



AEROSPACE RECOMMENDED PRACTICE

ARP4945

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Superseding ARP4945

Aerospace-Solenoid Valve, Hydraulic, Three Way,
Two Position, Direct Acting

RATIONALE

ARP4945A has been reaffirmed to comply with the SAE five-year review policy.

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1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) is intended as a guide to aid in the specifying and testing of direct acting three way, two position, single and multiple coil, normally open and normally closed solenoid valves used for the pilot actuation of hydraulic control systems and the control of hydraulic components.

The information presented should be useful in standardizing terminology, in specifying requirements and performance parameters, and in defining test methods.

The recommendations do not restrict or attempt to define the internal design features of solenoid valves. Standard mechanical, electrical and fluid porting interfaces are recommended to provide commonality, interchangeability, design flexibility and to be more affordable.

In general, this recommended practice is directed toward solenoid valves for use in military and commercial flight control and hydraulic actuation systems.

For military aircraft applications, this recommended practice covers solenoid valves for use in hydraulic actuation systems of the following types as defined in AS5440 with rated operating pressures to 8000 psi (55,160 kPa) and flow rates typically less than 1 gpm (3.785 L/min).

Type I -65 to +160 °F fluid temperature
 (-54 to +71 °C)

Type II -65 to +275 °F fluid temperature
 (-54 to + 135 °C)

For commercial aircraft applications, the information and guidelines of ARP4752 are considered. References are made to several documents that address phosphate ester hydraulic fluids. Detail Specification requirements, however, may need to be modified for a specific application.

When recommended by a paragraph, the word “should” is used. The word “shall” is used to designate a firm requirement of a paragraph.

2. REFERENCES:

This section includes a broad list of references that may be used in the preparation of a solenoid valve Detail Specification. It is recommended that only those references that are applicable and necessary in defining the requirements of the product be included.

2.1 Applicable Documents:

The following publications form a part of this document to the extent specified herein. The effective date of references shall be as specified in the purchase order or contract. If not specified, the effective date 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.

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

AMS-QQ-P-35	Passivation Treatments for Corrosion - Resistant Steel
AMS-QQ-C-320	Chromium Plating (Electrodeposited)
AMS-STD-2175	Classification and Inspection of Castings
AMS-H-6088	Heat Treatment of Aluminum Alloys
AMS-H-6875	Heat Treatment of Steel Raw Materials
AMS-F-7190	Forging, Steel, for Aircraft/Aerospace Equipment and Special Ordnance Applications
AMS-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
AMS-DTL-23053	Insulation Sleeving, Electrical Heat Shrinkable, Specification for
AMS-P-83461	Packing, Preformed, Petroleum Based Hydraulic Fluid Resistant, Improved Performance at 275°F (135°C)
ARP598	The Determination of Particulate Contamination in Liquids by the Particle Count Method
AS1241	Fire Resistant Phosphate Ester, Hydraulic Fluid for Aircraft
ARP1383	Impulse Testing of Aerospace Hydraulic Actuators, Valves, Pressure Containers and Similar Fluid System Components
AS4059	Aerospace - Cleanliness Classification for Hydraulic Fluids
ARP4386	Terminology and Definitions for Aerospace Fluid Power, Actuation, and Control Technologies
AS4716	Gland Design, O-ring and Other Elastomeric Seals
ARP4752	Aerospace Fluid Power - Design and Installation of Commercial Transport Aircraft Hydraulic Systems
AS5440	Hydraulic Systems, Aircraft, Design, Installation, Requirements for
AS8775	Hydraulic System Components, Aircraft and Missiles, General Specification for
AS8791/1	Retainer, Packing, Hydraulic, and Pneumatic Polytetrafluoroethylene, Single Turn
AS8879	Screw Threads - UNJ Profile, inch
AS22759	Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy
AS28775	Packing, Preformed, Hydraulic, +275 °F (O-Ring)
AS40401	Solenoid Electrical, General Specification for

2.1.2 ISO Publications: Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 261	General Purpose Metric Screw Threads - General Plan
ISO 10012-1	Quality Assurance Requirements for Measuring Equipment - Metrological confirmation system for measuring equipment

2.1.3 U.S. Government Publications: Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-HDBK-5400	Electronic Equipment, Airborne General Guidelines For
MIL-PRF-8516	Sealing Compound, Synthetic Rubber Electrical Connectors and Electric Systems, Chemically Cured

2.1.3 (Continued):

MIL-DTL-16878	Wiring, Electrical, Insulated, General Specification for
MIL-I-16923	Insulating Compound, Electrical, Embedding
MIL-W-22759	Wire Electrical, Fluoropolymer-Insulated, Crosslinked Modified ETFE, Normal Weight, Nickel-Coated, High Strength Copper Alloy, 200°C, 600 Volt
MIL-PRF-23586	Sealing Compound with Accelerator, Electrical, Silicone Rubber
MIL-PRF-83282	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base Metric Nato Code H-537
MIL-PRF-87257	Hydraulic Fluid, Fire Resistant; Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile
MIL-STD 130	Identification Marking of U.S. Military Property
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD 461	Requirements for the Control of Electromagnetic Interference
MIL-STD-464	Electromagnetic Environmental Effects Requirement for Systems
MIL-STD-681	Identification Coding and Application of Hook-up and Lead Wire
MIL-STD-704	Aircraft Electrical Power, Characteristics
MIL-STD-810	Environmental Engineering Considerations and Laboratory Tests
MIL-STD-889	Dissimilar Metals
MIL-STD-1472	Human Engineering Department of Defense Design Criteria Standard
MIL-STD-7179	Finishes, Coatings and Sealants for the Protection of Aerospace Weapons Systems
MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures
MIL-HDBK-310	Department of Defense Handbook - Global Climatic Data for Developing Military Products

U.S. Government Publications: Available from ASC/ENSI, Building 125, 2335 Seventh St., Ste 6, Wright Patterson AFB, OH 45433-7809.

AFSC DH 1-3 Personnel Subsystem Design Three Handbook
AFSC DH 1-4 Electromagnetic Compatibility

2.1.4 RTCA Publications: Available from Radio Technical Commission for Aeronautical Secretariat, One McPherson Square, Suite 500, 1425 K Street, NW., Washington DC 20005.

RTCA-DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

2.1.5 NAS Standards: Available from Aerospace Industries Association, 1250 Eye Street NW, Washington, DC 20005.

NAS 1613 Seal Element Packing, Preformed, Ethylene Propylene Rubber

2.1.6 ANSI Publications: Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI Z540.1 Laboratories, Calibration, and Measuring and Test Equipment

3. REQUIREMENTS:

3.1 Introduction:

This section is intended to be a guide for the preparation of a specification for a three-way, two position solenoid valve. The valve may be either a normally open or normally closed type. It is recommended that for standardization of document, the specification paragraphs be organized as follows:

1. SCOPE
2. REFERENCES
3. REQUIREMENTS
 - 3.1 Design Requirements
 - 3.1.1 Mechanical
 - 3.1.2 Hydraulic
 - 3.1.3 Electrical
 - 3.2 Performance Requirements
 - 3.3 Environmental Requirements
4. QUALITY ASSURANCE PROVISIONS
5. PREPARATION FOR DELIVERY
6. NOTES

Applicable documents should be listed under 2. REFERENCES.

The mechanical interfaces included in this specification show examples of plug-in and face mounted installation options, with and without interface connectors. The interface dimensional details and hydraulic definition apply to single or multiple coil designs. This information represents typical 3000 psi (21,000 kPa) aerospace solenoid valve designs that have proven to be reliable and cost effective.

The recommended Detail Specification limits stated in 3.2 and 4.2 are consistent with the requirements of most aerospace hydraulic actuation systems and can be met with reliable solenoid valve designs of proven producibility. Reducing the limits recommended will generally make the product more difficult to produce and increase its cost. Changes to the recommended limits should be carefully considered before closer control is arbitrarily imposed.

3.1.1 Terminology and Definitions: Unless otherwise stated, terminology and definitions shall be defined by or consistent with ARP4386.

3.1.1.1 Solenoid Valve: An electrically energized flow control valve that is capable of directing flow from a pressurized source to a control port when electrically energized (normally closed). When de-energized, the control port will be vented to the system return pressure. Alternately, a normally open design directs flow from a pressurized source to a control port when de-energized and vents the control port to return when energized.

3.1.1.2 Three Way, Two Position: A valve having three hydraulic ports arranged so that the valve action in one direction opens supply pressure to the control port and the reverse valve action vents the control port to return pressure.

3.1.1.3 Port Designation: A fluid connection to or from the solenoid valve. Fluid ports are labeled P, (Supply) C, (Control) and R, (Return).

3.1.1.4 Direct Acting: The solenoid alone causes the valve to operate -- that is, there is no amplification by internal hydraulic pilot.

3.1.1.5 Purchaser: The Purchaser is the organization that has the responsibility for the design and development of the hydraulic system that includes the solenoid valve. Typically, the Purchaser is an aircraft manufacturer or a modification center. The Purchaser is responsible for compiling the Procurement Specification.

3.1.1.6 Supplier: The Supplier is the manufacturer of the solenoid valve who is responsible for its design, production and qualification.

3.2 Detail Specification Considerations:

3.2.1 Scope: The introductory paragraph of the solenoid valve Detail Specification shall identify specifically the type of component. It is preferred to have a brief description of the application included in the introductory paragraph, together with any additional information, which describes broadly the solenoid valve requirements. Any unusual design or performance requirements may be cited to indicate the general nature of the hardware to be produced by the specification (i.e., high temperature, low leakage, high response, etc.)

- 3.2.2 Requirements: The Requirements section of the document defines specification requirements for the solenoid valve including all operating, non-operating, and storage conditions. The paragraphs below provide a comprehensive summary of requirements frequently specified. The specification should include only those requirements that are necessary to ensure that system performance requirements are met.

The solenoid valve must be designed to meet performance and all other requirements of the Detail Specification while installed in the hydraulic control system, during both ground and airborne operations, at the end of a life equivalent to that defined in the specification provided the environment is no more stringent than that specified. The lack of a design verification test shall not relieve the solenoid valve Supplier of the responsibility for full compliance with the requirement of the specification.

If applicable for a multiple coil design, it must be stated that during normal operation, each coil of a multiple coil design shall be supplied with current from an independent power source. It shall be stated whether the requirement applies to one or more coils operational.

- 3.2.3 Design Requirements: The solenoid valve shall be a completely self-contained package which meets the requirements for the total operation specified. It shall be designed in accordance with AS40401 and AS8775 except as specified. Any deviations from the requirements of the Detail Specification must be specifically noted by the Supplier and shall require written approval from the Purchaser prior to acceptance.

- 3.2.4 Mechanical: This paragraph briefly states the type of solenoid valve being specified, the number of coils and the fluid flow path when energized.

- 3.2.4.1 Workmanship: Workmanship shall be defined by process standards such that each solenoid valve complies with all requirements including proper operation and personnel safety.

- 3.2.4.2 Physical Description: The physical description of the solenoid valve shall include the following:

- a. Envelope dimensions
- b. Mounting definition
- c. Electrical connection and polarity
- d. Coil pin connections or lead wire color coding as applicable
- e. Dry weight

If the installation is face mounted, the solenoid valve hydraulic ports shall be defined and legibly marked. Suitable locating means shall be provided to prevent incorrect connection with the manifold. The port identification shall be as follows:

- a. Supply port - P
- b. Return port - R
- c. Control port - C

3.2.4.2 (Continued):

■ All assemblies having the same part number shall be functionally interchangeable.

The envelope shall represent the installation space available for the solenoid valve. It shall indicate maximum dimensions and specify the location and dimensions of electrical connectors or other critical areas as applicable.

Examples of three specific types of 3000 psi (21,000 kPa) low flow (less than 1 gpm or 3.78 L/min) solenoid valve installations are included for information and guidance. These are:

Figure 1 - Installation Data, End Face Mounted Solenoid Valve, Two Coil, Normally Closed

Figure 2 - Installation Data, Side Face Mounted Solenoid Valve, Four Coil, Normally Closed

Figure 3 - Installation Data, Plug in Solenoid Valve, Two Coil, Normally Closed.

Both electrical lead wire and connector interfaces are shown as well as single and multiple coil variations of the above types. Depending on the number of coils required, the coil envelope length may be changed from that shown in the figures. Consideration shall be given to specifying the mounting and porting configurations and methods of dimensioning given in Figures 1 through 3 for design standardization. The dimensional parameters shown represent proven producible and cost effective designs for single and multiple coil solenoid valves.

3.2.4.3 Identification: The solenoid valve shall be marked for identification in accordance with MIL-STD-130. Identification may be by nameplate or other permanent marking method as specified. Name plates shall be permanently attached with an approved adhesive. Decals shall not be used. Part marking shall be located as shown on the Source Control Drawing. Part marking typically includes the following:

- a. Equipment nomenclature
- b. Purchaser Cage Code
- c. Supplier Code Identification, Part Number (including dash number and revision number) and Serial Number
- d. Date of manufacture
- e. Country

The following additional information may be included:

- a. Purchaser part number
- b. Rated pressure
- c. Rated current
- d. Rated voltage
- e. Fluid



