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DETAIL REQUIREMENTS FOR 4000 AND 5000 PSI AIRCRAFT HYDRAULIC SYSTEMS

CANCELLED

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Documents

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1. SCOPE AND CLASSIFICATION

- 1.1 Scope: The purpose of this document is to outline and publish the criteria applicable to design and installation for types I and II, classes 4000 and 5000 psi aircraft hydraulic systems.
- 1.2 Classification: Aircraft hydraulic systems are identified by the following types and classes:

Types

Type I - 65 to +160 F temperature range

Type II - 65 to +275 F temperature range

(NOTE: Type III - 65 to +450 F temperature range is covered by MIL-H-8891.)

Classes

Class 4000 psi - Where the cut-out pressure of the main pressure controlling device is 4000 psi.

Class 5000 psi - Where the cut-out pressure of the main pressure controlling device is 5000 psi.

(Note: Classes 1500 and 3000 are covered by MIL-H-5440.)

2. APPLICABLE DOCUMENTS

The documents listed in section 2 of MIL-H-5440 are applicable as written except as specifically amended by this ARP.

3. REQUIREMENTS

- 3.1 General Performance: Each hydraulic system and its components shall be designed to operate satisfactorily under all conditions that the aircraft may encounter within the structural limitations of the aircraft, including forces or conditions caused by acceleration, deceleration, zero gravity (g), negative g, any flight attitudes obtainable with the aircraft, structural deflection, vibration or other environmental conditions. (For Navy aircraft, see Navy Department publications SD-24, Volumes I and II).
- 3.2 Materials: Materials used in the manufacture of hydraulic systems shall be of high quality, suitable for the purpose, and shall conform to applicable customer specifications. Materials conforming to contractor's specifications may be used, provided it can be clearly demonstrated that they are at least equivalent to customer specifications with respect to operating characteristics, and that a saving in weight or cost can be accomplished thereby. Contractor's specifications must be satisfactory to the customer and contain provisions for adequate tests. The use of contractor's specifications will not constitute waiver of customer inspection.
- 3.3 Fluid: For Type I and Type II systems, only fluid conforming to MIL-H-5606 shall be used in the hydraulic system or in test stands used for ground testing of the hydraulic system.
- 3.4 Seals: Standard sealing elements for use at 4000 and 5000 psi have not been established. Specifications MIL-P-5514, MIL-P-5516, MIL-G-5510, and MIL-P-25732 and MIL-R-8791 are recommended as guides, but complete qualification tests for use at 4000 and 5000 psi will be required.
- 3.5 General System Design: Hydraulic systems shall be as simple and foolproof as possible and in conformance with design, operation, inspection, reliability and maintainability objectives projected for the aircraft.
 - 3.5.1 System Temperature Limitations: The nominal operating fluid temperature shall not exceed the value specified below. For hotspots where temperatures in excess of the nominal operating temperature are anticipated, adequate cooling shall be provided to maintain fluid temperatures below the values at which detrimental thermal breakdown of the fluid occurs. The temperature at which maximum performance occurs shall be determined by the contractor, and submitted to the customer for approval. These data shall be included in the hydraulic system design report.

- 3.5.1.1 Type I Systems: The fluid temperature shall not exceed +160 F.
- 3.5.1.2 Type II Systems: The fluid temperature shall not exceed +275 F.
- 3.5.2 Outside Air Temperature and Altitude Operation Ranges: The hydraulic system shall start and operate satisfactorily within the design envelope of the aircraft. Hydraulic systems that are started on the ground and operate continuously during flight are not required to start at temperatures below -65 F. If bypass flow is necessary for -65 F starting, it is desirable that this flow be returned to the reservoir.
- 3.5.3 Fire Hazards: The hydraulic system shall be integrated with other systems in a manner that will minimize fire hazards caused by proximity of combustible gases, heat sources, electrical equipment, etc. If feasible, all hydraulic equipment shall be isolated from the engines and other hot areas by the use of shrouds, firewalls, or equivalent means. Sources of hydraulic fluid leakage from removable joints in lines and equipment located in the vicinity of material or conditions that will permit spontaneous ignition of the hydraulic fluid shall be protected by devices that will inhibit fluid ignition. A single failure in the hydraulic system or any other system, such as fuel, environmental control, electrical, etc. shall not cause a hydraulic fire.
- 3.5.4 Strength
- 3.5.4.1 Additional Loads: All hydraulic systems and components which are subjected, during operation of the aircraft, to structural or other loads which are not of hydraulic origin, shall withstand such loads when applied simultaneously with appropriate proof pressure as specified in Table I, without exceeding the yield point or normal load endurance limit of the material at the maximum operating temperature.
- 3.5.4.2 Accelerated Loads: Actuating cylinders and other components and their attaching lines and fittings, subject to accelerated loads, shall be designed and tested on the basis of a pressure equal to the maximum pressure that will be developed, without exceeding the yield point at the maximum operating temperature.
- 3.5.5 Pressure Limitations
- 3.5.5.1 System Pressure: Main system operating pressure shall be in accordance with Table I. Peak pressure (ripple and surge) resulting from any phase of the system operation shall not exceed 135% of the main system, subsystem, or return system operating pressure when measured with electronic equipment, or equivalent.
- 3.5.5.2 Back Pressure: The system shall be so designed that proper functioning of any unit will not be affected by the back pressure in the system. The system shall also be designed so that malfunctioning of any unit in the system will not render any other subsystem, emergency system, or alternate system inoperative because of back pressure.
- 3.5.5.3 Brakes: Back pressure resulting from the operation of any unit while the aircraft is on the ground shall create no greater back pressure at the brake valve return port than 90% of that pressure which will cause contact of braking surfaces. In addition, supply pressure to the brake subsystem shall not drop below the maximum brake-operating pressure during the operation of any other subsystem in the aircraft during taxiing, landing, or takeoff.

TABLE I
OPERATING PRESSURES, PSI

Characteristics	<u>Nominal operating pressure</u>		Percent operating pressure	Remarks
	4, 000	5, 000		
Automatic pressure regulator - accumulator system (closed center)				
(a) Regulator cut-out pressure	4, 000	5, 000	---	System design pressure
(b) Upper limit of operating pressure for all units (regulator cut-in pressure)	3, 500	4, 400	---	
(c) System relief valve minimum reseal pressure	4, 100	5, 100	---	
(d) Maximum system relief valve setting at maximum system flow	4, 850	5, 850	---	
Open-center type system (constant delivery pump)				
(a) System design pressure	4, 000	5, 000	---	Relief valve full flow setting
(b) Upper limit for operating pressure	3, 600	4, 500	---	
(c) Maximum system relief valve setting at maximum system flow	4, 000	5, 000	---	
Closed-center type system (variable volume pump)				
(a) Pump unloading pressure	4, 000	5, 000	---	System design pressure
(b) System relief valve minimum reseal pressure	4, 100	5, 100	---	
(c) Maximum system relief valve setting at maximum system flow	4, 850	5, 850	---	
Thermal relief valve setting (maximum)				
(a) Equal to system relief valve maximum setting plus values noted	150	150	---	---

TABLE I (Continued)
OPERATING PRESSURES, PSI

Characteristics	<u>Nominal operating pressure</u>		Percent operating pressure	Remarks
	4, 000	5, 000		
Proof pressure				
(a) Lines, hose, and fittings (pressure lines)	8, 000	10, 000	200	---
(b) Lines, hose, and fittings (return or back pressure)	200 percent of actual maximum pressure		---	
(c) Components, under system design pressure (fluid/gas)	6, 000	7, 500	150 (accumulators use 200)	
(d) Components under return or back pressure	150 percent of maximum service pressure		---	
(e) Pump supply lines, fittings and components	150 percent of actual maximum pressure		---	
(f) Installed system	4, 000	5, 000	100	
Burst pressure (minimum)				
(a) Lines, hose, and fittings (pressure lines)	16, 000	20, 000	400	Hose burst pressure to be in accordance with applicable detail specification.
(b) Lines, hose, and fittings return or back pressure	400 percent of actual maximum pressure		---	
(c) Components, under system design pressure (fluid/gas)	10, 000	12, 500	250 (accumulators use 400)	
(d) Components, under return or back pressure	300 percent of actual maximum pressure		---	
(e) Pump supply lines, fittings and components	300 percent of actual maximum pressure		---	
Collapse pressure of parts subject to suction	50 external	50 external	---	---

- 3.5.5.4 **Pressure Regulation:** Systems employing power-operated pumps shall utilize a pressure-regulating device and an independent means of limiting excessive pressure. When the pump-driving mechanism is in continuous operation, such as engine or transmission drives, a variable displacement pump shall be used. When the pump is driven by an electric motor, a pressure switch may be used to deactivate the electric motor as the primary method of pressure regulation. In any case, an independent safety relief valve shall be provided.
- 3.5.6 **Reservoir Pressurization:** Reservoir pressurization for Type II and III systems shall be so designed that air, or any gas, does not come into contact with the fluid during the normal function of the system or subsystems.
- 3.5.7 **Suction Line**
- 3.5.7.1 **Suction Line Flow:** The suction line from the reservoir to the power pumps shall be designed to provide adequate flow and pressure at the pump inlets, with the power pumps operating at maximum fluid volume output at the service ceiling of the aircraft, and with the hydraulic fluid at the expected stabilized temperature, but this stabilized fluid temperature shall be not warmer than -20 F, unless provisions are incorporated to control the fluid temperature. Due regard may be given to selecting a flight altitude of less than service ceiling which may be used for any system in which the pump does not operate during "in flight" conditions, but this altitude shall be not less than 10,000 ft above sea level. Test data and analysis shall be furnished for the approval of the customer, showing that satisfactory service life of the pumps will be indicated under all operating conditions of the aircraft. This information shall be included in the system design report (see 6.3).
- 3.5.7.2 **Suction Line, Cold Starting:** Unless otherwise specified by the customer, during cold starting on the ground at all ambient air temperatures down to -65 F, the above conditions of suction-line pressure drop shall not apply until stabilized fluid operating temperatures have been obtained.
- 3.5.8 **Fluid Velocity Limitations:** It is desired that tube sizes be such that the nominal velocity of fluid in pressure and return lines leading to the directional control valves not be in excess of approximately 15 fps, except where system analysis shows that proper functioning can be achieved even though the rate be higher. The velocity of flow in the suction lines shall be governed by the pressure requirements for suction lines, as specified herein. Table II indicates the nominal rates of flow for various tube sizes based on velocity of about 15 feet per second.
- 3.5.8.1 **Fluid Flow Effects:** The systems shall be so designed that malfunctioning of any unit or subsystem shall not occur because of reduced flow, such as created by single-pump operation of a multi pump system, or reduced engine speed of a single-pump system. The system shall also be so designed that increased flow will not adversely affect the proper functioning of any unit or subsystems, such as increased flow rate caused by accumulator operation, or units affected by air load operation.
- 3.5.8.2 **Acceleration Effects:** System and component operation shall not be adversely affected by the maximum "g" loading obtainable with the aircraft. Consideration shall be given to determine the effect of "g" on the actuated service, the fluid columns, other large fluid masses, the mass of the operating controls, and any other unit or subsystems that could be affected by the "g" capabilities of the aircraft.

TABLE II
NOMINAL FLOW IN TUBING

Nominal Tube OD (inches)	Dash No.	Flow (gpm)
1/4	-4	1.2
5/16	-5	2.3
3/8	-6	3.5
1/2	-8	6.0
5/8	-10	10.5
3/4	-12	16.0
1	-16	29.0
1-1/4	-20	45.0
1-1/2	-24	70.0

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