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## Accumulators, Ground, Hydropneumatic Pressure

RATIONALE

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1. SCOPE:

1.1 This specification covers ground type hydropneumatic pressure accumulators for use in ground support hydraulic systems at rated pressures ranging up to 5,000 psi including details pertinent to the design, fabrication, and performance of the accumulators.

1.2 Classification:

Hydropneumatic accumulators shall be of the following types and classes, as specified:

| | |
|---|---|
| Type I | - With diaphragm or bag-type separators |
| Type II | - With piston-type separators |
| Class 3000 | - Maximum rated pressure |
| Class 5000 | - Maximum rated pressure |

2. APPLICABLE DOCUMENTS:

2.1 The following specifications, standards, drawings, and publications, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Military

| | |
|---|---|
| MIL-E-4970 | Environmental Testing, Ground Support Equipment; General Specification for |
| MIL-P-5514 | Packings; Installation and Gland Design; General Specification for |
| MIL-H-5606 | Oil; Hydraulic, Aircraft, Petroleum Base |
| MIL-H-8775 | Examination of Product. |

2.1 (Continued):

STANDARDS

Federal

Federal Test Method Rubber; Sampling and Testing Standard No. 601

Military

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

DRAWINGS

Air Force-Navy Aeronautical Standard Drawings

AN 806 Plug - Flared Tube
AN 818 Nut - Coupling

PUBLICATIONS

Air Force-Navy Aeronautical Bulletin

No. 438 Age Controls for Synthetic Rubber Parts

3. REQUIREMENTS:

3.1 Qualification:

The accumulators furnished under this Specification shall be a product of which a representative specimen has been tested and has passed the Qualification tests specified herein.

3.2 Type II Accumulators (Barrel and Piston Surfaces):

The materials and surface finishes of the barrel and piston shall form a combination resistant to galling or seizing. The accumulator assembly shall suitably resist corrosion when subjected to a 100 hour salt spray test in accordance with Specification MIL-E-4970.

3.3 Operating Media:

The accumulator shall be designed to be compatible with hydraulic oil, MIL-H-5606, and inert gas.

3.4 Temperature:

The accumulator shall be designed for the operating temperature range of -40°F to +160°F. It shall be designed to meet the requirements as stipulated in Tables I and II.

3.5 Design and Construction:

3.5.1 General: Accumulators shall be designed and constructed to contain gas and hydraulic oil under pressure. The unit shall be designed to have a minimum burst pressure four times the maximum operating pressure. The accumulator shall be provided with an oil port and a gas port. The accumulators shall be designed such that they cannot be disassembled with a gas precharge.

3.5.2 Oil and Gas Ports: The oil port shall be designed to give a minimum of pressure drop owing to the restriction to oil flow. In Type II accumulators, means shall be provided to prevent a check valve effect of the piston against the oil end-cap.

3.5.3 Separators:

3.5.3.1 Type I Accumulators with Diaphragm or Bag-Type Separators:

3.5.3.1.1 Separators in Type I accumulators shall be designed to have a minimum of strength during operation. Sealing lips of diaphragm or bag-type separators shall be held in place and effect the required sealing by wedging, compressing or molding of the member in the sealing gland.

3.5.3.1.2 If nonextrusion buttons are used on the separator, they shall be large enough to function as intended and shall be permanently attached to the separator by riveting or other nondetachable methods.

3.5.3.2 Piston-type Separators: Piston-type separators in cylindrical accumulators shall contain packings consistent with the performance requirements of Tables I and II.

3.5.4 Gaskets (Type I and Type II Accumulators): All gaskets used for static sealing and their installation shall conform to the applicable requirements of Specification MIL-P-5514.

3.6 Performance:

3.6.1 The accumulators shall satisfy the performance tests specified in Section 4 under paragraphs headed as follows and conducted in the order listed below:

| | | |
|---|---|---|
| A) | Physical Properties of Separator Material | (4.3.1) |
| B) | Separator Under Pressure | (4.3.2) |
| C) | Volumetric Efficiency | (4.3.3) |
| D) | Proof Pressure | (4.3.4) |
| E) | Cycling and Endurance | (4.3.5) |
| F) | Leakage | (4.3.6) |
| G) | Seizing of Parts | (4.3.7) |
| H) | Burst Pressure | (4.3.8) |

3.6.2 The separators and separator material for Type I accumulators shall satisfy the performance tests specified in Section 4 under paragraphs headed as follows:

| | | |
|---|---|---|
| A) | Swelling | (4.3.1.1) |
| B) | Resistance to Aging | (4.3.1.2) |
| C) | Bending | (4.3.1.3) |
| D) | Uniformity of Physical Properties | (4.3.1.4) |
| E) | Blemishes | (4.3.1.5) |

3.7 Markings:

3.7.1 Each accumulator shall be provided with a permanently legible attached warning:

"RELEASE OIL PRESSURE BEFORE DISCONNECTING PRESSURE LINE. RELEASE GAS AND OIL PRESSURE BEFORE DISASSEMBLING, STORING, OR SHIPPING ACCUMULATOR"

3.8 Identification of Product:

3.8.1 Nameplate: Each accumulator shall be equipped with a nameplate which shall be marked in accordance with Standard, MIL-STD-130, and include at least the following information:

Manufacturer's Name
Manufacturer's Part No.
Manufacturer's Serial No.

3.8.1.1 A detachable tag shall be provided for Type I accumulators indicating the manufacturing date and compound code letter of the separator.

3.8.1.2 Age Life of Elastomer Materials: Accumulators containing "O" rings shall be marked in accordance with ANA Bulletin No. 438.

3.8.2 All diaphragm or bag-type separators shall be permanently and legibly marked with the manufacturer's separator part number and compound code number. The cure date of the bladder shall be permanently and legibly marked using the quarter system of identification. One dot shall be used for each quarter of the year starting from a referenced date specified on the drawing of the separator and on the installation drawing of complete accumulator.

3.9 Age Control:

Diaphragm or bag-type separators furnished separately, or in accumulator assemblies, shall be delivered to any Government activity or to any contractor for use on military equipment within 12 months of their cure date. Bladders which have been in storage in completed accumulators for more than three years shall be considered obsolete and unfit for use.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Qualification Tests:

4.1.1 Theoretical pressure-volume charts, based on pressurizing the accumulator under isothermal conditions at various temperatures between -40°F and 160°F shall be provided. The chart shall be based on gas precharge pressures ranging between 300 and 2,000 psi for class 3000 and between 300 and 4,000 psi for Class 5000.

4.1.2 Sampling Instructions: Type I accumulator qualification test samples shall consist of two accumulators of the type, class, and size on which qualification is desired and of the following:

a) Two of the diaphragm and bag-type separators of the same compound, size, having the same markings, etc. as the separator o be used in production accumulators. Proper notations shall accompany the separators, giving the name of manufacturer, compound number, and base material with its basic specific gravity and Shore Durometer hardness.

b) Six molded disks ¼ inch thick and 1 inch in diameter of the same compound and equivalent cure as the material used. If more than one compound is going to be used in the construction of separators, these samples shall be submitted for each compound.

4.2 Acceptance Rules:

The acceptance tests shall consist of individual tests and Sampling tests.

4.2.1 Individual Tests: Each accumulator submitted for acceptance under contract shall be subjected to the following tests, as described under "Test Methods":

a) Examination of Product (Spec. MIL-H-8775)
b) Blemishes (4.3.1.5)
c) Proof Pressure (4.3.4)
d) Oil Leakage (4.3.6.3)

4.2.2 Sampling Tests:

4.2.2.1 Accumulators: Accumulators, up to 2 percent of the order, or at least one accumulator, which has passed the Individual tests specified in 4.2.1, may be selected by the Inspector for further tests to determine conformance with any of the requirements of this specification as may be considered necessary.

4.2.2.2 Separator Material: On Type I accumulators, a sufficient number of test disks, ¼ inch thick by 1 inch in diameter, compression molded of the same compound to an equivalent cure to that used in making the separator, to determine hardness and specific gravity of the diaphragm material shall be made from each batch or mix of material. In addition, a sufficient number of such test disks and dumbbell specimens, in accordance with requirements of Federal Test Method Standard No. 601, cut from production separators, shall be taken for physical tests from each

4.2.2.2 (Continued):

production batch. These samples shall be prepared under the supervision of the Government Inspector and shall be subjected to the following Physical Properties of Separator Material (Type I accumulator) tests specified in 4.3.1, as described under "Test Methods":

a) Swelling (4.3.1.1)
b) Resistance to Aging (4.3.1.2)
c) Bending (4.3.1.3)
d) Uniformity of Physical Properties (4.3.1.4)

4.3 Test Methods:

4.3.1 Physical Properties of Separator Material (Type I Accumulator): The following tests of physical properties of Type I accumulator separators shall be made:

4.3.1.1 Swelling: Swelling of separator material shall be determined in accordance with the method described in Federal Test Method Standard No. 601, except that the specimens shall be 1 by 2 inch blocks obtained from the actual separator, and the period of immersion shall be seven days. The medium shall be hydraulic oil conforming to Specification MIL-H-5605, maintained at a temperature of 158° + 2°F. A closed type vessel or reflux condenser shall be used to hold the oil and samples. Oil which has been exposed in open vessels to temperatures of 160°F or higher, shall not be used for volumetric aging determinations. The material shall withstand this immersion without increasing the volume by more than 15 percent. The maximum negative volume change (shrinkage) shall not exceed 1 percent.

4.3.1.2 Resistance to Aging: The tensile strength, elongation, and hardness of the material shall be determined in accordance with Federal Test Method Standard No. 601. Hardness tests shall be made on the ¼ inch thick by 1 inch diameter disks. All other tests shall be performed on the dumbbell sections cut from actual separators. The test report shall specify from which part of the separator the dumbbell sections were cut. The samples of the material shall then be subjected to accelerated aging Geer oven method in accordance with Federal Test Method Standard No. 601, for a period of seven days. The tensile strength, elongation, and hardness shall be determined on the aged specimens, and the percentage of variation between the aged an unaged values reported. This test shall then be repeated with other samples, except that the aging shall be in oil conforming to Specification MIL-H-5606, in a closed vessel, at 158°F + 20°F for seven days. The material shall not have decreased in tensile strength by more than 20 percent, or in hardness by more than six points Shore Durometer after either of these aging tests.

4.3.1.3 Bending: A strip from the separator and a metal rod 1/8 inch in diameter shall be placed in a controlled temperature refrigerator. The temperature of air surrounding the test sample and rod shall be maintained at no warmer than -40°F for 72 hours. At the end of this time, the specimen of separator material shall be bent a full 180 degrees around the rod. The rate of bending shall be approximately 180 degrees in 5 seconds. No cracking or shattering of the compound shall be evident. The test material and rod shall not be exposed to room temperature during this bending test, nor shall the test strip be touched by the operator's hands within two inches of the area of bending.

4.3.1.4 Uniformity of Physical Properties: Specific gravity and Shore Durometer hardness of each batch of material shall be determined as specified in Federal Test Method Standard No. 601 on the 1 inch diameter by ¼ inch thick disks. These shall conform to values established during qualification tests within ±0.020 point on specific gravity and ±3 points Shore Durometer hardness.

4.3.1.5 Blemishes: Each diaphragm or bag shall be inserted in an inspection test fixture which duplicates the sealing gland design of the accumulator in which it is to be used, and gas pressure applied in such manner as to inflate the diaphragm or bag and stretch the entire surface to approximately 10 to 25 percent elongation. Wherever possible, the diaphragm or bag shall then be reversed in the fixture to insure that both surfaces can be inspected while in a stretched position. A soap, or similar solution which is compatible with the rubber material, shall be applied to the entire surface of the diaphragm or bag while in the stretched state to determine gas leakage. As an alternate, the entire fixture and diaphragm or bag may be immersed in water to determine leakage. The length of time for leakage test shall be not less than 5 minutes. There shall be no evidence of gas leakage. The diaphragm or bag-type separators shall be homogenous and free from foreign particles, blowholes, airpockets, etc. Sealing lips and surfaces shall be smooth and free from all nicks, blemishes, or other imperfections which may cause leakage of gas or hydraulic oil. Raised blemishes caused by small nicks in the mold shall not be cause for rejection when found on other than the sealing lips or surfaces.

4.3.2 Separator Under Pressure: The separator of Type II accumulators, employing a double wall construction, may be tested in a special test-jig to preclude damage to the inner shell caused by the application of unequal forces during these tests.

4.3.2.1 Under Fluid Pressure: Type I accumulators shall be assembled with the gas valve body in place in the gas port. A precharge pressure of 650 psi shall be applied to the gas side for class 3000 and 1,100 psi for class 5000. Oil pressure shall be increased to 4,500 psi for class 3000 and 7,500 psi for class 5000, and held for a period of 10 minutes. The temperature of the assemblies during this test shall be 70°F minimum. Extrusion of the diaphragm or bag through the bore of the gas valve body to such an extent that cutting of the diaphragm or bag may occur, or rupture of the diaphragm or bag, or the failure of the piston separator, shall be cause for rejection.

4.3.2.1.1 Type II accumulator separators shall withstand 4,500 psi with a tolerance of 100 psi for class 3000, and 7,500 psi ± 150 for class 5000, applied at the oil port with the gas port open, for 2 minutes without leakage or damage.

4.3.2.2 Under Gas Pressure (Type I Accumulators): With all tube fittings removed from the oil port, a gas precharge of 2,800 ± 100 psi for class 3000 and 4,650 ± 100 psi for class 5000, shall be applied at the gas port for a period of at least 10 minutes. The temperature of the assemblies during this test shall be 70°F minimum. Extrusion of the diaphragm or bag through the oil port, to such an extent that cutting of the diaphragm or bag may occur, or rupture of the diaphragm or bag, shall be cause for rejection.

4.3.2.2.1 Type II accumulator separators shall withstand 2,800 ± 100 psi for class 3000 and 4,650 ± 100 psi for class 5000 hydrostatic pressure at the gas port with the oil port open, for 2 minutes without leakage or damage.

4.3.3 Volumetric Efficiency: The volumetric efficiency of Type I accumulators only shall be determined in the following manner: Apply a gas precharge of 1,200 psi, increase the oil pressure from 0 to 3,000 psi by a means of a hand pump. The volume of oil pumped into the accumulator shall be accurately measured and recorded. The oil pressure shall then be allowed to return to zero psi at both fast and slow discharge rates, and the volume of oil exhausted accurately measured in each case. The fast rate of discharge shall be equal to at least 75 percent of that resulting from quickly opening a directional control valve of a size equivalent to the oil port size of the accumulator under test. Slow discharge shall be equivalent to a small stream flow which results from cracking a shutoff valve in the line. In all cases, flow shall be considered to have stopped, and measurements shall be taken as soon as the continuous discharge stream has slowed to drops only. This procedure shall be repeated twice with the accumulators in each of two positions, namely oil port on bottom, and on side, or horizontal. The volumetric efficiency shall be determined by the following formula:

$$\text{Volumetric Efficiency Percent} = 100 \times \frac{\text{Volume exhausted oil}}{\text{Volume admitted oil}}$$

The volumetric efficiency for Type I accumulators in any position in any test shall not be less than 88 percent. Type II accumulators shall trap no more than 5 percent of their total swept volume in dead spaces such as recessed piston heads or domed cylinder barrel and caps when filled with oil. With a gas pressure of 500 psi and with the separator bottomed at the oil end of the Type II accumulator, the pressure shall be slowly built up until the separator starts to move; the oil pressure to move the separator shall not exceed 700 psi. Separator movement may be determined by a sudden increase in gas pressure. The oil pressure shall be increased to 3,000 psi, and the separator shall not bottom at the gas end of the Type II accumulator.

4.3.4 Proof Pressure: Each accumulator with all oil exhausted shall be charged with gas such as nitrogen to approximately 1,000 psi with a tolerance of ±50 psi for class 3000 and 1,650 psi with a tolerance of ±100 psi for class 5000 in lieu of the gas charge, hydraulic oil may be used to fill the gas chamber. Oil pressure shall then be applied at the oil port until a pressure 6,000 psi for class 3000 and 10,000 psi for class 5000 is obtained and maintained for a period of 5 minutes. There shall be no evidence of leakage to the extent of forming a drop or bubble on either the gas or oil end, or sign of permanent distortion on any part of the accumulator. (In double-wall Type II accumulators, proof pressure for the separator tests shall be applied as not to subject the inner shell to unequal forces which could result in damage.)

4.3.5 Cycling and Endurance: With all oil exhausted, the accumulator shall be precharged with gas pressure as specified in the six steps of Table I or Table II and oil shall then be cycled to the accumulator in accordance with the corresponding pressures and temperatures specified in Table I or Table II. The oil and the gas in the accumulator shall attain the specified temperature before tests are started. Tests shall be conducted in the order indicated. In Type I accumulators, there shall be no leakage, cracking, flaking, swelling, or excessive deterioration of the separator, bonding of the separator to the metal, or corrosion of the metal in contact with the separator, particularly at the sealing lips. In Type II accumulators, the oil and gas leakage shall be recorded and shall not exceed that specified in Table I or Table II. Gas leakage during these tests shall not be determined unless there is evidence that it may exceed these rates. Gas leakage for step 2 of Table I or Table II, however, shall be determined as specified in the Gas Charge Leakage Test

4.3.5 (Continued):

(4.3.5.1). There shall be no rupture, external leakage, or evidence of excessive wear or malfunctioning of the accumulator during this test. Only one set of packing gland seals shall be used throughout this series of tests. All the actual test conditions shall be recorded.

4.3.5.1 Gas Charge Leakage Test for Type I Accumulators: Immediately after completion of tests specified in step I of Table I or Table II, the oil port of Type I accumulators shall be opened to the atmosphere. The accumulator shall be placed in a cold box, and the temperature shall be reduced to -40°F. Gas pressure shall be so replenished as to provide 1,000 psi gas pressure when the temperature is stabilized at -40°F. The accumulator shall be placed in a fixture as shown in Figure 3 for a period of 24 hours. There shall be no external leakage. Leakage of gas through the oil port shall not exceed the rate of:

5 milliliters of free gas per hour

4.3.6 Leakage: After completion of step 6 of Table I or Table II, for the Cycling and Endurance Test specified in 4.3.5, the following leakage tests as specified in 4.3.6.1, 4.3.6.2, and 4.3.6.3, shall be performed before disassembly of the accumulator. After completion of the leakage test, the accumulator separator shall be removed and inspected.

4.3.6.1 Gas Charge Leakage Test for Type II Accumulators: These accumulators shall be tested in a manner similar to Type I accumulators (Para. 4.3.5.1) except that internal leakage shall not be greater than:

3 milliliters per hour of free gas per inch of bore diameter

4.3.6.2 Oil Leakage Test (Type II only): With the gas port open to the atmosphere, oil pressure of 5 psi and 3,000 psi shall be applied to the oil port for periods of 1 hour each. There shall be no evidence of external leakage to the extent of forming a drop, and internal leakage shall not exceed two drops total.

4.3.6.3 Oil Leakage Test for Individual Tests, Type II only: This test shall be conducted in a manner similar to that described under the Oil Leakage Test specified in 4.3.6.2 except that pressure shall be applied for a period of 3 minutes only.

4.3.7 Seizing of Parts:

4.3.7.1 All accumulators having sliding parts, particularly Type II accumulators, shall be tested for seizing of parts throughout the temperature range of 160°F to -40°F. The accumulator for this test shall be selected (or machined) to insure that the clearance between sliding parts shall be within 10 percent of the minimum clearance permitted by the tolerances on the detail drawings. Operation of the unit during this test can be accomplished, as for instance in the Type II piston accumulator, by removing the seals from the pistonhead to reduce friction and then manually sliding the piston through its entire stroke by use of suitable push rods through the oil and gas ports. If oil is used to accomplish the cycling, the entire amount of oil used shall have reached the proper stabilized temperature. The method used shall be detailed in the test report.

4.3.7.1 (Continued):

The assembly shall be maintained at a temperature not less than 160°F for at least 6 hours, after which 2 cycles of operation shall be made. The assembly shall then be rapidly cooled to a temperature not warmer than -40°F and maintained at this temperature for at least 24 hours. The sliding parts shall be operated throughout the cooling period and at least two complete cycles after the 24 hour period. The assembly shall then be rapidly warmed up to room temperature and operated during this period. There shall be no evidence of malfunctioning or seizing of sliding parts caused by thermal contraction or expansion of the parts. (Sufficient full cycles of operation shall be made during cooling and warmup periods to insure that no momentary periods of binding occur caused by differential thermal expansion or contraction of parts, particularly when dissimilar materials of construction are used. The test equipment used, i.e., rate of warming or cooling, etc., size and design of test unit, etc. will affect the total number and frequency of operation cycles required during this phase of the test and will be left to the discretion of the contractor.)

4.3.7.2 This endurance test (4.3.5) shall be conducted in a test rig similar to that indicated in Figure 2. A strain gage or similar pressure pickup shall be located as indicated in Figure 2. This pressure pickup device shall be connected to a suitably responsive instrument in order that the rate of pressure buildup and peak pressures obtained can be accurately recorded. With a calibrated pressure gage showing the proper operating range as specified in Table I or Table II, and the test accumulator removed from the circuit and replaced with an AN 806 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 per second. With the test machine maintained in this setting, the test accumulator oil port shall be installed in place of the AN 806 plug (additional piping shall not be used). The diaphragm bag or piston may be removed for this endurance test and the resulting opening may be sealed by means of a suitable fixture.

For Type II accumulators incorporating a double cylinder wall design, however, the gas side of the accumulator shall be filled with oil, and the gas port shall be capped during this test. The rate of pressure buildup and the peak pressure as determined by the instrument with the accumulator installed, shall be recorded at the start and finish of the 1,000,000 cycle endurance test and at least at ten equally spaced intervals during the test. This test is to prove the design of the accumulator shell construction (Type I or Type II) during qualification tests. Subsequent changes in separator design of Type I accumulators, except for major sealing lip changes, do not require rerunning this test.

4.3.7.3 Oil charge the accumulator to 3,000 psi as shown in Table I or to 5,000 psi as shown in Table II. Type I accumulators shall be maintained in this condition for 72 hours and Type II accumulators for 24 hours, at the temperatures specified in step 3 of Table I or Table II. The ten 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-hour minimum interval, during which the accumulator is maintained at the specified temperature, shall elapse between each of the ten cycles. The ten cycles shall be conducted consecutively.

4.3.8 Burst Pressure: The gas chamber may be filled with oil during this test and separator may be removed, and pressure applied at the oil port at a maximum rate of 25,000 psi per minute until a pressure of 12,000 psi for class 3000 and 20,000 psi for class 5000 is obtained. For safety purposes solid material may be placed within the accumulator to displace oil volume. The pressures may be increased above that specified during qualification tests in order to secure data on actual burst pressure. The accumulator shall not rupture at the specified pressures.

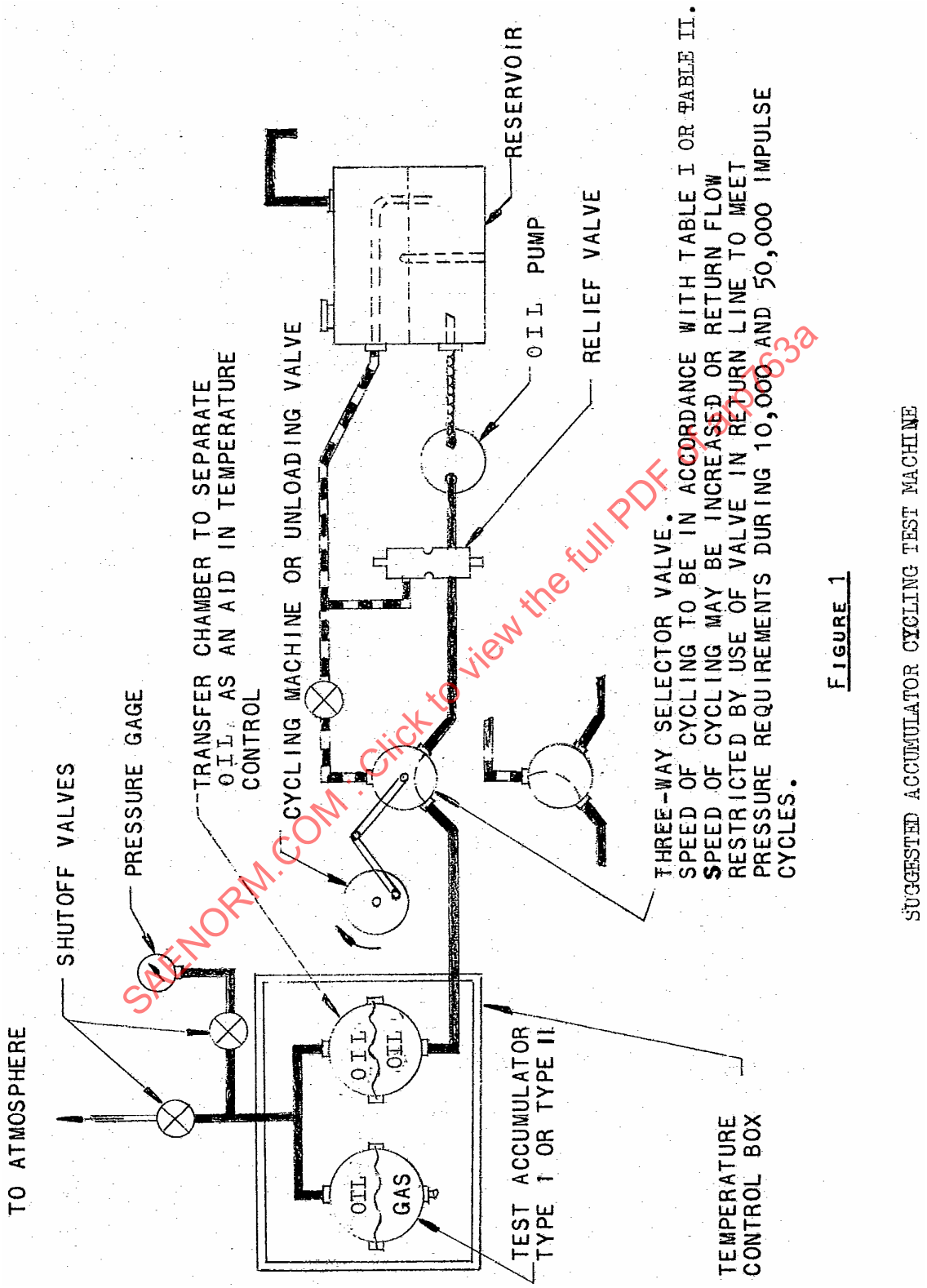


FIGURE 1

SUGGESTED ACCUMULATOR CYCLING TEST MACHINE