



AEROSPACE RECOMMENDED PRACTICE

ARP4943™

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Ground Support Equipment Hydraulic Systems,
Design and Installation, Recommended Practices for

RATIONALE

ARP4943 has been reaffirmed to comply with the SAE Five-Year Review policy.

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1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) covers the design and installation requirements for hydraulic systems (up to 8000 psig [56 MPa]) for ground support equipment (GSE). The GSE may be portable or stationary.

1.1 Classification:

The hydraulic systems defined by this document shall be capable of servicing aircraft systems and components of all types and classes defined in MIL-H-5440. The terminology, Class XXXX, where XXXX is the GSE system pressure, is utilized within this document.

2. APPLICABLE DOCUMENTS:

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

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP584	Coiled Tubing, Corrosion Resistant Steel, Hydraulic
ARP994	Design of Tubing Installation for Aerospace Fluid Power System, Recommended Practice for
AS1241	Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft
AIR1657	Handbook of Hydraulic Metric Calculations
AIR1922	(DRAFT) System Integration Factors That Affect Hydraulic Pump Life
AS4059	Cleanliness Classification for Hydraulic Fluid
AS4157	Coupling Assemblies, Hydraulic Self-Sealing, Quick Disconnect, 5000/8000 psi
AS4395	Fitting End, Flared Tube Connection, Design Standard
AS4396	Fitting End, Bulkhead Flared Tube Connection, Design Standard
AS4716	Gland Design, O-Ring and Other Elastomeric Seals
ARP4835	(DRAFT) Hydraulic Thermal Expansion Relief Valves
J1926	Specification for Straight Thread O-Ring Boss Port, Standard; August 1988
AMS 5561	Steel Tubing, Welded and Drawn, Corrosion and Heat Resistant

2.2 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 40, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-H-5440	Hydraulic Systems, Aircraft, Types I and II
MIL-G-5514	Gland Design, Packings, Hydraulic, General Requirements for
MIL-R-5520	Reservoir, Aircraft, Hydraulic, Non-Separated
MIL-H-5606	Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordnance
MIL-T-6845	Tubing, Steel, Corrosion Resistant 304, Aerospace Vehicle Hydraulic Systems, 1/8 Hard Condition
MIL-T-7081	Tube, Aluminum Alloy, Seamless Round
MIL-T-8504	Tubing, Steel, Corrosion Resistant 304, Aerospace Vehicle Hydraulic Systems, Annealed, Seamless and Welded
MIL-R-8791	Retainer, Packing, Hydraulic and Pneumatic, Tetrafluoroethylene Resin
MIL-V-8813	Valves, Aircraft, Hydraulic Pressure Relief, Type II System
MIL-F-8815	Filter and Filter Elements, Fluid Pressure, Hydraulic Line, 5 & 15 Micron Absolute, Type II Systems
MIL-S-9395	Switches, Pressure
MIL-P-24691	Pipe & Tube, Carbon Alloy & Stainless, Seamless & Welded, General Specification
MIL-C-25427	Coupling Assembly, Hydraulic, Self-Sealing, Quick Disconnect
MIL-T-28800	Test Equipment For Use With Electrical and Electronic Equipment
MIL-R-46198	Resin, Polyamide, Hot-Pressed or Pressed and Sintered
MIL-S-81836	Filter, Fluid, Pressure, Hydraulic, 5000/8000 psi, 3 Micron, Style A, Mechanical Indicator
MIL-V-81940	Valve, Sampling and Bleed, Hydraulic
MIL-H-83282	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft
MIL-P-83461	Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Improved Performance at 275 °F (135 °C)
MIL-F-85421	Fittings, Tube, Fluid Systems, Separable, Dynamic Beam Seal
MIL-F-85720	Fittings, Tube, Fluid Systems, Separable, High-Pressure
MIL-H-87257	Hydraulic Fluid, Fire Resistant; Low Temperature, Synthetic Hydrocarbon Base Aircraft and Missile
MIL-STD-470	Maintainability Program for Systems and Equipment
MIL-STD-785	Reliability Program for Systems and Development Equipment and Production
MIL-STD-882	System Safety Program Requirements
MIL-STD-889	Dissimilar Metals
MIL-STD-1247	Marking, Functions and Hazard Designation of Hose, Pipe, and Tube Lines for Aircraft, Missile and Space Systems
MIL-STD-1388	Logistics Support Analysis
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
AN 929	Cap Assembly, Pressure Seal Flared Tube Fitting
MS16142	Boss, Gasket Seal, Straight Thread Tube Fittings
MS21344	Fittings, Installation of Flared Tube, Straight Thread

2.2 (Continued):

MS33514	Fitting End, Standard Dimensions for Flareless Tube Connection and Gasket Seal
MS33515	Fitting End, Standard Dimension for Bulkhead Flared and Tube Connections
MS33583	Tubing End, Double Flare, Standard Dimensions for
MS33584	Tubing End, Standard Dimensions for Flared Tube
MS33611	Tube End Radii

2.3 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM A 312 Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes
ASTM A 376 Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes,
High Temperature

2.4 Acronyms and Abbreviations:

A list of peculiar abbreviations and acronyms should be provided for clarity and understanding. Reference may be made to standard abbreviations in the specification portion of this document.

2.5 Definitions:

Contracting agency will provide any nonstandard definitions.

3. REQUIREMENTS:

3.1 Materials:

Materials used in the manufacture of GSE hydraulic systems shall be high quality, industrial components suitable for the purpose and shall conform to applicable standards identified herein. Where no standard is specified, and the procuring activity has not specified one, materials conforming to contractor's specifications may be used, provided that they are equivalent to the industrial standards.

3.1.1 Dissimilar Metals: Unless protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined in MIL-STD-889.

3.2 Design:

The hydraulic systems and components thereof shall be designed to operate satisfactorily under all conditions that the GSE may encounter within the structural limitations of the GSE, including forces or conditions caused by specified acceleration or deceleration rates.

3.3 Fluid:

Fluid shall be as specified by the contracting activity. Fluid conforming to MIL-H-83282 or MIL-H-87257 is preferred for ground support equipment systems rated at 4000 psig (28 MPa) or greater. Other fluids may be utilized where applicable at operating pressures below 4000 psig (28 MPa). Fire retardant fluids such as those conforming to AS1241 require special care and handling and may pose safety hazards to the operator. Preservative fluids may be utilized, but only with the approval of the contracting activity.

3.4 Seals:

Seal materials shall be compatible with the specified fluid. To maximize utilization, consider materials mutually compatible with several fluids, such as MIL-H-5606, MIL-H-83282 and MIL-H-87257. AS4716 shall be used for gland design and packing installation. For static applications, O-ring packing squeeze shall be a minimum of 10% at the most adverse tolerance conditions. O-ring packings with cross section widths of 0.070 in (1.8 mm) or less are not recommended for dynamic applications.

- 3.4.1 Gland Design: Seal gland dimensions shall conform to the requirements of AS4716 and shall consider the recommendations of ARP1234 and APR 1232 except for specialized proprietary packings. These nonstandard glands shall be used only with the specific approval of the contracting activity. For system pressure levels above class 3000, the clearance gaps of AS4716 may be reduced from the minimum of 0.005 in (0.13 mm) to the minimum of 0.003 in (0.076 mm) 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 psig (21 MPa) and the seal life improved by using proprietary type packing shapes and high modulus backup ring materials.
- 3.4.2 Packings: O-ring packings shall conform to MIL-P-83461, MIL-P-83485, or other compound as specifically approved by the contracting activity. Packing configurations other than O-rings may be used in standard glands with the approval of the contracting activity.
- 3.4.3 Backup Rings: Backup rings shall conform to MIL-R-8791. Nonstandard backup rings may be used for systems with pressure level greater than class 3000, subject to the approval of the contracting activity.

3.5 General System Design:

Hydraulic systems shall be as simple and fool-proof as possible and in accordance with design, operation, inspection, and maintenance objectives.

3.5.1 Fluid Temperature Limitations:

- 3.5.1.1 Nonoperating/Storage: The hydraulic system shall be able to withstand temperatures of -65 to +160 °F (-54 to 71 °C) with relative humidity (condensing) ranging up to 100%.

- 3.5.1.2 Operating: The hydraulic system shall be capable of operating within temperatures of -40 to +160 °F (-40 to 71 °C) with relative humidity (noncondensing) ranging up to 95%.
- 3.5.2 Fluid System Temperature: Unless otherwise specified by the contracting agency, it is recommended that fluid system temperature be controllable between +80 °F (27 °C) (or ambient if higher) and +160 °F (71 °C) as measured at the outlet of the GSE. The temperature controller shall be capable of maintaining set temperature at ± 5 °F (± 3 °C) in the manual mode (operator selected set temperature) of operation or ± 5 °F (± 3 °C) in the automatic mode of operation. Refer to 3.7.11.3 for fluid operating limitations.
- 3.5.3 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, 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 firewalls, shrouds, or equivalent means that will prevent fluid ignition. When electric motors, switches and other sources of sparks are installed in the same compartment as hydraulic equipment, the electrical equipment shall be above the hydraulic equipment.
- 3.5.4 Loads: The installation of hydraulic systems and components shall be designed to withstand 1.5 times the operational static and dynamic loads which are not of hydraulic nature. The installation shall be designed to withstand such loads when applied simultaneously with the appropriate hydraulic pressure requirements identified in 3.5.5.
- 3.5.5 Pressure Limitations: The following limitations shall apply to all Classes of systems:
- 3.5.5.1 Variable Delivery Pump Systems: Pump unloading (cutoff) pressure shall be the system design pressure. The maximum limit of full-flow systems shall be system pressure less 150 psi (100 kPa). The system relief valve setting at maximum flow shall be system pressure plus 850 psi (590 kPa) (maximum) for Class 5000 systems and below, and 115% of system pressure for Class 8000 systems.
- 3.5.5.2 Thermal Relief Valves: Thermal relief valves shall be set at system relief valve setting plus 150 psi (100 kPa).
- 3.5.5.3 Proof and Burst Pressures: The following values, in percent of supply pressure, shall be utilized in the design of GSE:
- Lines and fittings utilized in the pressure side shall be 200% for proof and 300% for burst, while those in the return shall be 100% for proof and 150% for burst. Values for hoses shall be in accordance with the applicable procurement specification but shall be 125% (minimum) for proof and 250% (minimum) for burst.
 - Components containing air and fluid under pressure shall be 200% for proof and 400% for burst per ARP4379.

3.5.5.3 (Continued):

- c. Pump suction and case drain line components and reservoir shall be:
 - (1) 150% proof and 300% burst of reservoir operating pressure for non-pressurized reservoirs, and
 - (2) 200% proof and 400% burst of reservoir operating pressure for gas pressurized reservoirs.
- d. Components subjected to system pressure shall be 150% proof and 250% burst.
- e. Components under return pressure, except hoses, shall be 100% proof and 150% burst.
- f. Heat exchangers shall be 150% proof and 250% burst/collapse of design heat exchanger pressure.
- g. The system shall be 150% for proof. There shall be no burst test required.
- h. Those components subjected to suction shall have a burst rating of 50 psi (35 kPa) (external) pressure.

3.5.5.4 Surge Pressure: When operating at various pressures, peak pressure resulting from any phase of the system operation shall not exceed the 135% of the operating pressure for Class 5000 (and below) systems and 120% for Class 8000. This shall apply to the main system, subsystem or return system pressures when measured with electronic or other test equipment.

3.5.5.5 Back Pressure: System design must consider the effects of back pressure on various circuit components and functional devices that require drain lines. The circuit system design shall include safety provisions to prevent malfunctions caused by back pressure surges.

3.5.5.6 Pressure Regulation: Methods for limiting pressure in self-contained and facility supplied GSE are identified. When utilizing pressure control servovalves, independent filtration on the pilot port inlet shall be provided:

- a. Self-contained GSE shall have system pumps which shall utilize a pressure regulator device and an independent means of limiting excessive pressure. When the pump driving mechanism is in continuous operation, such as engine drives, a variable displacement pump must be used. In any case, an independent safety relief valve shall be provided.
- b. Facility supplied GSE shall utilize a pressure regulating valve and an independent means of limiting excessive pressure. When multiple pressures are required simultaneously, an equal number of pressure regulating valves shall be utilized. The pressure regulating device, if electrically actuated, shall fail to the low pressure setting.

3.5.5.7 Variable Pressure Systems: Pumps with variable pressure control for systems requiring power demand control shall be equipped with a maximum pressure override control set at 115% of system maximum operating pressure.