8.4 Separator Friction 14
4.8.5 Fluid Immersion 14
4.8.6 Volumetric Efficiency 14
4.8.7 Endurance Cycling 14
4.8.8 Pressure Impulse 14
4.8.9 Vibration 14
4.8.10 Additional Testing 14
4.8.11 Burst Pressure 15
4.8.12 Qualification Failures 15
5. PREPARATION FOR DELIVERY 15
5.1 Preservation 15
5.2 Packaging and Marking 15
6. NOTES 15

FIGURE 1 RECOMMENDED GAS LEAKAGE TEST SETUP 13

TABLE 1 QUALIFICATION TESTING 11
TABLE 2 ENDURANCE AND PRESSURE IMPULSE TEST CYCLES 16

1. SCOPE

This SAE Aerospace Recommended Practice (ARP) is intended as a guide in defining the requirements for aerospace piston separated hydraulic accumulators, including details pertinent to the design, fabrication, and performance of the accumulator. This type of accumulator has a piston separator and contains both high-pressure gas and fluid. The accumulator is used in aerospace hydraulic systems of the following types as defined in AS5440 with design operating pressures of up to 8000 psi (55,160 kPa).

- Type I: -65 to +160 °F (-54 to +71 °C) fluid temperature
- Type II: -65 to +275 °F (-54 to +135 °C) fluid temperature

For commercial aerospace or helicopter applications, the information and guidelines of ARP4752 or ARP4925 respectively, are considered.

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 15091-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AS1241	Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft
ARP1288	Placarding of Aircraft Hydraulic Equipment to Identify Phosphate Ester Fluid Compatibility
ARP1383	Impulse Testing of Aerospace Hydraulic Actuators, Valves, Pressure Containers, and Similar Fluid System Components
MA2012	Port, Internal, Straight Thread, Fitting Connection, Design Standard, Metric
AS4059	Aerospace Fluid Power - Cleanliness Classification for Hydraulic Fluids
ARP4150	Procedure for Inspection of Inservice Airborne Accumulators for Corrosion and Damage
ARP4386	Terminology and Definitions for Aerospace Fluid Power, Actuation and Control Technologies
AIR4543	Aerospace Hydraulics and Actuation Lessons Learned
AS4716	Gland Design, O-Ring and Other Elastomeric Seals
ARP4752	Aerospace - Design and Installation of Commercial Transport Aircraft Hydraulic Systems
ARP4925	Aerospace Design and Installation of Commercial Transport Helicopter Hydraulic Systems
AS4941	Aerospace - General Requirements for Commercial Aircraft Hydraulic Components

AS5440 Hydraulic Systems, Aircraft, Design and Installation Requirements for

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

AS33649 Bosses, Fluid Connection, Internal Straight Thread

AMS-P-83461 Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Improved

2.1.2 Department of Defense Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/.

MIL-PRF-5606 Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordinance

MIL-PRF-27401 Propellant Pressurizing Agent, Nitrogen

MIL-PRF-83282 Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft

MIL-PRF-87257 Hydraulic Fluid, Fire Resistant, Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile

MIL-STD-129 Marking for Shipment and Storage

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

MIL-STD-810 Environmental Test Methods

MIL-STD-2073-1 Standard Practice for Military Packaging

2.1.3 NAS Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NAS 847 Caps and Plugs, Protective, Dust and Moisture Seal

NAS 1611 Packing, Ethylene Propylene Preformed, O-Ring Phosphate Ester Resistant (-65 Degree F to 250/300 Degree F)

NAS 1612 Packing, Ethylene Propylene Preformed, O-Ring Phosphate Ester Resistant, Straight Thread Tube Fitting Boss (-65 Degree F to 250/300 Degree F)

2.1.4 RTCA Publications

Available from Radio Technical Commission for Aeronautics Inc., 1828 L Street, NW, Suite 805, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

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

2.2 Definitions

Refer to ARP4386 for general hydraulic systems terms that are used in this recommended practice. The following terms used in this document are defined as follows:

EXTERNAL GAS LEAKAGE: External leakage is the leakage of the precharge gas from within the vessel as evidenced by free gas bubbles when the accumulator is immersed in a test fluid.

INTERNAL GAS LEAKAGE: Internal leakage of gas across the piston head seal.

STATIC LEAKAGE: External fluid or gas leakage with the unit statically pressurized.

DYNAMIC LEAKAGE: Internal leakage, across the piston head seal, which occurs during operation (cycling)

PRECHARGE GAS VOLUME: The gas contained within the accumulator and separated from the hydraulic fluid, with the separator bottomed at the fluid end.

DESIGN OPERATING PRESSURE (DOP): Design operating pressure is the normal maximum steady state pressure of the accumulator. Excluded are:

- Reasonable tolerances and transient pressure effects such as may arise from acceptable pump ripple, or
- Reactions to system functioning or demands that may affect fatigue

NOTE: This term is used in commercial aircraft and helicopter applications. For military applications, the term “rated pressure” can be substituted.

SEPARATOR: The part of the accumulator that isolates the precharge gas from the hydraulic fluid.

VESSEL: The portion of the accumulator, which contains pressurized hydraulic fluid and the gas and separates both from the atmosphere.

SWEPT (EXPELLED) OIL VOLUME: The fluid expelled from the accumulator’s fluid port when the accumulator separator is moved from being fully bottomed against the Gas End cap to being fully bottomed against the Fluid End cap, at rated pressure an prescribed temperature.

TOTAL OIL VOLUME: The fluid capacity of the accumulator with the piston fully bottomed against the Gas End cap, at maximum rated pressure at cold temperature.

VOLUMETRIC EFFICIENCY: The capability of the accumulator to expel the hydraulic volume with which it has been filled. Volumetric Efficiency = (Expulsion Volume/Filling Volume) x 100%.

PROCUREMENT SPECIFICATION: The Procurement Specification is the document that includes the following:

- Technical Requirements
- Acceptance and Qualification Test Requirements
- Reliability Requirements
- Quality Requirements
- Packaging Requirements

FLUID PORT: The fluid port is the port that is connected to the hydraulic system, such that the accumulator receives and discharges hydraulic fluid.

GAS PORT: The gas port is the port that is connected to the gas charging equipment, such that it provides the flow path for the gas pressurization charge into the accumulator.

PRECHARGE PRESSURE: Gas pressure applied to the accumulator by the operator, typically specified as pressure at a given temperature.

ENDURANCE TEST: The endurance test is defined as the test which is intended to determine the wear characteristics of the accumulator in order to determine if it will perform satisfactorily throughout its operational life.

FATIGUE TEST: The fatigue test is defined as the test which is intended to validate the fatigue strength of the accumulator by repeated application of pressure impulses.

3. REQUIREMENTS

3.1 General

The requirements of AS5440 and AS8775 (military applications) or ARP4752 or ARP4925 and AS4941 (commercial applications) shall apply as requirements of this document, with the exceptions specified herein. When this document and the applicable above referenced specifications conflict, this document shall govern.

3.2 Qualification Testing

The accumulator furnished under this document shall be a product that has been tested and has passed the qualification tests specified in Section 4.

3.3 Design and Construction

The materials and processes used in the design and fabrication of components shall be of high quality, suitable for the purpose and shall conform to the applicable specifications. Materials conforming to the supplier's material specifications can be used provided the specifications are acceptable to the procurement agency and contain provisions for adequate tests.

3.3.1 Construction

Accumulators shall be designed and constructed to contain gas and hydraulic fluid under pressure. The accumulator shall be provided with a fluid port and a gas port as specified in 3.3.3.

3.3.2 Dimensions and Mounting Provisions

Dimensions and mounting provisions shall conform to the requirements as defined in the Procurement Specification.

3.3.3 Ports

3.3.3.1 Fluid Port

The fluid port shall be designed to give a minimum restriction to fluid flow. The port shall be per AS33649 (or MA2012) or as defined in the Procurement Specification.

3.3.3.2 Gas Port

A gas port per AS33649 (or MA2012) shall be provided unless otherwise specified by the Procurement Specification.

3.3.4 Weight

The accumulator weight shall be a minimum consistent with the performance and requirements of this document and the Procurement Specification.

3.3.5 Hydraulic Fluid

The accumulator shall be designed to operate with the hydraulic fluid specified by the Procurement Specification (for example: MIL-PRF-5606, MIL-PRF-87257, MIL-PRF-83282, or AS1241).

3.3.6 Seals

The seals contained within the accumulator shall be compatible with the operating fluid as specified in 3.3.5 (such as AMS-P-83461 or NAS 1613) and the operating temperature as specified in 3.6.3. The seal gland design shall be per AS4716 unless otherwise specified by the Procurement Specification. External seals shall have a minimum cross-section of 0.103 in (2.62 mm) (nominal) or larger except in boss seals.

3.3.7 Corrosion Protection

Materials subject to deterioration when exposed to the climatic and other environmental conditions specified shall be protected. The method of protection shall not prevent compliance with other requirements. The use of any protective coating that will crack, chip, scale or erode during life or as a result of climatic or other environmental conditions shall be avoided. Assembly requiring the contact of dissimilar metals shall be adequately protected against galvanic interaction in service by the use of an appropriate finish system. Protective coatings shall be compatible with the operating fluid as specified in 3.3.5 and shall meet the requirements stated in the applicable specifications.

3.3.8 Storage

The accumulator shall be constructed of materials which shall not degrade during the life of the accumulator. The accumulator shall be designed for a minimum shelf life of ten years after delivery.

3.3.9 Marking

3.3.9.1 Warning Label

Each accumulator shall be permanently marked with a legible warning in red letters stating: RELEASE GAS AND FLUID PRESSURE BEFORE DISASSEMBLING, STORING OR SHIPPING ACCUMULATOR.

3.3.9.2 Nameplate

Each accumulator shall be furnished with a nameplate and shall provide the following data unless otherwise specified in the Procurement Specification:

a. Accumulator, Hydraulic

b. Design Operating Pressure

c. Manufacture Date

d. Manufacturer's Serial Number

e. Manufacturer's Name

f. Manufacturer's Part Number

g. Nominal Gas Volume

h. Operating Fluid

3.3.10 Fluid Cleanliness

Unless otherwise specified in the Procurement Specification, the accumulator shall operate and meet all performance requirements with a fluid contamination level up to and including AS4059, Class 12. A maximum "in service" cleanliness level classification shall be specified by the Procurement Specification.

3.4 Structural Requirements

The accumulator shall be capable of meeting all the structural requirements specified below unless otherwise specified by the Procurement Specification.

3.4.1 Design Operating Pressure (DOP)

The accumulator shall be designed and constructed to have a design operating pressure as specified in the Procurement Specification. Care should be taken in the specification of the design operating pressure. This is because if the accumulator is used to store hydraulic fluid and is subjected to thermal effects (for example, if it used as a parking brake accumulator), the DOP will be the thermal relief valve cracking pressure.

3.4.2 Vessel Proof Pressure

The vessel shall be subjected to a proof pressure of two times the applicable design operating pressure defined by 3.4.1 (military applications) and three times the applicable design operating pressure defined by 3.4.1 (commercial applications).

3.4.3 Vessel Burst Pressure

The vessel shall be subjected to a burst pressure four times the applicable design operating pressure defined by 3.4.1 or as specified by the Procurement Specification, and shall be designed to withstand this pressure at maximum rated temperature of the accumulator as specified in 3.6.3.

3.4.4 Separator

The separator that isolates the hydraulic fluid and the gas shall be designed to operate with the maximum precharge pressure as defined by the Procurement Specification. Means shall be provided to prevent sealing off the fluid port when the piston is bottomed adjacent to the fluid port.

3.4.4.1 Separator Proof Pressure

Unless otherwise specified in the Procurement Specification, the separator shall be designed to withstand a differential pressure of 1.5 times the applicable design operating pressure as specified in 3.4.1

3.4.4.2 Separator Burst Pressure

Unless otherwise specified in the Procurement Specification, the separator shall be designed to withstand a differential pressure of two times the applicable design operating pressure per 3.4.1 and shall be designed to withstand this pressure at the maximum operating temperature of the accumulator per 3.6.3.

3.4.5 Pressure Impulse Cycling

Unless more stringent requirements are defined in the Procurement Specification, the accumulator shall be designed to withstand pressure impulse cycling as defined in Table 2, Step 7 Typical impulse curves are shown in ARP1383 Figures 1 and 2.

3.5 Performance Requirements

The accumulator shall be capable of meeting all the performance requirements specified below unless otherwise specified by the Procurement Specification.

3.5.1 Precharge Pressure

The Procurement Specification shall define the gas precharge pressure and respective temperature for charging the accumulator. The accumulator shall be charged with inert gas only, per MIL-PRF-27401 or equivalent, as specified by the Procurement Specification.

3.5.2 Separator Friction

The differential pressure at which the separator begins to move, over the total stroke of the accumulator, shall not be greater than 100 psi (700 kPa) in either direction unless otherwise specified in the Procurement Specification.

3.5.3 Leakage

3.5.3.1 Gas Static Leakage

An accumulator shall have no external leakage and an internal leakage of not more than specified below or as specified by the Procurement Specification, over the lifetime of the application.

a. 0.5 ml per hour of free gas for volumes up to 50 in^3 (0.8 L)

b. 1.0 ml per hour of free gas for volumes from 51 to 200 in^3 (0.8 to 3.3 L)

c. 3.0 ml per hour of free gas for volumes from 201 to 400 in^3 (3.3 to 6.6 L)

3.5.3.2 Gas Dynamic Leakage

The accumulator internal dynamic gas leakage shall be less than 0.5% of the gas volume for each 500 charge/discharge cycles as measured in the change in the gas charge pressure.

3.5.3.3 Fluid Static Leakage

An accumulator shall have no external static leakage at the rated pressures specified. Internal leakage shall not exceed two drops in 1 h or as specified in the Procurement Specification, over the lifetime of the application.

3.5.3.4 Fluid Dynamic Leakage

Leakage shall not exceed one drop per 250 charge/discharge cycles or as specified in the Procurement Specification, over the lifetime of the application.

3.5.4 Swept (expelled) Oil Volume

The swept oil volume (expelled oil volume) of the accumulator shall be specified in the Procurement Specification.

3.5.5 Volumetric Efficiency

The volumetric efficiency shall be such that the fluid expelled as the hydraulic pressure is reduced from maximum pressure to zero shall be in excess of 95% of the total oil volume of the fluid chambers. The expelled volume shall be as specified in 3.5.4.

3.6 Operational Requirements

The accumulator shall be capable of meeting all the operational requirements specified below unless otherwise specified by the Procurement Specification.

3.6.1 Endurance Cycling

The accumulator shall be designed to withstand endurance and pressure impulse cycling as defined in Table 2, Step 1 through 6, or as specified in the Procurement Specification. Accumulator performance during testing shall be verified as noted during testing.

3.6.2 Immersion

The accumulator shall meet all test requirements per Table 2 after being immersed in the operating fluid for a period of 72 h at the maximum operating temperature as specified in 3.6.3.

3.6.3 Operating Temperature

The accumulator shall be designed to operate at temperatures as specified in 1.0 for Type I or Type II systems for military applications, or as specified by the Procurement Specification for commercial aircraft or helicopter applications.

3.6.4 Vibration

The accumulator shall be installed in a test setup to simulate the aircraft installation. The accumulator shall be vibrated in accordance with the applicable test procedure of MIL-STD-810, Method 514.4 or RTCA/DO-160, Section 8. There shall be no mechanical failure of any part resulting from this test. Upon completion, the accumulator shall meet the functional test requirements as specified in 4.5.

3.6.5 Additional Testing

Additional testing, based on the use and environment of the accumulator, should be considered and specified as required by the Procurement Specification. For example, additional testing could include extreme temperature, temperature shock, humidity, sand, and dust. These tests should be accomplished per the applicable sections of AS8775 for military applications and AS4941 may be used for commercial applications. In the case of a military application fragmentation testing (gunfire) may be specified.

3.6.6 Reliability

The Procurement Specification shall state the required reliability requirements for the accumulator. AIR4543 should be consulted to ensure that the applicable lessons learned are incorporated into the accumulator design. AIR4150 should also be consulted to ensure that any potential long-term corrosion problems are eliminated in the design of the accumulator.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility of Inspection

Unless otherwise specified in the Procurement Specification, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize their own facilities or any commercial laboratory acceptable to the Procurement Agent. The Procurement Agent reserves the right to perform any of the inspections set forth in this specification whenever it is deemed necessary to assure that the accumulator conforms to the prescribed requirements.

4.2 Classification of Tests

The inspection and testing of the accumulators shall be classified as:

a. Qualification Tests (4.4)

b. Acceptance Tests (4.5)

4.3 General Testing Requirements

The accumulator shall be subjected to the qualification testing stated herein to demonstrate compliance with this specification. Acceptance of items under the qualification provisions specified herein shall not relieve the supplier of the responsibility to meet all other requirements of this specification.

4.4 Qualification Tests

Two qualification samples shall be subjected to the testing as specified and in the order listed in Table 1.

TABLE 1 - QUALIFICATION TESTING

Test	Required Paragraph	Test Method Paragraph	Unit A	Unit B
1. Acceptance Test		4.5	X	X
2. Fluid Immersion	3.6.2	4.8.5	X	
3. Volumetric Efficiency	3.5.5	4.8.6	X	
4. Separator Friction	3.5.2	4.8.4	X	X
5. Proof Pressure	3.4.2/3.4.4.1	4.8.1	X	X
6. Leakage	3.5.3	4.8.3	X	X
7. Endurance Cycling	3.6.1	4.8.7	X	
8. Impulse cycling	3.4.5	4.8.8	X	
9. Vibration	3.6.4	4.8.9		X
10. Additional Testing	3.6.5	4.8.10		X
11. Burst	3.4.3/3.4.4.2	4.8.11		X

4.5 Acceptance Tests

Each accumulator which is submitted for acceptance testing shall be subjected to the following test, as a minimum, in the order listed:

a. Examination of Product (4.6.1)

b. Proof Test (4.8.1)

c. Cycling (4.8.2)

d. Gas and Fluid Leakage (4.8.3)

e. Separator Friction Test (4.8.4)

f. Preparation for Delivery (Section 5)

4.6 Examinations

4.6.1 Examination of Product

Each accumulator shall be inspected for quality of workmanship and to determine compliance with this specification and referenced Procurement Specifications and drawings. Inspection records shall be retained by serial number so that failure and reliability studies may be conducted using these records as reference.

4.7 Test Methods

4.7.1 Temperature

All tests shall be conducted at room temperature of 59 to 95 °F (15 to 35 °C) and a fluid temperature of 68 to 158 °F (20 to 70 °C) unless otherwise specified.

4.7.2 Fluid Cleanliness

Unless specified in the Procurement Specification, fluid cleanliness shall be maintained at AS4059, Class 5 or better for all the tests except for the endurance test. The fluid contamination level for this test shall be not less than the maximum level specified for the accumulator application; typically this is AS4059 Class 8 or 9. The Procurement Specification and/or Test Procedure shall define the test methodology used to control contamination distribution and assure repeatable test results.

4.8 Tests

4.8.1 Proof Pressure

The accumulator shall be proof pressure tested as shown below. There shall be no leakage of fluid or permanent deformation or failure in any part of the accumulator.

4.8.1.1 Vessel

With the separator in approximately mid position, completely fill the fluid and gas chambers with hydraulic fluid and plug the gas port. Fluid pressure shall be applied at the fluid port until a pressure per 3.4.2 is obtained and maintained for 5 min.

4.8.1.2 Separator Proof Pressure

a. With the accumulator mounted in a vertical position and with the gas port down and the port open to the atmosphere, the accumulator separator shall withstand a fluid pressure per 3.4.4.1 applied at the fluid port for 2 min without leakage or damage.

b. With the accumulator mounted in a vertical position and with the fluid port down and the port open to the atmosphere, the accumulator separator shall withstand a fluid pressure per 3.4.4.1 applied to the gas port for 2 min without leakage or damage.

4.8.2 Cycling

The accumulator should be cycled for a minimum of 100 full stroke cycles or as specified in the Procurement Specification. The cycling should be accomplished with the gas chamber precharged in accordance with the Procurement Specification requirement, and pressure increased at the fluid port up to the design operating pressure. Dynamic leakage shall be as specified in 3.5.3.2 and 3.5.3.4.