INCH-POUND

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MILITARY SPECIFICATION

HYDRAULIC SYSTEMS, AIRCRAFT, DESIGN AND INSTALLATION REQUIREMENTS FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 scope. This specification covers the design and installation requirements for Types I and II aircraft hydraulic systems.

1.2 Classification. Aircraft hydraulic systems shall be of the following types and classes, as specified:

1.2.1 Types.

Type I   Maximum fluid operating temperature +160Y°F (+71°C).

Type II   Maximum fluid operating temperature +275°F (+135°C).

1.2.2 Classes. The class of operating pressure shall consist of the following:

a. Class 1500. 1500 psi nominal operating pressure

b. class 3000. 3000 psi nominal operating pressure

c. class 4000. 4000 psi nominal operating pressure

d. class 5000. 5000 psi nominal operating pressure

e. Class 8000. 8000 psi nominal operating pressure

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer, Naval Air Warfare Center Aircraft Division Lakehurst, Systems Requirements Department, Code SR3, Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A   FSC 1650

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

For multiple operation pressure level systems, such as 5000 psi and 3000 psi, the highest pressure shall determine the pressure class. The pressure class shall be annotated with a “V” to indicate variable pressures (example: class 5000V)

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, manuals and publications. The following specifications, standards, manuals and publications form a part of this document to the extent specified herein. Unless otherwise specificed, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

MILITARY

MIL-B-5087	Bonding, Electrical, and Lighning Protection, For Aerospace Systems
MIL-W-5088	wiring, Aerospace Vehicle
MIL-A-5503	Actuators: Aeronautical Linear utility Hydraulic General Specification For
MIL-F-5508	Fuse, Aircraft Automatic Quantity-Measuring, Hydraulic
MIL-J-5513	Joints, Hydraulic, Swivel
MIL-G-5514	Gland Design; Packings, Hydraulic General Requirements For
MIL-V-5519	Valves, Regulating Fluid Pressure
MIL-T-5522	Test Requirements and Methods for Aircraft Hydraulic and Emergency Pneumatic Systems
NIL-V-5525	Vaives, Aircraft Power Brake
MIL_V_5527	Valves, Aircraft, Hydraulic, Thermal Expansion Relief
MIL-V-5530	Valves, Aircraft Hydraulic Shuttle
MIL-H-5606	Hydraulic Fluid, Petroleum Base: Aircraft, Missile and Ordnance
MIL-P-5954	Pump Unit, Hydraulic, Electric Motor Driven, Fixed Displacement
MIL-P-5994	Pump, Hydraulic, Electric Motor Driven, Vari-able Delivery, General Specification For
MIL-T-6845	Tubing, Steel,Corrosion Resistant (530400), Aerospace Vehicle Hydraulic System, 1/8 Hard Condition
MIL-T-7081	Tube, Alumlnum Alloy, Seamless, Round, Drawn, 6061, Aircraft Hydraulic Quality
MIL-F-7179	Finishes, Coatings, And Sealants For the Protection of Aerospace Weapons Systems
MIL-P-7858	Pump, Hydraulic, Power Driven, Fixed Displacement

MIL-M-7997	Motors, Aircraft Hydraulic, Constant Displacement, General Specification For
MIL-G-8348	Gage Assemblies, Air Pressure, Dial Indicating Chuck Type, Self-Contained
MIL-T-8504	Tubing, Steel, Corrosion-Resistant (304), Aerospace Vehicle Hydraulic Systems, Annealed, Seamless and Welded
MIL-V-8566	Valves; Aircraft Hydraulic Flow Regulator
MIL-B-8584	Brake Systems, Wheel, Aircraft Design of
MIL-H-8775	Hydraulic System Components, Aircraft and Missiles, General Specification for
MIL-F-8785	Flying Qualities of Piloted Airplanes
MIL-R-8791	Retainer, Packing, Hydraulic, and Pneumatic Polytetrafluoroethylene Resin, (Single Turn)
MIL-V-8813	Valves: Aircraft, Hydraulic Pressure Relief, Type II Systems
MIL-F-8815	Filter and Filter Elements, Fluid Pressure, Hydraulic Line, 15 Micron Absolute and 5 Micron Absolute, Type II Systems
MIL-H-8891	Hydraulic Systems, Manned Flight Vehicles, Type III Design, Installation and Data Requirements For, General Specification For
MIL-R-8931	Reservoirs: Aircraft and Missle, Hydraulic, Separated Type
MIL-S-9395	Switch Pressure (Absolute Gage and Differential) General Specification For
MIL-F-9490	Flight Control Systems-Design, Installation and Test of Piloted Aircraft, General Specification For
MIL-F-18372	Flight Control Systems: Design, Installation and Test of Aircraft, General Specification For
MIL-V-19067	Valves, Check, Controllable, Hydraulic, Aircraft, Type II Systems
MIL-V-19068	Valves, Shuttle, Hydraulic, Aircraft, Type II Systems
MIL-V-19069	Valves, Check, Hydraulic, Aircraft, Type II Systems
MIL-P-19692	Pumps, Hydraulic, Variable Delivery, General Specification For
MIL-C-25427	Coupling Assembly, Hydraulic, Self Sealing, Quick Disconnect, General Specification For
MIL-H-25579	Hose Assembly, Tetrafluoroethylene, High Temperature, Medium Pressure
MIL-V-25675	Valves, Check, Miniature, Hydraulic, Aircraft and Missile
MIL-H-27267	Hose, Tetrafluoroethylene, High Temperature, Medium Pressure
MIL-F-27272	Fittings, Tetrafluoroethylene Hose, High Temperature, Medium Pressure, General Requirements For

MIL-V-29592	Valve, Air Vent, Automatic, Hydraulic, Low Pressure Type II Systems, Genera? Specificat-ion For
MIL-H-46170	Hydraulic Fluid, Rust Inhibited, Fire Resist-ant, Synthetic Hydrocarbon base
MIL-F-81836	Filter and Disposable Element, Fluid Pressure, Hydraulic, 3 Micron Absolute
MIL-V-81940	Valve, Sampling and Bleed, Hydraulic, Type II Systems
MIL-R-83248	Rubber, Fluorocarbon Elastomer, High Perform-ance Fluid and Compression Set Resistant
MIL-H-83282	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft, Metric, NATO Code Number H-537
MIL-F-83296	Fittings, Tetrafluoroethylene Hose, High Temperature, High Pressure, 3000 PSI, Hydraulic and Pneumatic
MIL-H-83298	Hose, Tetrafluoroethylene, High Temperature, high Pressure, 3000 PSI, Hydraulic And Pneumatic
MIL-F-83300	Flying Qualities of Piloted V/STOL Aircraft
MIL-P-83461	Packings, Preformed, Petroleum Hydraulic Fluid Resistant, Improved Performance at 275 degrees F {135 degrees C)
MIL-R-83485	Rubber Fluorocarbon Elastomer Improved Perform-ance at Low Temperatures
MIL-C-85052	Clamp, Loop, Cushion, General Specification For
MIL-V-85245	Valve, Relief, Hydraulic, High Response, Type II Systems, General Specification For
MIL-F-85421	Fittings, Tube, Fluid Systems, Separable, Dynamic Beam Seal, Requirements For
MIL-C-85449	Clamp Assembly, Sadd;e-Type, Cushion, General Specification For
MIL-F-85720	Fittings, Tube, Fluid Systems, Separable High Pressure, Dynamic Beam Seal, General Specification For
MIL-H-85800	Hose Assemblies, Polytetrafluoroethylene Aramid Fiber Reinforced, 5000 and 8000 psi, General Specification For

STANDARDS

FEDERAL

FED-STD-791	Lubricants, Liquid Fuels and Related Products; Methods of Testing

MILITARY

MIL-STD-1247	-	Markings, Functions and Hazard Designations of Hose, Pipe, and Tube Lines for Aircraft, Missile and Space Systems
MIL-STD-1472	-	Human Engineering Design Criteria For Military Systems, Equipment and Facilities
MIL-STD-1844	-	Gas Chromatography Method for Determination of Trace Chlorinated Solvents in Hydraulic Fluid
MIL-STD-2069	-	Requirements for Aircraft Non-nuclear Survivability Program
MIL-STD-2089	-	Aircraft Non-nuclear Survivability Terms

AIR FORCE-NAVY AERONAUTICAL

AN929	Cap Assembly, Pressure Seal Flared Tube Fitting

PUBLICATIONS

NAVY DEPARTMENT SPECIFICATION

SD-24	General Specification for Design and Construction of Aircraft weapon Systems
Vol . I	Fixed Wing Aircraft
Vol .II	Rotary Wing Aircraft
SD-8706	Data and Test, Engineering; Contract Requirements For Aircraft weapon Systems

NAVY DEPARTMENT TECHNICAL MANUAL

NAVAIR 01-1A-17	Aviation Hydraulics Manual
NAVAIR 01-1A-20	Aviation Hose and Tube Manual

(Copies of documents are available from the Navy Aviation Supply Office, Code 03443, 5801 Tabor Avenue, Philadelphia, PA 19120-5099).

2.1.2 Other Government documents and publications. The following other Government documents and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

United States Government Printing Office

GPO Style Manual

(Copies of the GPO Style Manual are available from the Superintendent of Documents, U.S. Government Printing Office, washington, DC 20402-0001.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation.

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

ARP 584	Coiled Tubing, Corrosion Resistant Steel, Hydraulic Applications
ARP 598	The Determination of Particulate Contamination in Liquids by the Particle Count Method
ARP 603	Impulse Testing of Hydraulic Hose, Tubing, and Fitting Assemblies
AS 604	Hose Assembly, TFE, 400”F, 3000 PSI, Hydraulic Heavyweight
AS 614	Hose Assembly, Tetrafluoroethylene Heavy Duty, High Temp., High Pressure, 4000 PSI, Hydraulic and Pneumatic
ARP 994	Recommended Practice for the Design of Tubing Installations for Aerospace Fluid Power Systems
ARP 1192	Procedure for Calibration and Verification of a Liquidborne Particle Counter: An Absolute Standard
AS 1290	Graphic Symbols for Aircraft Hydraulic and Pneumatic Systems
AS 1300	Boss-Ring Locked Fluid Connection Type Standard Dimensions For
AS 1339	Hose Assembly, TFE, 400°F,” 3000 PSI, Hydraulic, Lightweight
ARP 1383	Impulse Testing of Hydraulic Actuators, Valves, Pressure Containers, and Similar Fluid System Components
AS 1975	Hose Assemblies, PTFE, Aramid Reinforced, 4000 PSI, Hydraulic and Pneumatic
AIR 4057	Secondary Filters For Fluid System Reliability
AS 4059	Aerospace-Cleanliness Classification For Hydraulic Fluids
ARP 4146	Coil Tubing, Titanium Alloy, Hydraulic Applications
AS 4201	Port-Ring Locked Fluid Connection Type 8000 PSI Standard Dimensions For
AS 4251	Coupling Assemblies, Non-Locking Probe Style, Self-Aligning, Self-Sealing, Disconnects
ARP 4378	Hydraulic, Accumulator, Maintenance Free
AS 4396	Fitting End - Bulkhead Flared Tube Connection, Design Standard

ARP	4553	-	Hydraulic, Accumulator, Self Displacing
AMS	4945	-	Titanium Alloy Tubing, Seamless, Hydraulic 3.OAL-2.5V, Texture Controlled, 105000 psi (724 MPa) Yield Strength
AMS	5561	-	Steel Tubing, Welded and Drawn, 9.0Mn-20Cr-6.5NI-.28N High Pressure Hydraulic

(Application for copies should be addressed to the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the test of this document and the references cited herein (except for related associated detail specifications, specification sheets or MS standards), the text of this document takes precedence, Nothing In this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3 REQUIREMENTS

3.1 Materials. Materials used in the manufacture of hydraulic systems in military aircraft shall conform to applicable Government specifications. Materials conforming to contractor's specifications may be used, provided it can be clearly demonstrated that they are at least equivalent to Government specifications with respect to operating characteristic and that a savings In weight or cost can be accomplished. Use of aluminum materials in flight control components in 5000 psi systems and above, rewire special precautions to ensure conformance to the fatigue requirements for production configuration parts. The use of aluminum alloy parts for 5000 psi and greater is not encouraged and shall not be used unless approved by the contracting activity. Contractor's specifications must be accepted by the Government and contain provisions for tests. The use of contractor's specifications will not constitute waiver of Government inspection.

3.2 Design. The hydraulic systems and components shall be designed to operate 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, or any flight attitudes obtainable with the aircraft, structural deflection, vibration, or other environmental conditions. (For Navy use only, see Navy Department publications SD-24, Volumes I and II). The hydraulic systems shall be configured such that failure of any two fluid systems resulting from combat or other damage which cause loss of fluid or pressure will not result in complete loss of flight control. Fixed wing aircraft shall maintain level one (1) flying qualities of MIL-F-8785 with one fluid system failure (including the power source) and level three (3) flying qualities including carrier landing, with two fluid system failures. Rotary wing aircraft shall meet MIL-F-83300 flying qualities with two fluid system failures for return to the intended landing area (including shipboard areas and land). General aircraft combat survivability guidelines are provided in MIL-STD-2069 and MIL-STD-2089.

3.3 Fluid. Fluid conforming to MIL-H-83282 and MIL-H-5606 shall be used for hydraulic systems and associated ground equipment. Other hydraulic fluid may be used when specified by the contracting activity.

3.4 seals. MIL-G-5514 shall be used for gland design and packing installation. O-ring packing cross-sectional squeeze shall be minimum of 0.005 inch deflection for the most adverse tolerance conditions. Minor changes to gland dimensions may be necessary for the 0.070, 0.103 and 0.139 inch cross-section ()-ring grooves. If these minor modifications are made, an increase in gland width may be required to prevent gland overfill. O-ring packings with cross-sectional diameters of 0.070 inch or less, or their equivalent proprietary seals, shall not be used as external seals.

3.4.1 Gland Design. Seal gland dimensions shall conform to the requirements of MIL-G-5514 except for minor modifications made in paragraph 3.4. Nonstandard glands for specialized packings shall be used only with the approval of the contracting activity. For system pressure levels above class 3000, the diametral clearance gaps of MIL-G-5514 may be reduced from the minimum of 0.003 inch to improve seal life and aid in preventing packing extrusion. Care shall be taken to prevent binding and interference at the most adverse temperature extremes. Standard clearance may be used for system pressure levels greater than 3000 psi if proprietary-type packing shapes and high modulus backup ring materials are used.

3.4.2 Packing. O-ring packings shall conform to MIL-P-8461 or MIL-R-83248 or MIL-R-83485. Packing configurations other than O-ring may be used in standard glands if design permits. For MS33649 and AS 1300 ports, use MIL-P-83461/l and MIL-F-83461/2, as applicable.

3.4.3 Backup rings. Backup rings shall conform to MS27595. Backup rings conforming to MIL-R-8791 may be used on ayrtamlcapplications where minimum seal friction is required for satisfactory operation or where access to the gland prevents installation of MS27595. If MS27595 coninuous backup rings are used on dynamic piston applications, friction due to pressure entrapment between the backup rings must be considered in the design of the device. Nonstandard backup rings may be used for system pressure levels greater than class 3000, subject to the approval of the contracting activity.

3.5 Functional simulator. A functional simulator (s) for the hydraulic system shall be constructed to determine system performance. As required, separate simulators may be constructed for utility functions such as landing gear, wing fold, steering and brakes. However, all components required for flight control must be on one simulator. The utility functions not on the flight control simulator must be reproduced with hydraulic loads and valves necessary to functionally control this load in the system. Arrangement shall be made for the application of simulated flight loads. Tubes, fittings, and tube material for all simulators shall be identical to those installed in the first flight aircraft. Tubing installations shall match line length and total bend angle for each functional leg installed in the aircraft. Line to line connections where no change in tube size or flow direction occurs may be eliminated. Prototype components or laboratory models may be used for systems development testing. However, before first flight, testing shall be accomplished on the simulator with all components and simulated loading incorporated. This safety of flight testing shall simulate a mission profile to duplicate actual aircraft flight conditions. All functions shall operate .in sequence for a check on unusual back pressure, surges, temperature, pump pulsation, and vibration. They shall simulate start-up, flight-control checkout, door closing, braking, steering, flap retraction, gear retraction, and power flight control under takeoff, cruise, approach landing, and taxi conditions. All emergency modes and system failure conditions as required by 3.2 shall be demonstrated. The simulator shall be maintained beyond the development and test phase to be used to evaluate significant changes to the system during production of the aircraft.

3.6 General system design. Hydraulic systems shall be as simple and foolproof as possible and in accordance with design, operation, inspection, and maintenance objectives specified in the aircraft design requirements. For Navy aircraft, the hydraulic system shall be designed to accommodate the maintenance procedures described in NAVAIR 01-lA-17 and NAVAIR 01-lA-20 manuals. Each hydraulic system shall be separated from all other systems and fluid shall not be transferred between systems such that one reservoir level would increase and another reservoir level decrease.

3.6.1 Fluid temperature limitations. The hydraulic system, with MIL-H-83282 fluid shall be capable of starting and operating at fluid temperatures between -40°F (-40°C) and the upper limit of the operating envelope. Fluid temperatures shall not exceed +160°F (+71°C) for Type I systems and +275°F (+135°C) for Type II systems at any point in the system. Operation at these temperatures shall not result in any degradation of the system. With MIL-H-5606 fluid, the low temperature limit shall be -65°F (-54°C).

3.6.1.1 Climate extremes. Ground operation, flight operation and storage climatic extremes shall be in accordance with the weapon system procurement specification.

3.6.2 Fire hazards. The hydraulic system shall be so designed and installed with other systems that it will eliminate or isolate the system(s) from fire hazards caused by proximity of combustible gases, heat sources, bleed-air ducts or electrical ignition sources. Hydraulic lines and equipment located in the vicinity of heat and ignition sources that may cause spontaneous ignition or sustained fire of hydraulic leakage from these lines or equipment shall be protected by devices such as fire walls, shrouds, or equivalent means that will prevent fluid ignition. Rotating components that fail and continue to rotate shall be disconnected from their driving source or stopped to prevent heat generation and the possibility of fire.

3.6.3 Surge pressure. Peak pressure resulting from any phase of the system operation shall not exceed the percent value shown in Table I for the main system, subsystem, or return system pressures when measured with electronic or other test equipment.

3.6.3.1 Pressure limitations. Pressure limitations shall be in accordance with Table II.

Table I. System Peak Pressure

Pressure Class	Peak Pressure
1500, 3000, 4000 and 5000	135 % of system operating pressure
8000	120 % of system operating pressure

3.6.3.2 Back pressure. The system shall be so designed that proper functioning of any unit such as internal actuator locks or brakes will not be affected by the maximum back pressure in the system. The system systems shall also be so designed that malfunctioning of any unit in the system will not render any other subsystem, emergency system, or alternate system inoperative because of back pressure.

3.6.3.3 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 percent of that pressure which will cause contact of braking surfaces. In addition, supply pressure to the brake system shall not drop below the maximum brake-operating pressure during the operation of any other subsystem in the aircraft during taxiing, landing, or takeoff,

3.6.3.4 Pressure regulation. System pumps shall use an internal pressure regulating device to limit excessive pressure and to maintain constant pressure at varying flow demands. An independent safety relief valve shall also be incorporated into each system.

3.6.3.5 Variable pressure systems. Systems that vary the pump operating pressure as power demand varies shall provide hydraulic power with pump(s) failed at the high or low pressure setting to maintain flying qualities set forth in paragraph 3.2. All design factors and pressure ratings cited in this document shall be applied at the maximum pump discharge pressure.

3.6.3.6 Return system. As a minimum, lines, fittings, and equipment in return circuits shall be designed for 1/2 the system pressure, with the exception of some components as noted in Table II.

3.6.4 Strength.

3.6.4.? Additional loads. All hydraulic systems and components which are subjected, durinq 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 II without exceeding the material yield point at the maximum operating temperature.

3.6.4.2 Loads due to aircraft acceleration. All components and their attached lines and fittings, subjected to loads resulting from airframe accelerations, shall be designed-and tested on the basis-of a pressure equal to the maximum pressure that will be developed, at the maximum operating temperature. This operation shall not exceed the material yield pont.

3.6.5 Reservoir pressurization. The reservoir shall be designed so that the hydraulic fluid is completely separated from the atmosphere during norms functioning of the system. The reservoir pressure shall be adequate to provide pump full flow performance at -20°F (-29°C).

3.6.6 Fluid velocity limitations. Tubing size and maximum fluid velocity for each system shall be determined considering, but not limited to, the following:

a.. Allowable pressure drop at minimum required operating temperatures.

b. Pressure surges caused by high fluid velocity, rapid closure of valves, and rapid actuator piston deceleration.

c. Back pressure in return lines, as it may affect brakes and pump-.case drain lines.

d. Pump inlet pressure, as affected by long suction lines, and a high response rate variable-delivery pump. Consideration should be given to both pressure surges and cavitation.

3.6.6.1 Fluid flow effects. The systems shall be so designed that malfunctioning of any unit or subsystem will not occur because of reduced flow, such as-created by single-puhp operation of a multiple-pump system, or reduced engine speed. The systems shall also be designed such that increased flow will not adversely affect the proper functioning of any unit or subsystems; examples include increased flow rate caused by accummlator operation or units affected by the operation with aiding loads.

TABLE II. Hydraulic pressures

Component or Characteristic	Pressure (1) Class 5000 and below	Pressure (1) Class 8000	Remarks
Pump Pressures			
a. Pump pressure at zero flow	100%	100%	System design pressure
b. Pump minimum pressure at full flow	100% -150 psi	100% -150 psi	
Relief Valve Pressure Settings			
a. System relief valve maximum pressure at rated flow	100% +850 psi	100% +850 psi	See paragraph 3.11.21
b. Thermal relief valve cracking pressure	100% +1000psi	100% +1000psi	
Proof Pressures (minimum)			
a. Lines, fittings, hoses and couplings			Proof pressures values for hoses to be in accordance with the applicable specification
(1) Pressure circuits	200%	200%	
(2) Return and case drain circuits	100%	100%	
b. Accumulators	200%	200%	See paragraph 3.11.21
c. Low pressure side of reservoir and pump suction line for the following reservoir types:			
(1) Bootstrap reservoir	-	-	150% of reservoir operating pressure

TABLE II Hydraulic pressures (Cont'd)

(2) Gas pressurized reservoirs	-	-	200% of reservoir operating pressure
d. Components under system pressure	150%	150%	
e. Components under return pressure only	100%	100%	Except for hoses which shall be 125% of system pressure
f. Heat exchangers	150%	150%	150% of maximum operating pressure
g. Complete system			
(1) Pressure side	150%	150%	Aircraft installed systems only
(2) Return side	75%	75%	
Burst Pressures			
a. Lines, fittings, hoses and couplings	400%		Burst pressure values for hoses to be in accordance with the applicable specification
(1) Pressure circuits	400%	300%	
(2) Return and case drain circuits	200%	150%	
b. Accumulators	400%	400%	
c. Low pressure side of reservoir and pump suction line for the following reservoir types			
(1) Bootstrap reservoir	-	-	300% of reservoir operating pressure
(2) Gas pressurized reservoirs	-	-	400% of reservoir operating pressure
d. Components under system pressure	250%	200%	

TABLE II Hydraulic pressures (Cont'd)

e. Components under return pressure only	150%	150%	Except for hoses which shall be 125% of system pressure
f. Heat exchangers	-	-	250% of maximum operating pressure
g. Collapse pressure of parts subject to suction	50 psid external	50 psid external	

Note 1 : Percentage of supply pressure, pressure in psi or both.

3.6.7 Subsystem isolation. Two or more subsystems pressurized by a common pressure source, one of which is essential to flight operation and the other not essential, shall be so isolated so that the system essential to flight operation will not be affected by any damage to the nonessential system.

3.6.8 Ground service provisions. Each hydraulic system shall include a set of self-sealing couplings for attachment of ground power sources. System ground service provisions shall be so designed that pressurization of any hydraulic system in the aircraft is not necessary in order to test another hydraulic system. A central ground servicing station shall be provided for each system that includes connections for attachment of ground service equipment for system checkout and flushing, reservoir bleeding, reservoir fill, and accumulator nitrogen charging.

3.6.8.1 Ground service connections. A set of self-sealing couplings consisting of bulkhead halves and protective caps shall be provided at a convenient location in the aircraft, easily accessible from the ground, for attachment of ground service equipment. The aircraft bulkhead halves shall mate with the ground cart hose halves without the use of adapters. The self-sealing coupling shall be in accordance with MIL-C-25427 and its applicable specification sheets. Electric motor-driven pumps used it emergency or auxiliary systems shall not be used for ground test purposes unless the motor is designed for continuous operation.

3.6.8.1.1 Reservoir supercharging connection. When reservoirs are normally pressurized by either compressed air or nitrogen, a ground supercharging connection shall be provided and shall consist of a fitting end in accordance with MS33656-4 or AS 4396 for attachment to a ground super-charging unit. A protective cap in accordance with AN929 with a safety chanin shall be provided to protect the end connection when not in use.

3.6.8. 1.2 Reservoir filling connection. Reservoirs shall be filled by low-pressure replenishment methods. The reservoir filling connection shall be a check valve and a self-sealing coupling for attachment to ground filling equipment. Direct pouring of fluid into the resrvoir (including in-flight fluid replenishment provisions) shall not be provided. When the reservoir level is not readily visible from the fill connection, a remote indicator shall be provided at that point.

3.6.8.2 Ground service information. The following information shall be attached in a permanent manner on the aircraft near the ground service connections:

Set ground service reservoir pressurizing valve to ________ psi.
Set ground service stand relief valve to ________ psi.
Set ground service stand volume output to ________ gpm.
Set ground service stand pressure compensator to ________ psi.
Use hydraulic fluid conforming to ________
Ground service stand output filter shall be " l microns absolute.
(Any other precautions or information considered necessary.)

The contractor shall fill in the values of the blank underline.

3.6.9 Removal of entrapped air. Each hydraulic system shall be equipped with an air removal device to vent undissolved air from the system automatically without operator intervention. The automatic bleed valves shall be in accordance with MIL-V-29592 and shall be so designed that in case of failure in the open position, leakage of fluid shall be minimal. In the most adverse case of flight duration, pressure and temperature, the leakage shall not exceed the emergency reserve capacity of the reservoir. Each system shall also be equipped with a manual bleed valve. Bleed valves shall be accessible without exposing personnel to undue hazards.

3.6.9.1 On-board deaeration equipment. When the need is recognized, consideration shall be given to the use of on-board deaeration equipment that will remove both dissolved and undissolved air from the hydraulic oil and systems.

3.6.10 Power pumps. The hydraulic pump (s) shall be compatible with the installed aircraft system and shall not cause abnormal or undesirable effects on the installed aircraft system. Primary pump applications designed for continuous duty shall be provided with at least two qualified pump designs from separate manufacturing sources unless this requirement is waived by the contracting activity. All pumps qualified for a given application shall be physically and functionally interchangeable and shall be compatible with the system and each other to allow mixed use in multiple pump systems. The pump drive couplings shall be designed to include non-metallic spline bushings to minimize wear. The spline bushings shall be designed in accordance with MS14169 or MS14184 and shall be supplied with the gearbox.

3.6. 10.1 Emergency power pumps. Hydraulic power pumps designed to provide emergency power to flight critical systems or brakes shall not be used for any other functions.

3.6.10.2 Multiple pumps. Multiple engine aircraft shall have pumps directly driven by at least two engines. The hydraulic systems shall have a sufficient number of engine pumps, augmented if necessary by pumps povered by other separate sources, to provide power to all systems critical for safe operation of the air vehicle. This requirement shall be net with any combination of engines operating to maintain flight or to be used while taxiing.

3.6.10.3 Pump pulsation. For all power generating components (engine pumps, power packages, transfer units, etc), pump pulsations shall be controlled to a level which does not adversely affect the aircraft system tubing, components, and supports installation. The contractor shall determine by test the effect of pump pulsations (pump ripple) on the hydraulic system. Initial tests shall be conducted on the functional simulator, with recording equipment, and shall cover the complete speed range from zero revolutions per minute (rpm) to the maximum speed, pressures, and flows that the pump will be subjected to when Installed in the aircraft. Adverse effects including induced resonant vibrations shall be eliminated. Results of the functional simulator tests for pump ripple effects shall be documented, forwarded to the contracting activity, and shall be verified on the first aircraft, and any additional corrections required shall be made prior to the first flight.

3.6.10.4 Pump rotation reversal. For equipment not designed to withstand reverse rotation, the system and components shall be designed so that no single failure will permit reverse rotation.

3.6.10.5 Attenuators. The harmful effects of pump cavitation resulting from system failure or air ingestion from improper maintenance shall be considered in the design of each hydraulic system. Where appropriate, as determined upon review by the contracting activity, attenuators shall be installed to minimize these harmful effects.

3.6.11 Pump supply shutoff valves. Pump supply (section) shutoff valves shall be provided if the fire protection requirements of the particular model aircraft specify the need for such equipment in other systems, such, as fuel or lubricating oil systems, Or both. These valves, when required, shall not be located on the engine side of fire walls or flame-tight diaphragms but shall be located as close as the design will permit to these members. However, the valves shall be so removed from the engine that the loss of the engine from the attaching structure will not impair the operation of the valve. These valves shall be operable from the cockpit, to both the closed and open positions.

3.6.12 Special tools. Hydraulic systems shall be so designed that special tools will not be required for installation or removal of components. where special tools are absolutely necessary, they shall require approval by the contracting activity.

3.6.13 System pressure indication. Pressure indicating equipment shall be provided to indicate the system pressure in hydraulic systems or subsystems. This pressure indication may be displayed to the flight crew in conjunction with other information on a multifunction, multiplexed display. For the emergency conditions of decreasing or fluctuating pressure, the pressure Indication shall be displayed Immediately to the flight crew. On engine driven multiple pump systems, pressure Indicating equipment shall be provided for each pump to enable the flight crew to check for proper operation of each pump without shutdown of any engine.

3.6.13.1 System low-pressure warning light. In addition, but not as a substitute for the requirement of 3.6.13, a warning light shall be installed in the cockpit in a conspicuous location to warn the pilot of low hydraulic system pressure. The light shall be actuated by a pressure switch in the system. There shall be a separate warning light for each hydraulic system. The warning light, or lights, shall not be actuated by any combination of normal flight-control operations. A momentary flicker of the warning light during ground checkout only is permissible, provided such condition is described in the appropriate aircraft operation and maintenance manuals and provided such condition does not occur during flight unless a system malfunction exists.

3.6.13.2 Maintenance check gages and indicators. Pressure gages and indicators that require a preflight, postflight, or daily check shall not require workstands or platforms in order to read the gages or indicators.

3.6.14 Fluid sampling valves. A fluid sampling valve, conforming to MIL-V-81940, shall be provided in the system return line that is common to all actuating circuits and shall be located upstream of the main return line filter. The sampling valve (s) shall be located in a readily accesible area and shall allow convenient use of sampling containers. Fluid sampling valves shall also be provided in other portions of the system if considered necessary by the procuring activity. The sampling valve shall allow representative fluid samples to be taken while the system is fully pressurized. Contamina-ion generated by the operation of the valve shall not adversely affect the fluid sample. The valve nozzle shall include a protective cap, and the cap shall also prevent external leakage in the event of valve malfunction. The cap shall be provided with a security chain, or equivalent, to prevent loss of the cap.

3.6.15 Automatic diagnostic monitor system. Integral with each hydraulic system, a diagnostic system shall be provided to continuously monitor the system and components and detect out-of-tolerance conditions. These out-of-tolerance conditions shall be detected during flight operations and give indication of a failed or failing component and indicate maintenance actions needed such as filter replacement, accumulator recharging and over temperature indication. The information shall be stored during flight. At the completion of the flight, the information shall be displayed upon demand at a central location on the aircraft readily accessible to ground maintenance personnel without the use of work stands, platforms, or any other ground support equipment. Sensors installed in the hydraulic system to accomplish this monitoring shall not degrade the safety of the hydraulic system. Design of the system shall enable the integrity of the sensors and sensor circuits to be checked. At a minimum, the system shall monitor the following components and conditions and record the conditions indicating maintenance required and conditions indicating component deterioration leading to failure: main system hydraulic pumps, accumulators, filters, reservoir fluid levels, reservoir fluid temperature, and system free air (see 6.3).

3.7 Utility system design. All hydraulically operated services (excluding flight controls covered by 3.2) that are essential to the accomplishment of the basic aircraft mission (weapon-bay doors, in-flight refueling, etc) or essential to land and stop the aircraft (landing gear, brakes, excluding types I and IV brakes of MIL-B-8584) shall have provisions for emergency actuation. No failure of the utility system shall result in loss of the aircraft or damage that would prevent safe flight and safe landing of the aircraft.

3.7.1 Wheel brake systems. Wheel brake systems shall be in accordance "with MIL-B-8584.

3.8 Flight control system design. Flight control systems as defined in paragraph 6.2, which require hydraulic power for operation shall conform to MIL-F-9490. In dual flight control systems, both systems shall be so designed that ground service equipment may be connected to either one of the flight control systems and that system may be operated without adverse effects on the unpressurized system, such as overflow of the system or failure of any part thereof. In order to accomplish this objective, automatic bypass of the fluid in the unpressurized system from one side of the actuator piston to the other side may be provided.

3.8.1 System isolation. Whenever hydraulic power is required for primary flight controls, a completely separate, integral hydraulic system shall be provided to supply only the primary flight controls. This hydraulic system shall not be.used to supply any other system or component in the aircraft, unless approval is obtained from the contracting activity. This hydraulic system shall contain a minimum number of components. Dual actuator systems may employ the combined flight control and utility function for one-half of the power, In which case the flight control function shall be given pressure priority.

3.8.1.1 Hydromechanical components built-in-test (BIT) function. All primary flight control hydromechanical components shall be fully integrated into the BIT system.

3.8.2 Hydraulic power failures. In aircraft, where direct mechanical control is unable to obtain aircraft-controllability and the emergency requirements of MIL-F-8785 cannot be accomplished following hydraulic power failures, an emergency power source shall be designed to provide controllability.

3.8.2.1 Emergency system application. The means of engaging the emergency power system shall be either manual or automatic; however, they shall be of the simplest and most reliable nature possible, consistent with the requirements of the aircraft. Manual engagement of the emergency power system shall not be used unless specifically approved by the contracting activity. If the aircraft has a single engine, the emergency power source shall be independent of the operation of this engine. On multiple engine aircraft the emergency source of power shall be on a different engine than the primary source of power. In some cases, it is permissible to utilize the utility hydraulic system as the emergency source of power, if it is accomplished in such a way that there is no interconnection with the flight control power system. No single failure can cause loss of both flight control and utility systems. Consideration shall be given to the possibility of landings where in none of the engines are operating. Because some engines will not windmill enough to provide flight control power during landing, it may be necessary to provide emergency power sources not dependent upon engine operation. In aircraft which are capable of being landed without engine power, this condition shall not be considered an emergency, and provisions shall be made for landings with one of the power systems failed while out of fuel. when designing for this condition, extreme care must be exercised not to reduce the reliability of the power systems. The flight control power system shall return to normal operation upon correction of the emergency condition. where a ram air turbine is used as the source of emergency power, it shall be capable of extension and operation under any flight conditions. The ram air turbine shall be capable of retraction If the flight control system returns to normal operation.

3.8.2.2 Disengagement and bypass. Where direct mechanical control is utilized following primary hydraulic system failure, provisions shall be made for automatic, direct bypass-of the fluid from one side of the primary flight control actuator piston to the other side. where the actuator can be disengaged from the system, bypass will not be required. For dual actuator systems, the failed system shall provide automatic bypass. Bypass damping may be required on critical stiffness actuator designs.

3.8.3 System separation. Hydraulic systems shall be separated as far as the design will allow to be less vulnerable and survivable to gunfire or engine fires. Where design permits, multiple hydraulic systems should be on opposite sides of the fuselage, the wing spar, or similarly separated. The systems necessary for safe flight shall be separated a minimum of 18 Inches unless survivability and vulnerability analyses show that less separation is satisfactory. where it is deemed necessary for these systems to come together, as in a dual tandem surface actuator, the actuator shall be protected from the threat to a degree specified by the contracting activity.

3.8.4 Subsystems pressure. Subsystems and branch circuits which use a pressure lower than the full system pressure shall be designed to withstand and operate under full system pressure or shall have a relief valve installed downstream of the pressure reducing valve. This relief valve may be incorporated Into the same housing as the pressure reducer, provided the relief valve mechanism is independent of the pressure reducer mechanism. The relief valve shall be capable of handling the full flow of the pressure reducer. Bypass of the relief valve shall cause an external indicatior to signal a failed pressure reducer.

3.8.5 Flight control power sources. Aircraft primary flight control hydraulic systems shall have engine driven pumps as their source of power. Helicopter primary flight control systems shall have transmission driven pumps as a source of power so that power will be available during auto rotation.

3.8.6 System temperature. The hydraulic flight control actuators shall provide the required actuation rates under minimum and maximum in-flight fluid and ambient temperatures. The flight critical components shall not bind or jam under any combination of in-flight fluid and ambient temperature conditions including single undetected failures, such as relief valves, worn pumps, failed valves and other heat generating failures. The effects of differential fluid temperature in tandem units shall also be demonstrated.

3.9 Emergency system design for utility system.

3.9.1 Emergency system types. Where emergency devices are required in hydraulic systems, the emergency systems shall be completely independent of the main system up to, but not necessarily including, the shuttle valve, the actuating cylinder, or motor. The system shall be so designed that failure of an actuator in one subsystem shall not prevent the operation of or cause the failure of both normal and emergency actuation of another subsystem. These emergency systems shall utilize hydraulic fluid, compressed gas, gas generating devices, direct mechanical connection, or gravity. Mechanical connections may include electromechanical units.

3.9.1.1 High lift devices. Where safe operational landings cannot be accomplished without the use of hydraulically operated high lift devices, they shall be powered by dual actuator hydraulic systems or shall be provided with an emergency system.

3.9.2 Emergency line venting. The emergency line from the shuttle valves shall be vented to the reservoir or to a low pressure (15 psi gage maximum, above reservoir pressurization) nonsurging return line when the emergency system is not in use. When shuttle valve leakage is not critical, the line may be vented to the atmosphere. Provisions shall be made to bleed the compressed gas to the atmosphere rather than back to the reservoir after actuation of the emergency system.

3.10 Components. All components used in the system (s) shall conform to MIL-H-8775, and the appropriate detailed specifications, except the requirements shall be upgraded to agree with Table 11 with respect to operating and test pressures. All components used shall meet the impulse testing requirements as specified in ARP 603 or ARP 1383. All protective finishes shall be in accordance with MIL-F-7179.

3.10.1 Standard components. Standard components shall be used in preference to nonstandard components. Where no applicable AN, MS, or industry standard exists, a uniquely designed component compatible with the performance, installation, and inspection, and maintenance requirements shall be used.

3.10.2 Fixed orifices. Orifices larger than 0.005 inch diameter but smaller than 0.070 inch diameter shall be protected by adjacent integral strainer elements (last chance screens) having screen-openings one-third to two-thirds of the diameter of the orifice being protected. Orifices smaller than the 0.005 inch diameter are prohibited. Multiple-orifice fixed restrictors are recommended as a means of increasing the orifice diameter and allowing the use of coarser strainer elements, minimizing the risk of clogging. Orifice and strainer eiements, in combination, shall be strong enough to absorb system design flow and pressure drop without rupture or permanent deformation.

3.10.3 Actuators essential to safe operation of the aircraft. Where two or more independent hydraulic systems are utilized to power services essential for safe flight (e.g., primary flight controls), the actuation and control devices shall be designed and constructed (either parallel or series configuration) so that no single structural or hydraulic failure may cause loss of more than one hydraulic system allow transfer of fluid from one system to another. Aluminum shall not be used as a barrel material for actuators essential to safe operation (flight control and landing gear).

3.11 Component design and installation. If a fluid such as MIL-H-46170, which is different from the specified fluid, is used for component testing and shipping, it shall be drained prior to the installation of the component in the aircraft.

3.11.1 Design practice and installation. The hydraulic system component Installation requirements specified in the following subparagraphs are considered to be good design practice, however, it is recognized that variations from these practices will, in many cases, be necessary due to specific installation requirements. All installation of standard parts or components shall be designed to accommodate the worst dimensional and operational conditions permitted in the applicable part or component specification of an or MS standards. All components shall be installed and mounted to withstand all expected acceleration loads, wrench loads, and vibration effects.

3.11.1.1 Reverse installation. All system components shall be designed so that reverse installation cannot occur. Nonstandard components shall be used, if necessary, to conform to these requirements.

3.11.2 Accumulators. Accumulators shall be installed with the utmost consideration given to the protection of crew members and flight essential systems in case of rupture resulting from gun fire. Hydraulic accumulators shall be in accordance with ARP 4553 (self-displacing hydraulic accumulators), or ARP 4378 (maintenance-free hydraulic accumulators).

3.11.2.l Measurement of accumulator gas pressure. When accumulator gas charge is critical to the functioning of the hydraulic system or subsystem, a permanent pressure indicating device-shall be attached to the gas side of the accumulator. The pressure indicating device shall not be used to indicate equivalent hydraulic pressure to the crew members.

3.11 .2.2 Accumulator accessibility. In accumulator installations that require gas charging in the field, space shall be provided around the gas charging valve for use of a MIL-G-8348 high-pressure, gas-testing gage assembly and for standard fitting connections to charge accumulators.

3.11.2.3 Accumulator instructions. If the accumulator is rechargeable in the field, instructions for servicing the accumulator with gas pressure with the accumulator oil chamber discharged shall be provided adjacent to the accumulator. Information shall be included to indicate the proper gas preload pressure throughout the temperature range for which the accumulator will be serviced.

3.11.2.4 Gas requirements. Accumulators shall be charged with inert gas only.

3.11.3 Actuating cylinders. Hydraulic actuating cylinders shall be so installed that they shall not interfere with the adjacent structure and are readily accessible-for maintenance. and inspection. 'If design permits, the cylinder shall be installed in a protected area, or if exposed, they shall be protected from flying debris during landing and takeoff. Actuating cylinders other than those used for primary flight control shall conform to MIL-A-5503. For higher pressure systems, MIL-A-5503 shall be used except the performance pressures shall be per Table II.

3.11.4 Manual bleed valves. Manual bleed valves shall conform to MIL-V-81940 and shall be so located that they can be operated without removal of other aircraft components. Such installations shall permit attachment of a flexible hose so that fluid bleed off may be directed into a container (see 3.6.9).

3.11.5 Brake valves. Brake valves shall be installed in accordance with MIL-B-8584 and shall conform to MIL-V-5525.

3.11.6 Check valves. Check valves shall conform to MIL-V-25675, MIL-V-19067, or MIL-V-19069.

3.11.7 Directional control valves. The installation of diretional control valves shall be compatible with the control valve performance such that the system operation may not be affected by back pressure, internal flow, or pressure surges which might tend to cause the valves to open or move from their setting or cause them to transfer fluid from one system to the other. Hydraulic control valves shall not be installed in the pilot's cockpit or compartment.

3.11.7.1 Directional control valve handle installation. All installations of directional control valve handles shall conform to MIL-STD-1472. Valve installation shall incorporate internal or external stops capable of withstanding limit loads generated by the application of 75 lbs on the handle grip without detrimental effects.

3.11.7.2 Multiple control valve systems. In systems which incorporate two or more directional control valves, provision shall be made to prevent fluid from being transferred inadvertently, at any possible valve setting, from the cylinder ports of one valve into the cylinder ports of another valve.

3.11.7.3 Control valve actuation. Control valve operation may be direct, such as push-pull rods, cable control, or indirect, such as electrically operated" controls. Push-pull rods shall require a minimum or no adjustment. Sheathed flexible controls shall not be used. Cable control shall be designed to provide minimum adjustment and positive control. All controls shall be designed to prevent overtravel or undertravel of the valve control handle by use of external or internal stops. Electrically operated valves shall be provided with mechanical override control mechanisms.

3.11.7.4 Control valve wiring. Electrically operated control valves shall be wired in accordance with MIL-W-5088.

3.11.8 Pressure requlatinq valves. Valves that reduce pressure for utility circuits shall conform to MIL-V-5519.

3.11.9 Filters. Filters in accordance with MIL-F-8815 with an element collapse pressure of 150% of operating pressure shall be provided in all hydraulic systems. These filters shall be used to filter all circulating fluid In the system. The pump pressure line filter shall be located downstream from the ground servicing connection point, otherwise, an additional filter shall be required to filter fluid entering the aircraft from the ground servicing unit. All vent openings or fluid exposed to breathing action through vents shall be protected by filters. Line filters installed in the aircraft system in close proximity to an accumulator, shall be, if design permits, installed upstream from the accumulator. When a secondary or last chance type filter screen is used internal to or in close proximity to a component, provisions shall be made for removal and replacement of the screen. Sintered metal powder type elements shall not be used in hydraulic systems. These types of filters may be used only as aire vent filters. The system filter condition shall be monitored electronically.

3.11.9.1 Aircraft filters. All filters installed in the hydraulic system(s) shall be in accordance with the requirements of MIL-F-8815/4, MIL-F-8815/5,. and MIL-F-8815/6 as applicable. All filter elements shall be capable of maintaining the particulate contamination level equal to or better than the following: Class 8 per as 4059 in accordance with Method 3009 of FED-STD-791, with automatic particle counter calibrated per ARP 1192 or microscopic particle counts per ARP 598. Fluid samples for contamination tests shall be obtained from sampling valves specified in 3.6.14.

3.11.9.2 Filter locations. Filters shall be provide in the following locations as a minimum requirement.

3.11.9.1 pressure filter installation. A non-bypass-type filter shall be installed in the system pressure circuit and shall be so located that all fluid from the aircraft pump will be filtered prior to entering any major equipment or components of the system. In multiple pump systems, each pump shall have a separate filter installation.

3.11.9.2.2 Return filter installation. A bypass-type filter shall be installed in the return circuit. All fluid entering the return circuit shall be circulated through the filter prior to entering the return line to the pump(s) and reservoir.

3.11.9.2.3 Reservoir fill filter installation. A non-bypass-type filter shall be installed to filter all fluid entering the system through the reservoir fill connection. The main system return filter or the-pump case drain filter may also be used for this function provided check valves are installed in the system to prevent back flow to components. Also, the fill fluid flow rate shall be limited to prevent opening of the filter housing bypass valve.

3.11.9.2.4 Pump-case-drain filter installation. Each pump-case-drain line shall have a bypass-type filter installed.

3.11.9.2.5 Pump suction filter installation. Filters shall not be installed between the system reservoir and the pump suction port.

3.11.9.3 Hydraulic sequencing. Where hydraulic sequencying is critical, and where contamination can prevent proper sequencing, each sequence valve shall be protected from contamination in each direction of flow by a screen-type filter element. This element may be included as a part of the sequence valve assembly.

3.11.9.4 Ground support equipment filtration. All ground support equipment hydraulic filters shall be qualified to MIL-F-81836.

3.11.10 Fittings. As much as design permits, tube fittings shall be of the permanent type employing no screw threads. Threaded, reconnectable type fittings shall be used for component installation, production break points, and at other points consistent with the maintenance plan of the aircraft. Repair and replacement methods involving failed tubing and fittings shall be established for each aircraft model and shall be included in the applicable aircraft publications. Fittings with threaded connections shall conform to MIL-F-85421 for Class 4000 pressure or less and MIL-F-85720 for greater than Class 4000. For installation in the aircraft, no lubrication or bonding material shall be applied to the threads of reconnectable fittings except for the fluid specified in paragraph 3.3. Any other lubricating material necessary for the correct installation of the fitting is specified in the fitting specification and is permanently applied to the fittings (see 6.3).

3.11.10.1 Boss fittings. Ring locked type boss fittings shall be used in all components. Ports for these fittings shall conform to the requirement of AS 1300 for Class 5000 systems and below and AS 4201 for Class 8000 systems and below. These ring locked fittings shall mate to either MIL-F-85421 or MIL-F-85720 fittings. For Class 4000 systems and below, MS33649 port may be used if design permits.

3.11.11 Flow dividers. Flow dividers shallnot be used if the effect of a malfunction of the flow divider would result in an unsafe flight condition.

3.11.12 Flow regulators. Flow regulators may be installed in the hydraulic system to limit the rate of fluid flow. They shall conform to MIL-V-8566 for Type I systems. The direction and rate of fluied flow shall be clearly indicated on the flow regulator and the adjacent structure. Regulators used under continuous dynamic conditions shall not adversely affect the operation of the hydraulic system.

3.11.13 Protective devices. Hydraulic fuses, circuit breakers, reservoir level sensors, or other similar devices may be used to meet survivability requirements. Premature or inadvertent shutoff or any other malfunction of such devices shall not occur during any flow or pressure variations or any conditions of system operation. The function and reliability of such devices shall be demonstrated in the functional mock-up and simulator. Hydraulic fuses for Type I systems shall conform to MIL-F-5508 (see 6.3).

3.11.13.1 Second tier screens. It is recommended that second tier screens, as defined by AIR 4057 should, when fully clogged, withstand a proof pressure test without collapse, rupture, or permanent deformation.

3.11.14 Snubbers. Pressure snubbers shall be used with all hydraulic pressure transmitters, hydraulic pressure switches, and hydraulic pressure gages as required. Snubbers may be an integral part of the pressure transmitter switch or gauge. Pneumatic pressure gages are excluded from this requirement.

3.11.15 Manually operated pumps. Where a manually operated pump is required, either a hand-actuated or foot-actuated pump shall be selected, based on trade-off studies. In installations where a pump can be operated by personnel in a standing position, strong consideration shall be given to a foot pump to minimize physical exertion.

3.11.15.1 Manually operated pump suction line. No screen or filter shall be used in the suction line of the pump. The suction line shall be of a diameter and length to insure priming a dry pump and obtaining full rated flow at -40°F (-40°C) temperature within 12 complete cycles at a rate of 20 cycles per minute. The pump circuit shall be capable of full priming and rated flow in flight at the highest altitude at which pump operation is essential and Intended.

3.11.15.2. Manually operated pump check valve. A standard check valve shall be provided in the pump pressure line.

3.11.15.3 Hand pump handle length. The effective operating handle length of hand pumps shall be such that the handle load shall not exceed 67 pounds. The length of this handle travel at the handgrip shall not exceed 18 inches.

3.11.16 Flexible connections. Whenever relative motion exists between two points, metal coiled tubing in accordance with ARP 584 or ARP 4146 shall be used unless hoses, extension units, or swivels are demonstrated to be superior in the application and the environment. Hoses are preferred over extension units and swivels and shall be selected according to the followlng paragraphs.

3.11.16.1 Hose assemblies. Hose assemlies shall not be subjected to torsional deflection (twisting) when installed, or during system actuation. No hose clamp type installation shall be used in hydraulic systems. Class 1500 polytetrafluoroethylene hose assemblies shall conform to MIL-H-25579. These hose assemblies shall have permanent type end fittings and their installation shall allow space to permit replacement with spares conforming to MIL-H-27267 and MIL-F-27272. Class 3000 polytetrafluoroethylene hose shall conform to AS 604 and AS 1339. Class 4000 polytetrafluoroethylene hose shall conform to AS 614 and AS 1975. Installations shall permit replacemen with MIL-H-83298 and MIL-F-83296 hose assemblies. Class 5000 and Class 8000 aramid fiber hoses shall conform to MIL-H-85800.

3.11.16.2 Hose support. The support of a flexible line shall be such that it will not tend to cause deflection of the rigid lines under any possible relative motion that may occur. Flexible hose between two rigid connections may have excessive motion restrained where necessary but shall not be rigidly supported as by a tight rigid clamp around the outside diameter of the flexible hose. Extreme care should be used in the selection and placment the supports to assure that the flexible line is not restricted and does not rub on structure or adjacent members during any portion of its excursion. Clamping of aramid fiber hoses is not permitted unless absolutely necessary to prevent chafing. Extreme caution must be used in clcl these hoses to prevent any damage to the chafe guard or underlying fibers.

3.11.16.3 Hose bend radii. The minimum radius of bend for hose assemblies shall be a function of hose size and flexing range to which the hose installation will be subjected. The minimum bend radius as installed for hoses shall be in accordance with the applicable hose specification.

3.11.16.4 Hose protection. Hose shall be protected against chafing where necessary to preclude damage to the hose and to the adjoining structure, tubing, wiring, and other equipment.

3.11.16.5 Provisions for hose elongation and contraction. Hose assemblies shall be so selected and installed that elongation and contraction under pressure, within the hose specification limits, shall not be detrimental to the installation either by causing strains on the end fittings or excessive binding or chafing of the hose.

3.11.17 Lock valves. Where lock valves are used, provisions shall be made for fluid expansion and contraction throughout the temperature range. Where several actuating cylinders are mechanically tied together, only one lock valve shall be used to hydraulically lock all actuators so tied together (see 6.3).

3.11.18 Motors. All constant-displacement motors shall be in accordance with MIL-M-7997 and they shall be accessible for maintenance and inspection. Case flow connections shall be provided using a check valve in the case drain line. All case drain lines should be connected to the system return line upstream of the reservoir provided the return steady state pressure is lower than the motor case pressure. Connection of case drain lines to the actuators' return line is prohibited. Shaft seal drain shall vented overboard.

3.11.19 Power pump variable delivery. Variable delivery pumps shall be in accordance with MIL-P-19592. The pressure differential between the pump-case cooling port and the reservoir shall be such as to permit the pump to maintain cooling flow in any pump flow condition including zero flow.

3.11.19.1 Electric motor driven pumps. Electric motor driven hydraulic pumps in accordance with MIL-P-5954 or MIL-P-5994 may be used, as necessary, for either normal, emergency, or auxiliary operation of hydraulic systems.

3.11.20 Power pump fixed displacement. Fixed displacement pumps shall be in accordance with MIL-P-7858. Fixed displacement power pumps shall not be used as the main source of fluid power in any system.

3.11.21 Relief valves, system and thermal expansion. Relief valves shall conform to MIL-V-8813 or MIL-V-85245. The system relief valves shall be designed as safety devices to prevent bursting or other damage to the system if the normal pressure regulation device malfunctions, a blocked line condition occurs, or overload forces are generated on actuating units. Excessive system pressure caused by thermal expansion of the fluid shall be relieved through the thermal expansion relief valves. Relief valves are to be used as safety devices and not as pressure regulating devices.

3.11.21.1 System relief valves. System pressure relief valves shall relieve excessive pressure through bypass of fluid from the pressure to the return side (see Table II). The valves shall have a capacity equal to or greater than the rated flow of the largest pump when two or more pumps have a common pressure line. The systems shall be disigned so that the fluid flowing through the system relief valves does not exceed the temperature of 160°F (+71°C) for Type I systems or 275°F (+135°C) for Type II systems.

3.11.21.2 Thermal expansion relief valves. Thermal expansion relief valves shall conform to MIL-V-5527. For subsystems isolated from the system relief valve, local relief valves shall be installed to prevent excessive pressure rise and system damage resulting from thermal expansion of hydraulic fluid. The valve shall relieve fluid to the return side of the system. Internal valve leakage shall not be considered an acceptable method of providing thermal relief (see Table II for relief valve setting).

3.11.22 Reservoirs. Hydraulic reservoirs shall be designed in accordance with MIL-R-8931. When a hydraulic emergency system is used in any military aircraft, except trainer types, a separate emergency reservoir shall be provided. The emergency reservoir shall be located as remote as design permits from the main reservoir to minimize the effect of gunfire damage. Both the main and emergency reservoirs shall be serviceable through a common filler port unless design does not permit it. The fill and vent lines for all hydraulic reservoirs shall be designed so that rupture of any reservoir, fill, or vent lines will not cause fluid exchange between reservoirs or loss of sufficient fluid from any other reservoir to impair system operation. Reservoirs shall be protected from failure when rapid discharge of the main or emergency system into the reservoirs is encountered. Protection from overpressurization resulting from overfilling shall be incorporated into the reservoir subsystem. Pressurized reservoir installations shall include a repressurization valve for maintenance purposes.

3.11 .22.1 Reservoir location. It is desired that the reservoir shall be so located that the following conditions will be obtained:

a. A static head of fluid is supplied to the hand pump and the power-driven pump or pumps in all normal flight attitudes of the aircraft

b. The length of suction line to the pump is a minimum

CO The best available temperature and pressure is utilized, but must not be installed in engine compartments

d. There is maximum protection from combat damage

e. Suction lines shall be so routed as to prevent breaking of the fluid column caused by gravity after engine shutdown and during the parking period. Where such routing is not possible, provisions shall be installed to maintain the fluid column to the pump after engine shutdown. A swing gate type check valve in the suction port of the reservoir should normally maintain the fluid column to the pump.

f. If routing of the pump bypass cannot be accomplished so that breaking of the fluid column by gravity after engine shutdown is prevented, check valves shall be incorporated in the lines.

3.11 .22.2 Gas pressurized reservoirs. The inert gas pressure shall be controlled by an externally nonadjustable pressure-regulating device to control the gas pressure in the reservoir. A relief valve shall also be connected to the airspace to protect the reservoir and pump from excessive pressure. If the air pressure regulator and relief valve are combined one housing, a single failure in that unit shall not permit overpressurization of the reservoir.

3.11 .22.3 Reservoir air pressuization moisture removal equipment. When engine bleed air is used for reservoir pressurization, a moisture removal unit shall be installed at a location to protect the pressure regulation lines and equipment. Bleed line components shall be installed to minimize the effects of trapped moisture. A filiter shall be provided.

3.11 .22.4 Reservoir fluid level Indication. Reservoir fluid level indication shall be provided both on the reservoir itself as required in MIL-R-8931 and also in the cockpit. Both fluid level indications shall be temperature compensated for the correct volume for any temperature as specified in 3.6.1.1 of this document. Cockpit indicator fluid level markings shall correspond to the direct-reading fluid level indicator markings provided on the reservoir and shall be lighted in accordance with applicable cockpit lighting requirements. A warining light shall also be provided to signal the pilot of a low fluid level condition. The cockpit fluid level indicator shall not eliminate the requirement for the direct-reading fluid level indicator on the reservoir itself, as this is required for reservoir servicing with power off. The reservoir level moitoring and branch circuit isolation shall be accomplished electronically.

3.11 .22.5 Bootstrap reservoir pressurization. In the event that normal system pressure is lost for any reason, bootstrap reservoir pressurization shall be maintained to help prevent pump cavitation and assist in the purging of free air from the pump. This may be accomplished by placing the accumulators and check valves in the bootstrap circuit. Provision for depleting this trapped pressure and repressurizing the reservoir for ground maintenance shall be Incorporated into the circuit.

3.11.23 Restrictor valves. Adjustable orifice restrictor valves may be uses in experimental aircraft, but only fixed orifice restrictor valves shall be used in service test and production aircraft. One-way restrictors shall be designed with different port sizes on each end to prevent installation in the wrong flow direction. The direction of resticted and unrestricted flow shall be indicated on the restrictor. (For fixed orifice filtration requirements, see 3.10.2.)

3.11.24 Self-sealing couplings. Self-sealing couplings shall conform to MIL-C-25427. Hydraulic systems shall be provided with self-sealing couplings for each engine driven pump and so located that the pump can be readily removed for servicing. A coupling shall be used in each line going to each pump. Self-sealing couplings shall also be provided on all hydraulically operated brake installations where it is necessary to disconnect the brake line in order to remove the wheel. The self-sealing coupling shall be attached to the brake, and it shall be possible to remove the wheel without damaging the coupling. Self-sealing couplings shall also be provided at all other points in the hydraulic system which require frequent disassembly or, where convenient, to isolate parts of the system as in jacking and servicing one landing gear only. If required, provisions for connecting couplings with trapped pressure in the hydraulic system shall be incorporated in the coupling design. Clearaance shall be provided around the coupling to permit connection and disconnection. Self-sealing couplings installed adjacent to each other shall be of different size or be otherwise so designed that inadvertent cross connection of the lines cannot occur.

3.11.24.1 Airframe break points. When self-sealing couplings are provided at airframe break points, especially in flight control systems, and where disconnection.of such a coupling or couplings will adversely affect the operation of any of these systems, the coupling design shall prevent inadvertent disconnection. The design shall also provide an indication when a coupling connection is incomplete. If the means of preventing inadvertent disconnection are not absolutely positive, the system shall be so designed that a hydraulic lock resulting from an inadvertent coupling disconnection will not be the cause of an aircraft accident.

3.11.24.2 Component, modular quick disconnects. When self-sealing couplings are used to mount components, they shall conform to AS 4251 except at specified pressure. The design shall provide delection and separation forces. LOcating pins may be used to aid installation as specified in the procurement document.

3.11.25 Shuttle valves. Shuttle valves shall conform to MIL-V-5530 for Type I systems and MIL-V-19068 for Type II systems. Shuttle valves shall not be used in installations in which a force balance can be obtained on both inlet ports simultaneously which may cause the shuttle valve to restrict flow from the outlet port. Where shuttle valves are necessary to connect an actuating cylinder with the normal and emergency systems, the shuttle valve unit shall be built into the appropriate cylinder head, using component parts of applicable AN or MS approved shuttle valves in a cartridge. Where the above installation cannot be made, a standard shuttle valve may be located at the actuator port and shall be tested to the same requirements as the actuator. In the event neither of the above installations is possible, a length of rigid line is permissible between the cylinder port and the shuttle valve, provided the rigid line and shuttle valve are firmly attached to the actuating cylinder. Hoses shall not be used between the actuating cylinder port and the shuttle valve.

3.11.26 Pressure switches. Pressure switches may be installed in hydraulic systems where the regulation of hydraulic pressure is required by controlling an electric motor driven pump. Precautions shall be taken to prevent chatter or cutoff. Pressure swithches shall conform to the requirements of MIL-S-9395.

3.11.27 Swivel joints. Swivel joints shall be designed in accordance with MIL-J-5513 except all pressure-to-atmosphere dynamic seals shall be dual .unvented. Hoses and coilde tubes have superior in-service life and should be used in place of swivel joints where design permits. Where lines or fittings are used to drive swivel joints, they shall be supported and strong enough to ensure proper operating installation.

3.11.28 Tubing.

3.11.28.1 Tubing materials. Tubing shall be either corrosion resistant steel conforming to MIL-T-6845, MIL-T-8504, AMS 5561, or titanium alloy conforming to AMS 4945. Aluminum alloy tubing per MIL-T-7081 may be used in pump suction lines and drain lines only. The minimum wall thickness in any alloy or tube size shall be 0.020 inch.

3.11.28.2 Tube ovality and bends. Bends shall be uniform and shall be in accordance with MS33611. Tubing ovality shall not exceed 3% for titanium alloys, 5% for corrosion resistant steels, and 10% for aluminum alloys. These ovality limits apply to tubing as installed in the air vehicle.

3.11.28.2.1 Tubing pre-stress (autofrettage). For tube flatness greater than the limits of MS33611, tubing pre-stress (autofrettage) may be used to reduce the flatness to meet the requirements of MS33611 for tube assemblies.

3.11.28.3 Installation of small size tubing. If tubing in sizes smaller than 3/8-inch outside diameter (-6 size) is used in hydraulic systems, particular care shall be taken to properly install, support, and protect it, and it must be shown that proper operation of the service in which such tubing is used will be possible at -40°F (-40°C) temperature.

3.11.28.4 Straight tubing. Straight tubing between two rigid tubing end connections shall not be used.

3.11.28.5 Tubing and fitting identification. All hydraulic fluid lines shall be permanently marked using identification markings which are in accordance with MIL-STD-1247. Hoses do not have to be marked if the adjacent tubing or component identify the function. Hydraulic lines shall be marked in conspicuous locations throughout the aircraft in order that each run or line may be traced. This marking shall indicate the unit operated and the direction of flow, such as LANDING GEAR UP ======> or FLAPS DOWN ======>. These markings shall be repeated as often as necessary, particularly on lines entering and emerging from closed compartments, to facilitate maintenance work. Where fittings are located in members, such as bulkheads and webs, each fitting location shall be identified (placarded) as to system function, using the same terminology as on its connecting line.

3.11.28.6 Tubing support. All hydraulic tubing shall be supported from rigid structure by MIL-C-85052 (MIL-C-85052/l or MIL-C-85052/3) loop type cushion clamps, MIL-C-85449 (MIL-C-85052/1 or MIL-C-85052/3) saddle type cushion clamps, or line block clamps. Supports shall be placed as closely as design permits to the start of the bend to minimize tube overhang. Maximum spacings between supports are specified in Table III, except that where tubes support fittings such as unions and tees, spacings should be reduced approximately 20 percent. When the required spacing cannot be met, analysis shall be provided to substantiate that the line natural frequency falls outside of any excitation frequency band within the region of interest. Where tubes of different diameters are connected together, spacing of the smallest tube diameter shall be used. Provisions shall be made in support location to accommodate change in tubing length caused by expansion and contraction. In order to facilitate inspection and repair, tubing shall not be bundled together.

3.11.28.7 Location of hydraulic tubing. Hydraulic lines shall not be installed in the cockpit or cabin and shall be remote from personnel stations. In addition, hydraulic lines shall be located remotely from exhaust stacks and manifolds, electrical, radio, oxygen, and equipment lines, and insulating materials. In all cases, the hydraulic lines shall be routed below these items to prevent fire from line leakage. Hydraulic lines shall not be grouped with lines carrying other flammable fluids in order to prevent inadvertent cross connection of different systems. Hydraulic drain and vent lines shall exhaust in areas where the fluid cannot be blown into the aircraft, collect in pools in the structure, or be blown onto or near exhaust stacks, manifolds, or other sources of heat. Tubing shall be located so that damage cannot occur from being stepped on, used as handholds, or by manipulation of tools during maintenance. Components and lines shall be so located that easy accessibility for inspection, adjustment, and repair is possible. Hydraulic tubing shall not be used to provide support of other aircraft installations, such as wiring, other aircraft tubing, or similar installations. Attachment of so-called marriage clamps for spacing of such installations is likewise prohibited. Marriage clamps may be used where required to maintain clearances between hydraulic tubing runs, but not for support of such tubes.

3.11.28.8 Tubing flares and assembly. Tubing flares shall conform to MS33583 or MS33584 and shall be used only in drain or vent lines. When installing tube connections, care must be exercised to keep the wrecnh torque used to assemble each joint within the limits specified on MS21344.

3.11.29 Design of system installations. The installation practices of ARP 994 should be used as a guide.

3.11.29.1 Component lines. Two or more lines attached to a hydraulic component shall be designed so as to prevent incorrect connection to the component.

3.11.29.2 Drain lines. Drain or overboard vent lines coming from the pump, reservoir, or other hydraulic componennts shall not be connected to any other line or any other fluid system in the aircraft in such manner as to permit mixture of the fluids at any of the components being drained or vented.

TABLE III. Hydraulic Line Support Spacing

Dash Size	Nominal Tube OD (inches)	Maximum Length Between Support Centers (measured along tube)				
		Titanium (inches)		Steel (inches)		Aluminum alloy (inches)
		(1)	(2)	(1)	(2)	
-3	.188	13	7	14	8	12
-4	.250	15	8	16	10	13.50
-5	.313	16	9	18	11	15
-6	.375	17	10	20	12	16.50
-7	.438	18.5	11	21.5	13	18
-8	.500	20	12	23	14	19
-9	.563	21	12.5	24.25	15	20.50
-10	.625	22	13	25.50	15	22
-11	.688	23	14	25.50	15	22
-12	.750	24	15	27.50	16	23
-13	.813	25	15.50	28	17	24
-14	.875	26	16	28.50	17	25.25
-15	.938	27	16.50	29	17.5	25.25
-16	1.000	28	17	30	18	26.50
-20	1.250	31	19	31.50	19	28.50
-24	1.500	34	21	32.50	19.5	29.50

(1) Normal Vibration Environment
(2) Severe Dynamic Environment - Nacelle, Landing gear, Pump pressure line to the filter.

3.11.29.3 Mounting lightweight components. Lightweight components that do not have mounting provisions may be supported by the tubing installation, provided the component is rigidly installed and does not result in destructive vibration or cause other adverse conditions to the tubing installation. Clamps or similar devices may be used to support such units to structure, provided that nameplates, flow-direction arrows or markings, or tother data is not obscured and that the supporting members do not affect the operation of the unit. If the unit cannot be supported by a clamp, the tubes on each side of the components shall be clamped to structure within two inches of the component.

3.11.29.4 Electrical bonding, grounding, and lightning protectors. The aircraft hydraulic system components, tubing, and distribution elements shall be bonded to the aircraft in accordance with MIL-B-5087. All electrically conductive components shall have a mounting point to structure resistance not exceeding 2.5 mill milliohms.

3.11.29.5 Vibration. The complete hydraulic system, including lines and components, shall be designed to withstand the efffect of vibration, pump pulsation, and shock loads encountered during service operation of the aircraft. Care shall be taken to ensure that main pump pressure discharge lines, clamps and components can withstand the most adverse conditions of pump cavitation, pulsation, and vibration. Aramid fiber braid hose per MIL-G-85800 and AS 1975 and wire braid hose per AS 1339 shall not be used in pump discharge lines .due to the hose's low vibration-tolerant construction.

3.11.29.6 Tubing clearance. Where tubing is supported to structure or other rigid members, a minimum tube to structure clearance equal to hte tube clamp thickness shall be maintained with such member. A minimum clearance of 0.25 inch shall be maintained with adjacent structure, tubing, or other installations. In areas where relative motion of adjoining components exists, a minimum clearance of .25 inch shall be maintained under the most adverse conditions that may be encountered. It is an objective that tube replacement or repair be accomplished without removing adjacent tubes. ARP 994 provides data on tool clearances required for installation arid repair of tubes using various approved fittings.

3.11.29.7 Pump suction line design. The pump suction line shall be designed to provide flow and pressure at the pump inlet port. This requirement shall include operating the pump at the maximum output flow and shall include all ground and flight conditions the aircraft will encounter. Zero g and negative g conditions and low temperature start and operation shall also be included in the above requirement.

3.11.29.8 Flight control actuators. Consideration should be given to the clearance between moving flight control system components and structure or other components to ensure that no possible combination of temperature effects, airloads, or structural deflections can cause binding, rubbing, or jamming of any portion of the primary flight control system.

3.12 Hydraulic system information. To obtain approval of the hydraulic system, the information in the following subparagraphs shall be included.

3.12.1 Hydraulic system analysis and design study. This study shall be done on proposed new aircraft during the preliminary design and definition phases of research, experimental, or prototype aircraft (see 6.3 and Appendix A).

3.12.2 Developmental and preproduction study. This study shall be done during the development phase of the hydraulic system (see 6.3 and Appendix A).

3.12.2.1 Component tests. Tests shall be made on components other than those specified in Appendix B, 30.1 when analysis suggests that these tests are required (see 6.3 and Appendix B).

3.12.3 Hydraulic system production study. This study applies if there are any changes in the hydraulic system after the development phase (see 6.3 and Appendix A).

3.12.3.1 Functional test specification. This is a specification incorporating the necessary functional tests of the hydraulic system of production aircraft (see 6.3 and Appendix B).

3.12.3.2 Schematic diagram. The schematic diagram should be such as to present the system in a clear and easily readable form, with complete subsystems grouped and labeled accordingly (see 6.3 and Appendix A).

3. 12.3.3 Schematic diagram of the mechanical to hydraulic systems. This is a schematic diagram linking the mechanical system with the hydraulic system (see 6.3 and Appendix A).

3.12.3.4 Schematic diagram for electrical wiring. This is a schematic diagram of the electrical portion of the hydraulic system (see 6.3 and Appendix A).

3.12.4 Hydraulic system design. The design information shall be gathered prior to or with the final schematic diagram (see 6.3 and Appendix A).

3.12.5 Hydraulic system nonstandard component cross-sectional assembly drawings. The nonstanard component cross-sectional assembly drawings shall contain information for an evaluation to determine whether the nonstandard component should be used (see 6.3 and Appendix A).

3.12.6 Functional simulator design and test program. A general design for the functional simulator shall be made 30 days prior to construction of the simulator (see 6.3 and Appendix A).

3.12.7 Vibration test plan. A hydraulic system vibration test plan shall be written for first flight aircraft (see 6.3 and Appendix A).

3.13 Workmanship. Workmanship shall be of such quality as to assure that the hydraulic systems furnished under this specification are free of defects that compromise, limit or reduce performance or intended use.

4 QUALITY ASSURANCE PREVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3. The inspection requirements set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements; however, this does not authorize submission of known defective material, either indicated or actual, and does not commit the Government to accept defective material.

4.2 Inspection. The hydraulic system installation of one of the first complete experimental and production aircraft shall be subject to inspection for conformance to the requirements of this specification by engineering representatives of the contracting activity. It is expected that this inspection will be performed at the contractor's plant concurrently with similar engineering inspections of other systems of the aircraft. Detailed arrangements for the inspection will be the subject of correspondence between the contracting activity and the contractor.

4.2.1 Vibration prior to first flight. The hydraulic system of the first flight aircraft shall be tested prior to first flight to determine if any destructive vibration occurs as the result of any and all combinations of engine and hydraulic pump speed, and hydraulic pump flws pressurer. Hydraulic lines, hoses and their supports, fittings, and all components shall be checked. Corrective action shall be taken if required.

4.2.2 Ground and flight tests. The ground and flight test requirements for the testing of aircraft hydraulic systems designed in accordance with this specification shall be as specified in MIL-T-5522.

4.3 Cleaning of parts and systems. To assure that the hydraulic system is free of contamination, all parts of the hydraulic system shall be thoroughly cleaned prior to installation, and each new hydraulic system shall be operated at least 10 times in order to ensure filtration of all circulating fluid. Ground equipment which is used for this cleaning process shall be provided with filters specified in 3.11.9.4. Dead-end lines in the system shall be properly connected with jumpers to completely clean such lines. If the fiber element in the hydraulic system is used during this operation, it shall be replaced. Chlorinated solvents shall not be used to clean hydraulic components, lines of fittings.

4.3.1 System contamination level for production aircraft. A minimum of two contamination tests (see requirements 3.11.9.1) shall be performed on each major system, separated by a minimum of 2 flight hours and a determination made that a stable or decreasing particulate level has been achieved. Particulate contamination level shall be below the level specified in 3.11.9.1. The level of water in each hydraulic system shall be less than 250 parts per million at delivery. The level of chlorine shall be less than 100 parts per million at delivery. The method used to measure chlorine shall be .electron capture gas chromatography per MIL-STD-1844.

5 PREPARATION FOR DELIVERY

The section is not applicable to this specification.

6 NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The design and installation requirements covered by this specification are intended for use in aircraft hydraulic systems, such as the utility system, the flight control system, various subsystems, and with component installation procedures for temperatures from -65°F (-54°C) to 275°F (+135°c). Type III systems, -65°F (-54°C) to 450°F (+232°C), are covered by MIL-H-8891.

6.2 Definitions.

6.2.1 Utility system. The utility system includes all systems used for the normal operation of any services on the aircraft, excluding the systems used for the operation of the aircraft primary control surfaces.

6.2.2 Flight control system. Primary flight controls inlude those control systems used to actuate such surfaces as ailerons, rudders, elevators, stabilizers, or combined function surfaces.

6.2.2.1 Power boosted flight control system. A power boosted flight control system is a reversible control system wherein the pilot effort, which is exerted through a set of mechanical linkages, is at some point in these linkages boosted by a hydraulic power source.

6.2.2.2 Power operated flight control system. A power operated flight control system is an irreversible control system wherein the pilot, through a set of mechanical linkages, or electrical signals, actuates a power control servo-mechanism. This mechanism actuates the primary control surface or corresponding device. A system of this type may have electrical or electronic pilot input modes.

6.2.2.3 Combined flight control utility system. A combined flight control utility system (combined system) as a system that supplies a portion of the power required to operate the flight control system and also supplies power to the utility system.

6.3 Consideration of data requirements. The following data requirements should be considered when this specification is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are request cd/provided and that the DID's are tailored to reflect the requirements of specific acquisitiom. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form be pre-1423) must pared to obtain the data, except where DOD FAR Supplement 227.405-70 exempt .the requirement

Reference Para.	Number	DID Title	Suggested Tailoring
3.6.15	DI-NDTI-80809A	Test/Inspection Reports	Contracting activity approval prior to finalization of sys-tem design
3.11.10	DI-NDTI-80809A	Test/Inspection Reports	Contracting activitiy approval prior to installation
3.11.13	DI-NDTI-80809A	Test/Inspection Reports	Specific application subject to approval of the contracting activity
3.11.17	DI-NDTI-80809A	Test/Inspection Reports	Selection of lock valve for design subject to approval of contractinging act ivity
4.1.1	DI-NDT1-80809A	Test/Inspection Reports	10.2
3.12.1, 3.12.2 and 3.12.3	DI-MISC-80678	Certification/Data Report	
3.12.2.1 and 3.12.3.1	DI-MISC-80653	Test Reports	Delete 10.2a
3.12.3.2 thru 3.12.7	DI-MISC-80673	Certification/Data Report	

The above DID's were those cleared as of the date of this specification. The current issue of DoD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

6.4 Subject term (key words) listing.

Airplane fluid power
Fluid power
High pressure fluid power components

6.4.1 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:
Army - AV
Navy - AS
Air Force - 99

Review activity:
Air Force - 82, 71, 11
Navy - SH, 0S

User activity:
Army - AR, MI, ME, AT,

Preparing activity:
Navy - AS
(Project No. 1650-0441) .

APPENDIX A

CERTIFICATION/DATA REPORT TECHNICAL CONTENT REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers information that shall be included in the certification/data report when specified in the contract or order. This appendix is mandatory only when data item description DI-MISC-80678 is cited on the DD Form 1423.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. DATA SUBMITTAL

30.1 Hydraulic system analysis and design study report. The data listed in this paragraph should be submitted for evaluation of design studies of a proposed new aircraft during the preliminary design and definition phases of a research, experimental, or prototype aircraft. The contractor should submit a report covering such design studies and analyses as are required to establish the design parameters of the hydraulic system of the proposed aircraft. The design analysis should show that the hydraulic system fulfills the needs imposed by the weapon system requirements. This report should include the following Information and data:

a. Pressure and flow rates versus time for each mission profile along with the power load analysis

b. A thermal analysis with temperature-versus-time curves for fluid temperature for typical missions and for ground operations. This analysis shall include the highest and lowest temperatures expected in flight Including the maximum temperatures due to single failures such as worn pumps and relief valve bypass.

c. Fluid selection. Nonflammable (or less flammable) hydraulic fluids should be considered in the interest of reducing the potential fire hazard in a combat environment. The fluid selection should be based on a trade study to insure that specific improvements in safety and survivability are realized without excessive penalty in hydraulic system performance, operational capability, or cost of the aircraft. The trade study should consider reliability and all logistic aspects over the expected life of the aircraft including supply and maintenance as well as impact on support and service equipment on the flight line, in repair shops, and overhaul facilities.

d. Analyses or trade studies should include the following:

(1) Optimum approach to permanent tube joining

(2) Optimum separable tube fitting design

(3) Whether tubing materials having a strength-to-weight ratio higher than that of MIL-T-6845 can be used successfully, consistent with (1) and (2) alone, and be available within the time constraints of the program schedule.

30.2 Developmental arid preproduction data report. The following data should be submitted for approval during the development phase of the hydraulic system and should be for use as production procurement data:

a. A hydraulic system ground and flight test report in accordance with MIL-T-5522.

b. Detail specifications, test procedures and test reports for the following components:

(1) Pumps and motors
(2) Flight-control actuators
(3) Valves and switches
(4) Flexible connectors including hoses (if nonstandard)
(5) Packings and packing installations (if nonstandard)
(6) Fluids (if nonstandard)
(7) Fittings and tubings (if nonstandard)
(8) Hydraulic power transfer units (if used)

NOTE: Other components that may require surveillance, in view of the criticality of the particular item to the proper functioning of the weapon system, may be specified after the hydraulic system schematic diagrams have been reviewed. The list of surveillance items will be established during the service-contractor conference (see 3.5.1).

c. Analyses of failures and malfunctions affecting performance and safety.

30.3 Production data report. Where changes have been made in the hydraulic system over the developmental hydraulic system, the developmental data required in 30.2 should be submitted.

30.4 Schematic diagram report. The schematic diagram should consist of one copy of the conventional size and one copy approximately 11 inches in height. The arrangement of the schematic diagram should be such as to present the system in a clear and easily readable form, with complete subsystems grouped and labeled accordingly. Emphasis should be placed on simplicity and clarity of presentation, with location in the aircraft being of secondary importance. Nomemclature of each unit should be made adjacent to or in the vicinity of each unit. In addition, the schematic diagram should contain the following information:

a. Operating pressure of all systems and subsystems.

b. All relief valve reseat and full flow pressures.

c. Initial gas pressure of accumulators and their normal gas and fluid capacities.

d. Pressure range of pressure regulators.

e. Diameter, wall thickness, and material of tubing.

f. Total and reserve fluid capacities of the reservoir, Or reservoirs, and the system; reservoir pressure; and method of pressurization.

g. Displacement of fluid in cubic inches of each actuating cylinder for both extension and retraction.

h. Actuating cylinder piston head diameter, rod diameter, effective piston area, total and working stroke of each cylinder.

i. Displacement per revolution and number of required revolutions of hydraulic motors for each half-cycle of operation and the torque load required for each unit.

j. Type of power-driven pump and displacement, Including flow rate curve showing engine and pump rpm, for all phases of flight such as takeoff, climb, cruise, and landing.

k. Indicated fluid flow direction through all hydraulic lines.

1. Reservoir pressurizing system source, operating pressure, and schematic diagram of plumbing.

m. Name and part number of all units. Standard part numbers should be indicated where applicable. Nonstandard units should also include name of manufacturer and the manufacturer's part number.

n. Connections for testing with auxiliary or ground test power system should be indicated.

o. Tubing and hose lines should be identified in accordance with AS 1290.

p. Hydraulic components should be shown in simple schematic form. Multiple position units, such as selector valves, should clearly indicate internal fluid porting. Flow path of selector valves should be shown for each position of the valves. Hydraulic components should be shown in accordance with AS 1290.

q. Maximum and normal system temperature (estimated). In estimating maximum and normal system temperatures, the following " conditions should be specified:

(1) Location of temperature
(2) Altitude
(3) Ambient temperature
(4) Compartment temperature
(5) Engine power setting
(6) Time duration of flight and time duration limitations for ground operation at maximum system temperature

APPENDIX A

r. Pressure and temperature pickup locations to be installed for instrumentation purposes in accordance with MIL-T-5522 should be indicated on the copies of the schematic diagrams submitted to the contracting activity.

s. Hydraulic system block diagram. (This may be a separate sheet of the schematic diagram).

30.5 Mechanical to hydraulic system schematic diagram. This is a simple schematic diagram of linkage showing mechanical disconnects, downlocks, and uplocks, and other data to tie the mechanical system to the hydraulic system for analysis.

30.6 Electrical wirinq schematic diagram. This is a simple schematic wiring diagram of the electrical portion of the hydraulic system giving current loads and describing functions. (This diagram and data may be on a separate drawing).

30.7 Hydraulic system design report. The hydraulic system design report should be submitted prior to or with the final schematic diagram. The report should incorporate sufficient design calculations and data to verify that the hydraulic system design complies with all design requirements. A hydraulic system temperature survey (minimum through maximum) should be included considering the location of the hydraulic system in the aircraft. The time of flight at maximum system temperature and conditions under which this temperature occurs should be included. Compartment temperatures should be estimated. For primary flight control systems, peak and average flow rates and the power spectrum should be indicated. Durationof peak flow rates should also be indicated. The minimum temperature at which full performance occurs should be determined by the contractor and submitted for approval.

30.8 Hydraulic system nonstandard component cross-sectional assembly drawings report. The cross-sectional assembly drawings for each nonstandard hydraulic component shall contain information in order that an evaluation of the unit can be made. Such information shall include the applicable specification, the material protective finish of each part, and bearing load and life data for the application. This information may appear as a written addition to the drawing. Reason for hte use of a nonstandard component, where a standard exists, should be submitted with the component drawing.

30.9 Functional simulator design and test program report. A report describing the general design of the functional simulator, as described in paragraph 3.5.1, and the anticipated test program should be submitted to the contracting activity for approval no later than 30 days prior to beginning construction of the simulator in order that any modification to the simulator " or revision of the test program recommended by the contracting activity may be included.

30.10 Vibration test plan report. A test plan for the vibration test in 4.2.1 should be submitted to the contracting activity for approval within 30 days prior to the start of the test.

APPENDIX B

TEST REPORT TECHNICAL CONTENT REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers information that shall be included in the test reports when specified in the contract or order. This appendix is mandatory only when data item description DI-MISC-80653 is cited on the DD Form 1423.

20. APPLICABLE DOCUMENTS

This section is not applicable to this specification.

30. COMPONENT AND FUNCTIONAL TEST REPORTS

30.1 Contractor proposed component tests. The following procedure should be adopted by the contractor for components not listed under 30.2(b) in Appendix A:

a. The contractor should certify, upon completion of validating tests, that the hydraulic component conforms to the applicable military or contractor-prepared specifications approved by the contracting activity and is satisfactory for use in the particular aircraft weapon system and hydraulic system.

b. The test reports, as welll as the specifications and other applicable engineering data covering the hydraulic system components, other than those specified in Appendix A, 30.2(b) should be retained by the contractor and should be available to the contracting activity upon request, with the exception that all the cross-sectional assembly drawings should be submitted for information.

c. The contractor should list, in a status of equipment list, those components that are contractor-certified for data availability and compliance with the applicable Government-approved specifications.

30.2 Functional test specification report. A specification incorporating the necessary functional tests of the hydraulic system of production aircraft should be submitted to the contracting activity for approval.

ALPHABETICAL INDEX

ALPHABETICAL INDEX (CONT'D)

ALPHABETICAL INDEX (CONT'D)

ALPHABETICAL INDEX (CONT'D)

ALPHABETICAL INDEX (CONT'D)

ALPHABETICAL INDEX (CONT'D)