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INTERNATIONAL
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AEROSPACE RECOMMENDED PRACTICE

SAE ARP4378

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Accumulators, Hydraulic, Cylindrical, Aircraft, Maintenance Free, Factory Precharged

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1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) establishes the minimum requirements and procedures for the design, construction, testing and performance of aerospace, maintenance free, factory pre-charged hydraulic accumulators. The accumulators are designed for use in aircraft hydraulic systems at maximum rated operating pressures up to 8000 psi (55158 KPa). The temperature range of the accumulator is -65 to 275 °F (-54 to 135 °C).

1.1 Purpose:

The purpose of this ARP is to define the requirements for maintenance free hydraulic accumulators and provide a specification for use in the procurement of these devices. Additional or supplemental requirements may be included in the accumulator procurement specification or contract.

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 laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Documents: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

AS4059 Aerospace Cleanliness Classification for Hydraulic Fluids

ARP1383 Impulse Testing of Hydraulic Actuators, Valves, Pressure Containers and Similar Fluid System Components

2.1.2 National Aerospace Standards Association Inc. Publications: Available from the National Aerospace Standards Association, Inc., 1321 Fourteenth St., N.W., Washington, DC 20005.

NAS 1638 Cleanliness Requirements of Parts Used in Hydraulic Systems

2.1.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA, 19120.

MIL-C-5501 Caps and Plugs, Protective Dust and Moisture Seal
MIL-H-8775 Hydraulic System Components, Aircraft and Missiles, General Specification for
MIL-PRF-27401 Propellant Pressurizing Agent, Nitrogen
MIL-P-27407 Propellant Pressurizing Agent, Helium

MIL-STD-130 Identification Marking of U.S. Military Property
MIL-STD-810 Environmental Test Methods
MIL-STD-6866 Inspection, Penetrant Method of

AN806 Plug, Flared Tube

Code of Federal Regulation 49 (49CFR) Transportation

2.1.4 ASTM Specifications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103

ASTM E 1444 Magnetic Particle Examination

2.1.5 Federal Aviation Regulations: Available from U.S. Department of Transportation, Office of the Secretary, Distribution Service Branch, M-484.1, Washington, DC 20590

Federal Aviation Regulations (FAR) Part 25, Airworthiness Standards: Transport Category Airplanes

2.1.6 Joint Aviation Regulations: Available from Westward Digital Limited, 37 Windsor St., Cheltenham, Gloucestershire, GL52 2DG, England

Joint Aviation Regulations (JAR), JAR-25 Large Aeroplanes

2.2 Definitions:

The following terms used in this specification are defined as follows:

MAXIMUM RATED PRESSURE: The maximum cutout pressure at the main pressure controlling device of the hydraulic system.

PRE-CHARGE: The factory sealed gas charge within the accumulator with the separator bottomed at the fluid end. (usually specified as pressure at temperature)

SEPARATOR: A part of the accumulator that separates the gas and the hydraulic fluids.

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

3. TECHNICAL REQUIREMENTS:

3.1 General:

Unless otherwise specified, the requirements of Section 3 of MIL-H-8775 which are applicable to accumulators, shall be considered a part of this ARP.

The accumulator shall also be designed to meet the requirements of Federal Regulation 49CFR SECT 173.306, Para (f)(3). Accumulators manufactured for use on commercial aircraft shall meet the applicable requirements of Federal Aviation Regulations (FAR) Part 25 or Joint Aviation Regulations (JAR) JAR-25.

3.2 Pre-production Tests:

Accumulators furnished under this ARP shall be products which have been tested and passed the pre-production tests specified in Section 4. Qualification by similarity provisions of MIL-H-8775 apply for accumulator components or designs which have previously passed the pre-production testing specified in Section 4.

3.3 Design and Fabrication:

3.3.1 General: Accumulators shall be designed and constructed to contain gas and hydraulic fluid under pressure. The accumulator shall be designed with a fluid port only. The gas side of the accumulator shall be pre-charged and hermetically sealed prior to delivery. The accumulator shall require no maintenance for its service life.

3.3.2 Dimensions / Mounting Provisions: Dimensions and mounting provisions shall conform to the requirements of the procurement specification.

3.3.3 Fluid Port: The fluid port shall be designed to give a minimum restriction to fluid flow. If an obstruction to the fluid port is required, the flow area of the fluid passage shall be not less than 70% of the OD area of the tubing size for which the fluid port is specified by the procuring activity.

3.3.4 Pressure Read-Out: Each accumulator may have an optional maintenance free readout device (i.e. pressure gage or transducer), which senses the gas charge pressure. If used, the pressure readout device shall be considered part of the pressure vessel and therefore must meet the proof pressure, leak test, vibration, cycling, and burst pressure requirements specified herein.

3.3.5 Pre-charge Gas: The accumulator shall be pre-charged with nitrogen conforming to MIL-PRF-27401 and/or helium per MIL-P-27407. The pre-charge shall contain 5% minimum by pressure of helium for leak detection, using a helium mass spectrometer.

3.4 Performance:

The accumulator shall be designed to the following requirements

3.4.1 Pressures: Each accumulator shall be designed and constructed to meet or exceed the requirements for the maximum rated operating pressures as specified by the procurement specification or contract.

3.4.1.1 Vessel Proof Pressure: The accumulator pressure vessel shall be designed to withstand a proof pressure of two times the maximum rated operating pressure or three times the pre-charge pressure (49CFR Requirement), whichever is greater, applied at the maximum rated temperature of the accumulator for a period of 5 min minimum. This requirement is for the accumulator pressure vessel only and does not include the internal separator.

3.4.1.2 Accumulator Proof Pressure: The pre-charged accumulator shall be designed to withstand a hydraulic proof pressure of 1.5 times the maximum rated operating pressure or three times the pre-charge pressure (49CFR Requirement), whichever is greater. The accumulator shall be designed such that the separator shall not bottom on the gas end of the accumulator during accumulator proof pressure testing, through the entire temperature range, or as specified by the procurement specification or contract.

3.4.1.3 Vessel Burst Pressure: The accumulator pressure vessel burst pressure shall be the larger of:

a. Four times the maximum rated operating pressure or as specified by the customer.
b. Five times the pre-charge pressure (49CFR requirement).

This requirement is for the accumulator pressure vessel only and does not include the internal separator.

3.4.2 Separators: The separator (hydraulic fluid/gas) shall be designed to operate with a maximum pressure differential equal to the maximum pre-charge pressure, at the maximum rated temperature. These conditions exist in operation when a pre-charged accumulator exhausts all the expellable hydraulic fluid and the hydraulic port is open to atmospheric pressure.

3.4.2.1 Proof Pressure: The separator shall be designed to withstand a differential pressure of 1.5 times the maximum pre-charge pressure on the gas side.

3.4.2.2 Separator Friction: The hydraulic fluid pressure at which the separator begins to move shall not be greater than 25 psi (172 KPa) above the pre-charge pressure.

3.4.3 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 shelf life of ten years minimum after delivery.

3.4.4 Pre-charge Pressure: The procurement specification or contract shall specify the required pre-charge pressure and temperature for the accumulator. The pre-charge pressure shall not reduce more than 3% in ten years with any combination of storage or operation.

3.4.5 Internal Cleanliness: Internal cleanliness shall be equal to or better than the values as specified in Class 5 of NAS 1638 or AS4059 for particle size ranges above 5 micrometers.

3.4.6 Leakage:

3.4.6.1 Gas Leakage: A new pre-charged accumulator shall have a total gas leakage, internal and external, of not greater than 1 X 10^{-7} standard cubic centimeters of helium per second at atmospheric pressure.

3.4.6.2 Fluid Leakage: There shall be no evidence of external fluid leakage.

3.4.7 Endurance Cycling: The accumulator shall be designed to withstand pressure cycling as specified in Table 1, Steps 1 through 5.

3.4.8 Pressure Impulse Cycling: The accumulator shall be designed to withstand pressure impulse cycling as specified in Table 1, Step 6 and the applicable procedure of ARP1383 as modified herein.

3.4.9 Fragmentation: If required by the procurement specification or contract, the accumulator, when struck by gunfire as specified in 4.7.10, shall remain in one piece and the greatest dimension of the opening (cut or tear) created by the projectile shall not exceed the dimensions of the hole (cut) created by the projectile by more than 3 in (76 mm) in any one direction.

3.4.10 Maximum Oil Volume: The maximum oil volume that can be introduced into the accumulator upon the occurrence of a separator rupture is equivalent to the pre-charge gas volume.

3.4.11 Maximum Swept Oil Volume: The maximum swept oil volume occurs either at proof pressure or at the system relief pressure at cold temperature. To determine the maximum swept 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 swept oil volume. Real gas laws, including compressibility, should be used to calculate these volumes.

3.5 Marking:

3.5.1 Warning Label: Each accumulator shall be permanently marked with a legible warning in red letters stating:

PRESSURIZED VESSEL, DO NOT PUNCTURE OR INCINERATE

This container meets the requirements of 49CFR, Sect. 173.306, Para.(f)(3).

TABLE 1 - Endurance and Impulse Cycling

Step Number	Number of Cycles	Fluid Temp. [°F (°C)]	Hyd. Fluid Pressure Lower Limit Max	Hyd. Fluid Pressure Upper Limit Min	Cycle Rate [CPM]
1	50	-65 max (-54 max)[1]	7% of Max Rated Operating Press	Max Rated Operating Press	[2]
2	500	-65 max (-54 max)[1]	7% of Max Rated Operating Press	Max Rated Operating Press	0.2 to 2.0
3	12000	275 min (135 min)[3]	7% of Max Rated Operating Press	Max Rated Operating Press	3.0 to 10.0
4	50000	275 min (135 min)[3]	87% of Max Rated Operating Press	Max Rated Operating Press	3.0 to 20.0
5	12000	50-90 (10-32)	7% of Max Rated Operating Press	Max Rated Operating Press	3.0 to 20.0
6(a)[4]	12500	50-90 (10-32)	10 psi	117% of Max Rated Operating Press	10.0 to 50.0
6(b)[4]	500000	275 min (135 min)[3]	7% of Max Rated Operating Press	Max Rated Operating Press	10.0 to 50.0
6(c)[4]	1000000	50-90 (10-32)	67% of Max Rated Operating Press	Max Rated Operating Press	10.0 to 50.0

NOTES:

[1] The customer specified minimum operating temperature should be the maximum test temperature used if the customer specifies a minimum operating temperature lower than -65 °F (-54 °C).

[2] The accumulator shall be pressurized to a minimum of the maximum rated operating pressure. Accumulators shall be maintained in this condition for 24 h at the temperature specified in Step 1 of Table 1. The 50 cycles shall be fast discharge (equivalent to that resulting from a quick opening of a directional control valve of comparable port size) followed immediately by normal recharge rate with oil at the specified temperature. A 2 h minimum interval, during which time the accumulator is maintained at the specified temperature shall elapse between each of the 50 cycles. The 50 cycles shall be conducted consecutively.

[3] The customer specified maximum operating temperature should be the minimum test temperature used if the customer specifies a maximum operating temperature higher than 275 °F (135 °C).

[4] This test shall be performed per ARP1383 Procedure I except as modified herein. Testing shall be conducted in a test rig with a pressure transducer or similar pressure measuring device located in the first 12 in (305 mm) of plumbing leaving the accumulator. The pressure pickup device shall be connected to a suitable instrument in order that the rate of pressure buildup and peak pressures obtained can be accurately recorded. With a calibrated pressure gauge showing the proper operating reading as specified in Table 1, and the test accumulator removed from the circuit and replaced with a standard AN806 plug, the regulator valve, flow rate, etc. shall be so adjusted that the instrument will show a pressure buildup rate of 125,000 to 200,000 psi (861,843 KPa to 1,378,949 KPa) per second. With the test machine maintained in this setting, the test accumulator fluid port shall be installed in place of the standard AN806 plug (additional piping shall not be used). The gas side of the accumulator shall be filled with fluid and sealed during this test. The rate of pressure buildup and the peak pressures as determined by the instrument with the accumulator installed, shall be recorded at the start and finish of the cycling test and at least 10 approximately equally spaced intervals during the test. This test is intended to prove the design of the accumulator pressure vessel and pressure vessel construction during preproduction tests and may be performed without the separator installed.

3.5.2 Nameplate: Each accumulator shall be furnished with a nameplate marked in accordance with MIL-STD-130 and shall include the following information as a minimum:

Hydraulic Accumulator
Manufacturer's Name
Manufacture Date
Manufacturer's Part Number
Manufacturer's Serial Number
Maximum Operating Pressure
Proof Pressure
Pre-charge Pressure at Room Temperature
Pre-charge Gas Volume
Approved Hydraulic Fluids

3.6 Corrosion Protection:

3.6.1 Internal Surfaces: All internal surfaces exposed to the pre-charge gas shall be coated with a film of oil which is compatible with the pre-charge gas.

All internal surfaces exposed to hydraulic fluid shall be coated with the hydraulic fluid intended for use in the accumulator. The internal surfaces of the accumulator need not comply with the corrosion protection requirements as specified in 3.2.1 of MIL-H-8775.

3.6.2 External Surfaces: The external surfaces of the accumulator shall comply with the corrosion protection requirements as specified in 3.2.1 of MIL-H-8775 or be painted with a suitable primer and top coat which meets the humidity, fungus, sand and dust, and salt fog requirements as specified in MIL-H-8775. The fluid boss spotface and threads, the face of the optional pressure indicator, and optional electrical connector shall be free of primer and paint.

3.7 Environmental:

3.7.1 Vibration: The pre-charge pressure of the accumulator shall be within the acceptable tolerance range of 3.4.4 and shall meet gas leakage requirement of 3.4.6.1 after being exposed to vibration in accordance with MIL-STD-810C, Method 514.2, Procedure I, Curve L, or as specified in the procurement specification or contract.

3.7.2 Ambient Temperature: The accumulator shall be designed for an ambient temperature at operational conditions of -65 to 275 °F (-54 to 135 °C) or as specified in the procurement specification or contract.

3.7.3 Hydraulic Fluid: The accumulator shall be compatible with the system hydraulic fluid at all operating conditions.

3.8 Physical Defect Inspection:

All detail parts shall be subjected to Non-Destructive Testing prior to assembly. All magnetic highly stressed parts shall be subjected to magnetic particle inspection in accordance with ASTM E 1444. Nonmagnetic highly stressed parts shall be subjected to liquid penetrant inspection in accordance with MIL-STD-6866. Cracks or other injurious defects disclosed by the inspection shall be cause for rejection.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

Unless otherwise specified in the procurement specification or contract, the supplier is responsible for performance of all inspection requirements as specified herein. The supplier may utilize his own facilities or any commercial laboratory acceptable to the customer. The purchaser maintains the right to perform any of the inspections set forth in this specification whenever it is deemed necessary to assure that the item conforms to prescribed requirements.

4.2 Classification of Tests:

The inspection and testing of accumulators shall be classified as:

a. Pre-production Tests (4.4) (for design qualification)
b. Acceptance Tests (4.5)

4.3 General Test Requirements:

Unless otherwise specified, the quality assurance provisions of MIL-H-8775 form a part of this ARP.

4.3.1 Test Medium: The test medium shall be the system hydraulic fluid or a similar fluid that is compatible with all components of the accumulator.

4.4 Pre-production Tests:

Two pre-production samples shall be subjected to the testing, (including the test sequence) as specified in Table 2. The units subjected to pre-production testing shall not be used as production hardware.

TABLE 2 - Preproduction Testing

Test	Requirement Paragraph	Test Method Paragraph	Unit A	Unit B
Vessel Proof Pressure	3.4.1.1	4.7.2.2	X	X
Acceptance Test	N/A	4.5	X	X
Gas Volume Verification	N/A	4.7.11	X	X
Separator Friction	3.4.2.2	4.7.1	X	X
Fluid Immersion (as required)	3.7.3	4.7.12	X	X
Helium Leak Test	3.4.6.1	4.7.4	X	X
Vibration	3.7.1	4.7.3	X	
Helium Leak Test	3.4.6.1	4.7.4	X	
Precharge Verification	3.4.4	4.7.5	X	
Endurance and Impulse Cycling	3.4.7, 3.4.8	4.7.6, 4.7.7	X Table 1 (Steps 1-5)	X Table 1 (Step 6)
Helium Leak Test	3.4.6.1	4.7.4	X	X
Precharge Verification	3.4.4	4.7.5	X	
Burst Pressure	3.4.1.3	4.7.9	X	
Fragmentation (as required)	3.4.9	4.7.10		X

4.5 Acceptance Tests (Production):

Each pre-charged and permanently sealed accumulator which is submitted for acceptance shall be subjected to the following tests in the order listed:

a. Non-destructive Testing (4.7.8)
b. Proof Pressure (4.7.2)
c. Pre-charge Verification (4.7.5)
d. Helium Leak Test (4.7.4)
e. Examination of product (4.6.1)

4.6 Examinations:

4.6.1 Examination of Product: Examination of product shall be in accordance with MIL-H-8775.

4.6.2 Packaging, Packing, and Marking: Preparation for delivery shall be examined for conformance to Section 5.

4.7 Test Methods:

4.7.1 Separator Friction: Starting with the hydraulic pressure at zero psi, increase the pressure until the separator begins to move. The pressure at which the separator begins to move shall not be greater than 25 psi (172KPa) above the pre-charge pressure. This test shall be performed at three temperatures -65 °F (-54 °C), ambient room temperature, and 275 °F (135 °C).