



# AEROSPACE STANDARD

**AS5440™****REV. B**Issued 1998-04  
Revised 2024-12

Superseding AS5440A

Hydraulic Systems, Military Aircraft, Design and Installation, Requirements For

## RATIONALE

AS5440 has been updated to Revision B for the following reasons:

- Minor technical changes have been made.
- The references called up in the document have been updated.
- Editorial changes have been made to improve the readability of the document.

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## 1. SCOPE

This specification covers the design and installation requirements for Type I and II military aircraft hydraulic systems.

### 1.1 Intended Use

The design and installation requirements covered by this specification are intended for military aircraft hydraulic systems, such as the utility system, the flight control system, and various subsystems, and with component installation procedures for temperatures from -65 to 275 °F (-54 to +135 °C).

NOTE: Type III systems with a temperature range of -65 to 450° F (-54 to +232 °C) are covered by MIL-H-8891.

### 1.2 Classification

Military aircraft hydraulic systems shall be of the following types and classes, as specified below.

#### 1.2.1 Types

- a. Type I: Maximum fluid operating temperature +160 °F (+71 °C)
- b. 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 (10345 kPa) nominal operating pressure
- b. Class 3000 - 3000 psi (20690 kPa) nominal operating pressure
- c. Class 4000 - 4000 psi (27580 kPa) nominal operating pressure
- d. Class 5000 - 5000 psi (34500 kPa) nominal operating pressure
- e. Class 8000 - 8000 psi (55000 kPa) nominal operating pressure

NOTE: For variable pressure level systems, such as 5000 psi (34500 kPa) and 3000 psi (20690 kPa), the highest pressure shall determine the pressure class. The pressure class shall be annotated with a "V" to indicate variable pressures (for example, class 5000V).

## 2. REFERENCES

### 2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of the other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

NOTE: Documents listed as "Inactive" or "Cancelled" are provided for information purposes only. The procuring agency may use these documents as guidance or invoke them as necessary.

## 2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

|             |                                                                                                                                                                                                                                                 |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AMS4081     | Aluminum Alloy Tubing, Hydraulic, Seamless, Drawn, Round, 1.0Mg - 0.60Si - 0.28Cu - 0.20Cr (6061-T4), Solution Heat Treated and Naturally Aged                                                                                                  |
| AMS4083     | Aluminum Alloy Tubing, Hydraulic, Seamless, Drawn, Round, 1.0Mg - 0.60Si - 0.28Cu - 0.20Cr (6061-T6), Solution and Precipitation Heat Treated                                                                                                   |
| AMS4944     | Titanium Alloy Tubing, Seamless, Hydraulic, 3.0Al - 2.5V, Cold Worked, Stress Relieved                                                                                                                                                          |
| AMS4945     | Titanium Alloy Tubing, Seamless, Hydraulic, 3Al - 2.5V, Controlled Contractile Strain Ratio Cold Worked, Stress Relieved                                                                                                                        |
| AMS4946     | Titanium Alloy Tubing, Seamless, Hydraulic, 3Al - 2.5V, Texture Controlled Cold Worked, Stress Relieved                                                                                                                                         |
| AMS5561     | Steel, Corrosion and Heat-Resistant, Welded and Drawn or Seamless and Drawn Tubing, 9.0Mn - 20Cr - 6.5Ni - .028N High-Pressure Hydraulic                                                                                                        |
| AMS7287     | Fluorocarbon Elastomer (FKM), High Temperature/HTS Oil Resistant/Fuel Resistant, Low Compression Set/70 to 80 Hardness, Low Temperature Tg -22 °F (-30 °C), for Seals in Oil/Fuel/Specific Hydraulic Systems                                    |
| AMS7379     | Rubber: Fluorocarbon Elastomer (FKM), Low Temperature Sealing Tg -40 °F (-40 °C) 70 to 80 Type 'A' Hardness For Elastomeric Seals in Aircraft Engine Oil, Fuel and Hydraulics Systems                                                           |
| AMS7410     | Rubber: Fluorocarbon Elastomer (FKM), Aircraft Engine Oil, Fuel and Hydraulic Fluid Resistant 70 to 80 Shore Type A Hardness, Low Temperature Sealing Tg -47 °F (-43.9 °C) for Elastomeric Seals in Aircraft Engine, Fuel and Hydraulic Systems |
| AMS-P-83461 | Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Improved Performance at 275 °F (135 °C)                                                                                                                                                |
| AMS-T-6845  | Tubing, Steel, Corrosion-Resistant (S30400), Aerospace Vehicle Hydraulic System, 1/8 Hard Condition                                                                                                                                             |
| AIR1362     | Aerospace Hydraulic Fluids Physical Properties                                                                                                                                                                                                  |
| AIR1657     | Handbook of Hydraulic Metric Calculations                                                                                                                                                                                                       |
| AIR1899     | Aerospace Military Aircraft Hydraulic System Characteristics                                                                                                                                                                                    |
| AIR4057     | Secondary Filters for Fluid Systems Reliability                                                                                                                                                                                                 |
| AIR4543     | Aerospace Hydraulics and Actuation Lessons Learned                                                                                                                                                                                              |
| AIR5829     | Air in Aircraft Hydraulic Systems                                                                                                                                                                                                               |
| ARP584      | Coiled Tubing - Corrosion Resistant Steel, Hydraulic Applications, Aerospace                                                                                                                                                                    |
| ARP994      | Design of Tubing Installations for Aerospace Hydraulic Systems                                                                                                                                                                                  |
| ARP1383     | Aerospace - Impulse Testing of Hydraulic Components                                                                                                                                                                                             |
| ARP4146     | Coil Tubing - Titanium Alloy, Hydraulic Applications, Aerospace                                                                                                                                                                                 |
| ARP4378     | Accumulator, Hydraulic, Welded Bellows, Factory Pre-Charged                                                                                                                                                                                     |

|         |                                                                                                                                   |
|---------|-----------------------------------------------------------------------------------------------------------------------------------|
| ARP4379 | Aerospace - Accumulator, Hydraulic, Cylindrical, Piston Separated                                                                 |
| ARP4386 | Terminology and Definitions for Aerospace Fluid Power, Actuation and Control Technologies                                         |
| ARP4553 | Self-Displacing Hydraulic Accumulator                                                                                             |
| ARP4727 | Gland Design, Computation of Seal Squeeze and Gland Volume                                                                        |
| ARP4763 | Aerospace - General Requirements for Hydraulic Relief Valves                                                                      |
| ARP4835 | Recommended Design and Test Requirements for Hydraulic Thermal Expansion Relief Valves                                            |
| ARP4946 | Recommended Design and Test Requirements for Hydraulic Check Valves                                                               |
| ARP5891 | Achieving Cleanliness Standards for Aircraft Hydraulic Systems During Manufacture                                                 |
| ARP7212 | Recommended Design and Test Requirements for Hydraulic Flow Regulators                                                            |
| AS568   | Aerospace Size Standard for O-Rings                                                                                               |
| AS603   | Impulse Testing of Hydraulic Hose, Tubing, and Fitting Assemblies                                                                 |
| AS604   | Hose Assembly, Polytetrafluoroethylene, Metallic Reinforced, 3000 psi, 400 °F, Heavyweight, Hydraulic                             |
| AS614   | Hose Assembly, Polytetrafluoroethylene, Metallic Reinforced, 4000 psi, 400 °F, Heavy Duty, Hydraulic and Pneumatic                |
| AS1290  | Graphic Symbols for Aircraft Hydraulic and Pneumatic Systems                                                                      |
| AS1300  | Port - Ring Locked Fluid Connection Type, Standard Dimensions For                                                                 |
| AS1339  | Hose Assembly, Polytetrafluoroethylene, Metallic Reinforced, 3000 psi, 400 °F, Lightweight, Hydraulic and Pneumatic               |
| AS1709  | Coupling Assembly, Hydraulic Self Sealing, Quick Disconnect                                                                       |
| AS1975  | Hose Assembly, Polytetrafluoroethylene, Para-Aramid Reinforced, 3000/4000 psi, 275 °F, Standard Duty, Hydraulic, Aircraft Systems |
| AS4052  | Gland Design: Scraper, Landing Gear, Installation                                                                                 |
| AS4059  | Contamination Classification for Hydraulic Fluids                                                                                 |
| AS4088  | Aerospace Rod Scraper Gland Design Standard                                                                                       |
| AS4201  | Port - Ring Locked Fluid Connection Type, 8000 psi, Design Standard                                                               |
| AS4251  | Coupling Assemblies, Non-Locking Probe Style, Self-Aligning, Self-Sealing, Disconnects                                            |
| AS4330  | Tubing, Flared, Standard Dimensions For, Design Standard                                                                          |
| AS4395  | Fitting End, Flared, Tube Connection, Design Standard                                                                             |
| AS4396  | Fitting End, Bulkhead, Flared, Tube Connection, Design Standard                                                                   |
| AS4716  | Gland Design, O-Ring and Other Seals                                                                                              |
| AS5202  | Port or Fitting End, Internal Straight Thread, Design Standard                                                                    |

|         |                                                                                                                                             |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------|
| AS5466  | Aerospace - General Requirements for Hydraulic Fuse - Quantity Measuring                                                                    |
| AS5467  | General Requirements for Hydraulic Fuse - Flow Rate                                                                                         |
| AS5586  | General Requirements for Hydraulic System Reservoirs                                                                                        |
| AS5781  | Retainers (Backup Rings), Hydraulic and Pneumatic, Polytetrafluoroethylene Resin, Single Turn, Scarf-Cut, For Use in AS4716 Glands          |
| AS5782  | Retainers (Backup Rings), Hydraulic and Pneumatic, Polytetrafluoroethylene Resin, Solid, Un-Cut, for Use in AS4716 Glands                   |
| AS5994  | Pump Units, Hydraulic, Electric Motor Driven, Variable Delivery                                                                             |
| AS6235  | Face Seal Gland Design, Static, O-Ring and Other Seals for Aerospace Hydraulic and Pneumatic Applications                                   |
| AS7997  | Motors, Aircraft Hydraulic, Constant Displacement, General Specification For                                                                |
| AS8584  | Brake Systems, Wheel, Military Aircraft                                                                                                     |
| AS8775  | Hydraulic System Components, Aircraft and Missiles, General Specification for                                                               |
| AS19692 | Aerospace – Military Type Variable Delivery, Pressure Compensated Hydraulic Pump                                                            |
| AS33583 | Tubing End, Double Flare, Standard Dimensions For                                                                                           |
| AS33611 | Tube Bend Radii                                                                                                                             |
| AS50881 | Wiring Aerospace Vehicle                                                                                                                    |
| AS85421 | Fittings, Tube, Fluid Systems, Separable, Beam Seal, 3000/4000 psi, General Specification for                                               |
| AS85720 | Fittings, Tube, Fluid Systems, Separable, High Pressure Dynamic Beam Seal, 5000/8000 psi, General Specification for                         |
| AS94900 | Vehicle Management Systems - Flight Control Function, Design, Installation and Test of Piloted Military Aircraft, General Specification For |
| MA2010  | Packing, Preformed - O-Ring Seal Standard Sizes and Size Codes, Metric                                                                      |

## 2.1.2 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

or, if using the Switzerland address:

Available from International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, [www.iso.org](http://www.iso.org).

|           |                                                                                                          |
|-----------|----------------------------------------------------------------------------------------------------------|
| ISO 22089 | Aerospace - Hydraulic power transfer units - General specifications for                                  |
| ISO 22181 | Aerospace fluid systems and components - Variable displacement hydraulic motors - General specifications |

### 2.1.3 NAS Publications

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

NASM85449 Clamp Assembly, Saddle-Type, Cushion, General Specification For

NASM85449/1 Clamp Assembly, Saddle-Type, Cushioned, NBR Rubber, 321 CRES, 275 °F, Fuel Resistant, General Purpose

NASM85449/3 Clamp Assembly, Saddle-Type, Cushioned, Silicone Fabric, Reinforced, 321 CRES, 500 °F, General Purpose

### 2.1.4 NAVAIR Publications

Available from Naval Air Warfare Center - Aircraft Division (Code AB43300), 48298 Shaw Rd., Building 1461, Patuxent River, MD 20760-1900.

NAVAIR 01-1A-17 Aviation Hydraulics Manual

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

### 2.1.5 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil>.

AN929 Cap Assembly, Pressure Seal Flared Tube Fitting

MIL-DTL-5508 Fuses, Aircraft Automatic Quantity-Measuring, Hydraulic (Inactive)

MIL-DTL-5513 Joints, Hydraulic, Swivel

MIL-DTL-8348 Gage Assemblies, Air Pressure, Dial Indicating Chuck Type, Self-Contained (Inactive)

MIL-DTL-9395 Switches Pressure (Absolute, Gage and Differential), General Specification For

MIL-DTL-19068 Valve, Shuttle, Hydraulic, Aircraft, Type II Systems (Inactive)

MIL-DTL-25579 Hose Assembly, Tetrafluoroethylene, High Temperature, Medium Pressure, General Specification For

MIL-DTL-27267 Hose, CRES Wire Reinforced, Polytetrafluoroethylene, 450 Degrees F, Medium Pressure

MIL-DTL-27272 Fittings, Polytetrafluoroethylene Hose, High Temperature, Medium Pressure, General Requirements For

MIL-DTL-83296 Fittings, Corrosion Resistant Steel, High Temperature, High Pressure (3000 PSI), Hydraulic and Pneumatic, General Specification for

MIL-DTL-83298 Hose, Conductive, Polytetrafluoroethylene Tube, High Temperature, High Pressure (3000 PSI), Hydraulic and Pneumatic

MIL-DTL-85052 Clamp, Loop, Cushion, General Specification For

MIL-DTL-85052/1 Clamp, Loop, Tube, 17-7 PH CRES, 275 °F, Fuel and Petroleum Based Hydraulic Fluid Resistant

MIL-DTL-85052/3 Clamp, Loop, Tube, 17-7 PH CRES, 500 °F

|               |                                                                                                                                                  |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| MIL-F-8815    | Filter and Filter Elements, Fluid Pressure, Hydraulic Line, 15 Micron Absolute and 5 Micron Absolute, Type II Systems, General Specification For |
| MIL-F-8815/4  | Filter, Fluid, Pressure, Hydraulic Line, 3000 PSI, Absolute 5 Micron, Style A, Bypass, -65 Degrees F to +275 Degrees Fahrenheit                  |
| MIL-F-8815/5  | Filter, Fluid, Pressure, Hydraulic Line 3000 PSI, Absolute 5 Micron, Style B, Non Bypass, -65 Degrees F to +275 Degrees Fahrenheit               |
| MIL-F-8815/6  | Filter Elements, Noncleanable, Fluid Pressure, Hydraulic Line, 3000 PSI, 5 Micron Absolute -65 Degrees F to +275 Degrees Fahrenheit              |
| MIL-F-83300   | Flying Qualities of Piloted V/STOL Aircraft                                                                                                      |
| MIL-G-5514    | Gland Design; Packings, Hydraulic General Requirements For (Inactive)                                                                            |
| MIL-H-8891    | Hydraulic Systems, Manned Flight Vehicles, Type III Design, Installation and Data Requirements For, General Specification For (Inactive)         |
| MIL-H-85800   | Hose Assemblies, Polytetrafluoroethylene Aramid Fiber Reinforced, 5000 and 8000 psi, General Specification For                                   |
| MIL-HDBK-2069 | Aircraft Survivability                                                                                                                           |
| MIL-HDBK-2089 | Aircraft Survivability Terms                                                                                                                     |
| MIL-P-5954    | Pump Unit, Hydraulic, Electric Motor Driven Fixed Displacement (Not for New Design)                                                              |
| MIL-PRF-5503  | Actuators: Aeronautical Linear Utility, Hydraulic, General Specification For                                                                     |
| MIL-PRF-5606  | Hydraulic Fluid, Petroleum Base; Aircraft, Missile, and Ordnance (Inactive)                                                                      |
| MIL-PRF-6083  | Hydraulic Fluid, Petroleum Base, for Preservation and Operation                                                                                  |
| MIL-PRF-25675 | Valves, Check, Miniature, Hydraulic, Aircraft and Missile (Inactive)                                                                             |
| MIL-PRF-46170 | Hydraulic Fluid, Rust Inhibited, Fire Resistant, Synthetic Hydrocarbon Base, NATO Code No. H-544                                                 |
| MIL-PRF-81836 | Filter and Disposable Element, Fluid Pressure, Hydraulic, 3 Micron Absolute, General Specification For                                           |
| MIL-PRF-83282 | Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft, Metric, NATO Code Number H-537                                            |
| MIL-PRF-87257 | Hydraulic Fluid, Fire Resistant; Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile                                               |
| MIL-STD-464   | Electromagnetic Environmental Effects Requirements for Systems                                                                                   |
| MIL-STD-1247  | Markings, Functions and Hazard Designations of Hose, Pipe, and Tube Lines for Aircraft, Missile, and Space Systems (Inactive)                    |
| MIL-STD-1472  | Human Engineering                                                                                                                                |
| MIL-STD-1797  | Flying Qualities of Piloted Aircraft                                                                                                             |
| MIL-STD-5522  | Test Requirements and Methods for Aircraft Hydraulic and Emergency Pneumatic Systems                                                             |
| MIL-STD-7179  | Finishes, Coatings, and Sealants for the Protection of Aerospace Weapons Systems                                                                 |

|             |                                                                                                                         |
|-------------|-------------------------------------------------------------------------------------------------------------------------|
| MIL-T-8504  | Tubing, Steel, Corrosion-Resistant (304), Aerospace Vehicle Hydraulic Systems, Annealed, Seamless and Welded (Inactive) |
| MIL-V-5519  | Valves, Regulating Fluid Pressure (Inactive)                                                                            |
| MIL-V-5525  | Valves, Aircraft Power Brake (Inactive)                                                                                 |
| MIL-V-5530  | Valves, Aircraft Hydraulic Shuttle (Cancelled)                                                                          |
| MIL-V-8566  | Valves; Aircraft Hydraulic Flow Regulator (Inactive)                                                                    |
| MIL-V-8813  | Valves, Aircraft, Hydraulic Pressure Relief, Type II Systems (Inactive)                                                 |
| MIL-V-19067 | Valves, Check, Controllable, Hydraulic, Aircraft, Type II Systems (Inactive)                                            |
| MIL-V-29592 | Valve, Air Vent, Automatic, Hydraulic, Low Pressure Type II Systems, General Specification For                          |
| MIL-V-81940 | Valve, Sampling and Bleed, Hydraulic, Type II Systems                                                                   |
| MIL-V-85245 | Valve, Relief, Hydraulic, High Response, Type II Systems, General Specification For                                     |
| MS14169     | Circular Spline and Adapter Details Engine Driven Accessories                                                           |
| MS14184     | Nonmetallic Shaft-Coupling Details, Engine Driven Accessories                                                           |
| MS21344     | Fitting, Installation of Flared Tube, Straight Threaded Connectors, Design Standard For                                 |

## 2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

### 2.2.1 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil>.

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

## 2.3 Definitions

General definitions for terminology used within this document may be found in ARP4386. The following definitions are unique to this document.

**UTILITY SYSTEM:** This is the hydraulic system that supplies power for the normal operation of any services on the aircraft, excluding the operation of the aircraft's primary flight control system surfaces.

**FLIGHT CONTROL SYSTEM:** This is the hydraulic system that supplies power for primary flight control systems used to actuate such surfaces as ailerons, rudders, elevators, stabilizers, spoilers, rotor blades, vectoring, or combined function surfaces.

**COMBINED FLIGHT CONTROL UTILITY SYSTEM:** This is the hydraulic system that supplies a portion of the power required for primary flight control and also supplies power to the utility services.

### 3. REQUIREMENTS

#### 3.1 Materials

Materials used in the manufacture of hydraulic systems in military aircraft shall conform to applicable government and industry specifications. The use of contractor specifications instead of the applicable government and industry specifications requires the approval of the procuring agency.

The use of aluminum materials in flight control components in 5000 psi (34500 kPa) systems and above requires special precautions to ensure conformance to the fatigue requirements for production configuration parts. The use of aluminum alloy parts for 5000 psi (34500 kPa) and greater is not encouraged and shall not be used unless approved by the contracting activity.

#### 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:

- a. Acceleration or deceleration
- b. Zero gravity (g), negative g, or any flight attitudes obtainable with the aircraft
- c. Structural deflection
- d. Vibration
- e. Other environmental conditions

The hydraulic systems shall be configured such that failure of any two fluid systems resulting from combat or other damage which causes the loss of fluid or pressure will not result in a complete loss of flight control.

Fixed-wing aircraft shall maintain level one flying qualities of MIL-STD-1797 with one fluid system failure (including the power source) and level three flying qualities including carrier landing, with two fluid system failures.

Rotary wing aircraft and piloted V/STOL 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-HDBK-2069 and MIL-HDBK-2089.

#### 3.3 Hydraulic Fluid

Fluid conforming to MIL-PRF-83282 and/or MIL-PRF-87257 shall be used for hydraulic systems and associated ground equipment.

##### NOTES:

- 1. The use of MIL-PRF-5606 is discouraged; however, it is considered an acceptable substitute for MIL-PRF-87257 if required by the contracting activity.
- 2. MIL-PRF-83282 has the best flammability resistance followed by MIL-PRF-87257 and then MIL-PRF-5606.

The operational fluid shall be used as the preservative fluid when storing components. Hydraulic fluids containing barium (i.e., MIL-PRF-46170 or MIL-PRF-6083) shall not be used as a test or preservative fluid.

### 3.4 Hydraulic Seals

O-rings with cross-sectional diameters of 0.070 inch (1.78 mm) or less, or their equivalent proprietary seals, shall not be used as external seals. The best practice is to avoid the usage of 0.070 inch (1.78 mm) or less in internal sealing applications.

#### 3.4.1 Gland Design

The configuration and dimensions of seal glands for radial sealing shall conform to the requirements of AS4716 for dynamic and static applications.

Non-standard glands for specialized seal assemblies shall only be used with the approval of the contracting activity.

For static face sealing (internal and external pressure applications), seal glands shall conform to the requirements of AS6235.

For system pressure levels above class 3000, the diametral clearance gaps of AS4716 may be reduced from the minimum of 0.003 inch (0.08 mm) to improve seal life and aid in preventing seal assembly extrusion. Care shall also be taken to prevent binding and interference at the most adverse temperature extremes. AS4716 provides a minimum of 0.005 inch (0.13 mm) or 5%, whichever is larger, at ambient temperature and extremes of tolerance and eccentricity. Standard clearance may be used for system pressure levels greater than 3000 psi (20690 kPa) if proprietary-type seal assemblies and high-modulus backup ring materials are used.

The use of the procedures detailed in ARP4727 is recommended for the calculation of seal squeeze and gland occupancy volume for radial seals when reviewing seal and gland design details.

#### 3.4.2 O-Ring and Seal Assemblies

O-ring elastomer materials shall conform to AMS-P-83461, AMS7287, AMS7379, or AMS7410. Seal assembly configurations other than O-rings may be used in standard glands if the design permits. Any elastomer components within those assemblies shall use materials per AMS-P-83461, AMS7287, AMS7379, or AMS7410.

Other elastomer materials and designs can be qualified for specialty applications based on system requirements. The use of these materials is subject to the approval of the Purchaser.

O-rings not covered by a specification should conform to AS568 or MA2010 for dimensions and tolerances. When nonstandard seals are necessary to demonstrate compliance with the requirements of the Procurement Specification, they may be used subject to the approval of the Purchaser and indicated on the component's assembly drawing.

#### 3.4.3 Backup Rings

AS5781 and AS5782 backup rings shall be used in AS4716 seal glands. Solid backup rings shall conform to AS5782. Scarf-cut backup rings conforming to AS5781 may be used on dynamic applications where minimum seal friction is required for satisfactory operation or where access to the gland prevents installation of AS5782. If AS5782 solid backup rings are used on dynamic piston applications, friction due to pressure entrapment between the backup rings shall be considered in the design of the device.

Extra care, training, and drawing notes should be implemented to prevent backup rings designed for AS4716 grooves from being inadvertently used in MIL-G-5514 grooves and vice versa. Note that backup rings per AS5781 and AS5782 are color-coded to help prevent incorrect installation into MIL-G-5514 glands.

Nonstandard backup rings may be used for system pressure levels greater than class 3000, subject to the approval of the contracting activity. AS5781 and AS5782 provide alternate backup ring material recommendations for pressure applications higher than 3000 psi (20690 kPa).

### 3.4.4 Scrapers

Components with rod seals that may be exposed to water, dirt, or ice shall have a scraper using a gland per AS4088 or AS4052, as applicable. The scraper lip shall maintain contact with the rod throughout the expected temperature range. The outer diameter of the scraper shall also maintain contact with its gland throughout the expected temperature range and under all expected rod eccentricity within the rod gland.

## 3.5 General System Design

Hydraulic systems shall be as simple and foolproof as possible and per 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 01-1A-17 and NAVAIR 01-1A-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 would decrease.

### 3.5.1 Fluid Temperature Limitations

The MIL-PRF-83232 fluid hydraulic system shall be capable of starting and operating at fluid temperatures between -40 °F (-40 °C) and the upper limit of the operating envelope.

The MIL-PRF-87257 fluid hydraulic system shall be capable of starting and operating at fluid temperatures between -65 °F (-54 °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 contracting agency approval, any reduced actuator rates at low temperatures may be acceptable.

#### 3.5.1.1 Climate Extremes

Ground operation, flight operation, and storage climatic extremes shall be per the weapon system procurement specification.

### 3.5.2 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 the 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, incorporate a shear shaft to allow disconnect in the event of seizure, or be stopped to prevent heat generation and the possibility of fire.

### 3.5.3 Surge Pressure

Peak pressure resulting from any phase of the system operation shall not exceed the percent value shown in Table 1 for the main system, subsystem, or return system pressures when measured with electronic or other test equipment. Any failure (such as a blown line) which causes a pressure surge in excess of acceptable peak pressure limits shall be substantiated with the fatigue life of the system and approved by the contracting activity. This resulting surge pressure shall not exceed the proof pressure. The use of a relief valve to limit peak pressure is discouraged and is only acceptable if approved by the contracting agency. The relief valve response time and wide-open failure modes shall be assessed.

**Table 1 - System peak pressure**

| Pressure Class, psi (kPa)                                      | Peak Pressure                                                                                                              |
|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| 1500, 3000, 4000, and 5000<br>(10350, 20690, 27600, and 34500) | 135% of the system's nominal operating pressure on the pressure side, 50% of nominal operating pressure on the return side |
| 8000 (55000)                                                   | 120% of the system's nominal operating pressure on the pressure side, 50% of nominal operating pressure on the return side |

## 3.5.3.1 Pressure Limitations

The pressure limitations shall be as follows:

- Pump pressure: Pump output pressures shall be in accordance with Table 2A and the fluid temperature, speed, and flow conditions defined in AS19692, 3.2.2 and 3.2.3.
- Relief valve pressure setting: See Table 2B.
- Minimum proof pressure: See Table 2C.
- Minimum burst pressure: See Table 2D.

**Table 2A - Pump pressures**

| Component or Characteristic           | Pressure (see Note 1)                                  |                                                        | Remarks                                                                                                                |
|---------------------------------------|--------------------------------------------------------|--------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
|                                       | Class 5000<br>(34500 kPa)<br>and below                 | Class 8000<br>(55000 kPa)                              |                                                                                                                        |
| 1. Pump pressure at zero flow         | 100% + 150 psig<br>(1035 kPa) max                      | 100% + 150 psig<br>(1035 kPa) max                      | 100% = Class Pressure<br>(Maximum pump output<br>pressure shall not<br>exceed Class Pressure<br>+ 150 psi [1035 kPa].) |
| 2. Pump minimum pressure at full flow | Pump pressure at<br>zero flow -150 psig<br>(-1035 kPa) | Pump pressure at<br>zero flow -150 psig<br>(-1035 kPa) |                                                                                                                        |

**Table 2B - Relief valve pressure settings**

| Component or Characteristic               | Pressure (see Note 1)                          |                                                | Remarks                                   |
|-------------------------------------------|------------------------------------------------|------------------------------------------------|-------------------------------------------|
|                                           | Class 5000<br>(34500 kPa)<br>and below         | Class 8000<br>(55000 kPa)                      |                                           |
| 1. System relief valve                    |                                                |                                                | 100% = Class Pressure<br><br>See 3.10.22. |
| a. Maximum pressure at rated flow         | 100% + 850 psid<br>(100% + 5900 kPa)           | 100% + 850 psid<br>(100% + 5900 kPa)           |                                           |
| b. Minimum pressure at reseal             | Maximum pump<br>output + 100 psid<br>(700 kPa) | Maximum pump<br>output + 100 psid<br>(700 kPa) |                                           |
| 2. Thermal relief valve cracking pressure | 100% + 1000 psid<br>(100% + 7000 kPa)          | 100% + 1000 psid<br>(100% + 7000 kPa)          |                                           |