

Submitted for recognition as an American National Standard

**Aerospace - General Requirements for Commercial
Aircraft Hydraulic Components**

FOREWORD

This SAE Aerospace Specification (AS) was written when:

- a. The FAR and JAR 25.1435 airworthiness regulations, which are specifically concerned with hydraulic systems, were being revised.
- b. Many of the U.S. Government documents (MIL-SPECS, MS and AN standards, etc.) were being deleted, significantly revised or converted into Non-government documents.

However, rather than delay the publication of AS4941 for some time, it was decided to:

- a. Publish the initial version of AS4941 with the current standard of these airworthiness regulations/ U.S. Government documents.
- b. To incorporate the changes as required at the first revision.

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1. SCOPE:

This specification covers the requirements that are common to most components used in commercial aircraft hydraulic systems.

This specification shall be used to develop Procurement Specifications for components.

1.1 Purpose:

The purpose of this specification is to provide in one document, the requirements for the design, construction, acceptance testing and qualification testing of commercial aircraft hydraulic system components. In addition, parameters that must be specified in the Procurement Specification for each component are also identified.

1.2 Field of Application:

This specification primarily applies to components that are fitted to commercial aircraft hydraulic systems that are designed to comply with FAR and/or JAR 25 regulations. However, this specification can be also used for hydraulic system components fitted to aircraft that are certificated to FAR and/or JAR 23 regulations.

AS4941 does not apply to hydraulic system distribution elements such as hoses, pipe couplings and tubes. This is because the requirements for these items are already provided by other National, Government or International standards.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this specification to the extent specified herein. The latest issue of the SAE publications applies. The applicable issue of the other documents shall be the issue in effect at 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.

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

AS568	Aerospace Size Standard for O-rings
AS1241	Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft
ARP1288	Placarding of Aircraft Hydraulic Equipment to Identify Phosphate Ester Fluid Compatibility
AS1290	Graphic Symbols for Hydraulic and Pneumatic Systems
AS1300	Boss, Ring Locked Fluid Connection Type, Standard Dimensions for
ARP1383	Impulse Testing of Hydraulic Actuators, Valves, Pressure Containers and Similar Fluid System Components.
ARP1870	Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety
AS3121	Plug Expansion Aluminium, 2024-T4, Long, Standard and .010 Oversize Diameters
AS3122	Plug Expansion Aluminium, 2024-T4, Long
AS3123	Plug Expansion Aluminium, 2024-T4, Short, Standard and .010 Oversize Diameters
AS3124	Plug Expansion Aluminium, 2024-T4, Short
AS3125	Plug Expansion CRES, 416, Long, Standard and .010 Oversize Diameters
AS3126	Plug Expansion CRES, 416, Long
AS3127	Plug Expansion CRES, 416, Short, Standard and .010 Oversize Diameters
AS3128	Plug Expansion CRES, 416, Short
AS3129	Plug Expansion CRES, 303, Long, Standard and .010 Oversize Diameters
AS3130	Plug Expansion CRES, 303, Long
AS3131	Plug Expansion CRES, 303, Short, Standard and .010 Oversize Diameters
AS3132	Plug Expansion CRES, 303, Short
AS4059	Aerospace Cleanliness Classification for Hydraulic Fluids
AS4088	Rod Scraper Gland Design Standard
AS4273	Fire Testing of Fluid Handling Components for Aircraft Engines and Aircraft Engine Installations
AIR4543	Aerospace Hydraulics and Actuation Lessons Learned
AS4716	Gland Design, O-rings and other Elastomeric Seals
ARP4752	Design and Installation of Commercial Transport Aircraft Hydraulic Systems
AS8879	Screw Threads - UNJ Profile, Inch
AMS 2403	Plating, Nickel General Purpose
AMS 2404	Electroless Nickel Plating
AMS 2405	Electroless Nickel Plating Low Phosphorus
AMS 2406	Plating, Chromium Hard Deposit
AMS 2409	Plating, Immersion Tin for Aluminium Alloys
AMS 2410	Plating, Silver Nickel Strike, High Bake
AMS 2411	Silver Plating for High Temperature
AMS 2412	Silver Plating Copper Strike, Low Bake
AMS 2413	Plating, Silver-Rhodium
AMS 2423	Plating, Nickel Hard Deposit
AMS 2424	Plating, Nickel Low-Stressed Deposit
AMS 2433	Plating, Nickel-Thallium-Boron or Nickel-Boron Electroless Deposition

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2.1.2 FAR Publications from the FAA: Available from the Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591.

FAR Part 23 Code of Federal Regulations, 14 CFR1.1, Part 23 Airworthiness Standards, Normal, Utility, Acrobatic and Commuter Category Airplanes

FAR Part 25 Code of Federal Regulations, CFR1.1, Part 25 Airworthiness Standards, Transport Category Airplanes

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

NAS1599 Connectors, General Purpose, Electrical, Miniature Circular, Environment Resisting, 200 Deg C Maximum Temperature

NAS1611 Packing, Ethylene Propylene Preformed O-ring Phosphate-Ester Resistant (-65 Degrees F to 250/300 Degrees F)

NAS1612 Packing, Ethylene Propylene Preformed, Straight Thread Tube Fitting Boss, Phosphate-Ester Resistant -65 Degrees F to 250/300 Degrees F

NAS1613 Seal Element, Packing, Preformed, Ethylene Propylene Rubber

NAS1638 Cleanliness of Parts Used in Hydraulic Systems

2.1.4 Radio Technical Commission for Aeronautics Documents: Available from RTCA Secretariat, 44 Suite 500, 1425 K Street, N.W., Washington, DC 20005.

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

2.1.5 IEEE Documents: Available from Institute of Electrical and Electronics Engineers Inc., 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331.

C63.14 American National Standard Dictionary for Technologies of Electromagnetic Compatibility (EMC), Electromagnetic Pulse (EMP), and Electrostatic Discharge (ESD)

2.1.6 International Standards Organization Documents: Available from American National Standards Institute, 11 West 42nd Street, New York, NY 10036-8002.

ISO 2685 Environmental Test Conditions for Airborne Equipment - Resistance to Fire in Designated Fire Zones

ISO 3323 Aircraft, Hydraulic Components, Marking to Indicate Fluid for Which Component is Approved

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2.1.7 ASTM Publications: Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM B 339 Standard Specification for Pig Tin

ASTM B 545 Standard Specification for Electrodeposited Coatings of Tin

ASTM B 633 Zinc Coating, Electrodeposited, Requirements for

2.1.8 Joint Aviation Authorities Committee Documents: Available from Civil Aviation Authority Printing and Publications Services, Grenville House, Cheltenham, Glos. GL50 2BN, United Kingdom.

JAR 23 Joint Airworthiness Requirements, Normal, Utility, Acrobatic and Commuter Category Aeroplanes

JAR 25 Joint Airworthiness Requirements, Large Aeroplanes

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

MIL-S-5002 Surface Treatments and Inorganic Coatings for Surfaces of Weapons Systems

MIL-C-5541 Chemical Conversion Coatings on Aluminium and Aluminium Alloys

MIL-H-5606 Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordnance

MIL-M-7969 Motor, Alternating Current, 400 Cycle, 115/200 Volt System, Aircraft, General Specification

MIL-M-8609 Motors, Direct Current, 28 Volt System, Aircraft, General Specification for

MIL-A-8625 Anodic Coatings for Aluminium and Aluminium Alloys

MIL-R-8791 Retainer, Packing, Hydraulic and Pneumatic, Tetrafluoroethylene Resin

MIL-P-25732 Packing, Preformed, Petroleum Hydraulic Fluid

MIL-C-38999 Connector, Electrical, Circular, Miniature, High Density Quick Disconnect

MIL-R-83248 Rubber, Fluorocarbon Elastomer, High Temperature Fluid, and Compression Set Resistant

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

MIL-R-83485 Rubber Fluorocarbon Elastomer, Improved Performance at Elevated Temperatures

MIL-H-87257 Hydraulic Fluid, Fire Resistant, Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile

MIL-STD-276 Impregnation of Porous Non-Ferrous Metal Castings

MIL-STD-461 Electromagnetic Interference Characteristics, Requirements for Equipment

MIL-STD-462 Electromagnetic Interference Characteristics, Measurement of

MIL-STD-464 Electromagnetic Environment Effects Requirements for Systems

MIL-STD-704 Electrical Power, Aircraft, Characteristics and Utilization of

MIL-STD-810 Environmental Test Methods and Engineering Guidelines

MIL-STD-889 Dissimilar Metals

MIL-HDBK-454 Electronic Equipment, General Guidelines for

MS21209 Insert, Screw Thread, Coarse and Fine, Screw Locking, Helical Coil, CRES

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2.1.9 (Continued):

MS21343	Boss Spacing - Hydraulic Design Standard for
MS24391	Plug-Bleeder, Tube, Precision Type
MS27595	Retainer, Packing Backup, Continuous Ring, Tetrafluoroethylene
MS33514	Fitting End, Standard Dimensions for Flareless Tube Connection and Gasket Seal
MS33515	Fitting End, Standard Dimensions for Bulkhead Flareless Tube Connections
MS33547	Pin, Spring, Functional Limitations of
MS33566	Fitting, Installation of Flareless Tube, Straight Threaded Connectors
MS33649	Bosses, Fluid Connection - Internal Straight Thread
QQ-P-416	Plating, Cadmium Electrodeposited

2.2 Definitions:

COMPONENT: A component is a valve, actuator, accumulator, filter, reservoir, pump, or a similar device of a hydraulic system. A component can also be a sensor that provides continuous measurement or switching at discrete settings of pressure, temperature, fluid level or flow.

NON-DERANGEMENT TEMPERATURE: A non-derangement temperature is an extreme ambient temperature that the component may be subjected to but is not expected to function. However, the component is required to operate correctly when the ambient temperature is subsequently within the declared operating temperature range.

PROCUREMENT SPECIFICATION: The procurement specification is the document that includes the following:

- Technical requirements.
- Acceptance and qualification test requirements.
- Reliability requirements.
- Quality requirements.
- Packaging requirements.

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

STANDARD PART: A standard part is a part to a military or industry standard with controlled interface dimensions and which is assigned a part number by the applicable standard, for example, MS, AS, AN and NAS part numbers.

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2.2 (Continued):

SUPPLIER: The supplier is the manufacturer of the component who will be responsible for the design, production and qualification of the component. The supplier shall be approved by the Purchaser for the design, development and manufacture of aerospace hydraulic components.

TURN ON VOLTAGE: Turn on voltage is the voltage that is associated with the inrush current that occurs when an electrically operated component is initially supplied with electrical power.

3. REQUIREMENTS:

The Purchaser shall prepare a Procurement Specification for each component for which design approval is desired.

The purchase order or invitation to bid that is associated with the Procurement Specification shall identify the effective date of the standards that are cited in the Specification.

3.1 General:

In the case of a conflict between the requirements of this specification and the Procurement Specification, the requirements of the latter shall take precedence.

3.1.1 System Specification: The components shall be designed for use in hydraulic systems as defined in ARP4752.

3.1.2 System Characteristics: The Procurement Specification shall include the characteristics of the hydraulic system in which the component is to be used.

3.1.3 Graphical Symbols: Graphical symbols in accordance with AS1290 shall be used for:

- a. The functional schematic diagram of the component, if it is shown on the main assembly drawing.
- b. Any schematic diagrams that are provided in test circuits requirements and test reports.

- 3.1.4 Airworthiness Requirements: The hydraulic component shall comply with Federal Airworthiness Regulations (FAR), Part 25 (for U.S. certified aircraft) or to Joint Airworthiness Requirements (JAR), Part 25 (for non-U.S. certified aircraft).

The sections in these regulations that can be applied to hydraulic components are as follows:

25.X899	Electrical bonding (JAR 25 only)
25.581	Lightning protection
25.603	Materials
25.613	Material strength properties and design values
25.621	Casting values
25.863	Flammable fluid fire protection
25.1183	Flammable fluid carrying components
25.1301	Function and installation of equipment
25.1309	Equipment, systems and installations
25.1353	Electrical equipment and installation*
25.1431	Electronic equipment*
25.1435	Hydraulic systems

* Only if the component incorporates electrical elements (for example, motors, switches, etc.)

The impact of these requirements on the design, manufacture and qualification of commercial aircraft hydraulic system components shall be referred to throughout this document.

3.2 Qualification:

FAR/JAR 25.1301 regulations state that each item of installed equipment shall be:

- Of a kind and design appropriate to its intended function.
- Installed according to the limitations specified for that equipment.
- Able to function correctly when installed.

In order to comply with this regulation, each hydraulic component shall be qualified to demonstrate that it will operate correctly within the functional and environmental limitations that are specified for it.

3.3 Functional Requirements:

3.3.1 Design Operating or Working Pressure: This is defined in 3.7.1.

3.3.2 Fluid Temperature:

3.3.2.1 Rated Temperature: The rated temperature of the component shall be the maximum continuous fluid temperature that the component is subjected to, and shall be stated in the Procurement Specification.

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3.3.2.2 Minimum Continuous Fluid Temperature: A minimum continuous fluid temperature at the supply port of the component may be specified in the Procurement Specification.

3.3.3 Hydraulic Fluid: The applicable hydraulic fluid shall be specified in the Procurement Specification.

Commercial type aerospace hydraulic components will generally use AS1241 fluids. However, for some applications (predominately small commercial aircraft), the components may use MIL-H-5606, MIL-H-83282 or MIL-H-87257 fluids.

It should be noted that AS1241 fluids are not mixable or interchangeable with MIL-H-5606, MIL-H-83282 or MIL-H-87257 fluids. In addition, seals used for AS1241 fluids are generally not compatible with the MIL-SPEC fluids and vice versa.

3.3.4 Rated Flow Capacity: The rated flow capacity shall be specified in the Procurement Specification or the applicable detail drawing.

3.3.5 Pressure Drop at Rated Flow: The component shall be designed to provide either the required restriction as a function of flow or not exceed a maximum restriction consistent with the other requirements of this specification. The pressure drop at rated flow and at other designated test points shall be defined by the Procurement Specification or the applicable detail drawing.

3.3.6 Actuation Above System Pressure: Components shall be designed to be capable of actuation or deactuation under pressure equal to the thermal relief or the system relief maximum setting of the circuit in which they are installed. There shall be no seizing or excessive force input.

For electrically operated components, the voltage shall not be greater than the maximum turn on voltage or greater than maximum rated current. The turn on voltage shall not exceed 80% of the nominal voltage. The maximum current rating (continuous and intermittent) based on the worst case environment, and the maximum turn on voltage, shall be specified in the Procurement Specification.

3.4 Environmental Requirements:

All components shall be designed to operate under the environmental conditions specified below without:

- a. Any time limitation less than the design life specified by the component.
- b. Any impairment of function or change of adjustment.

Except as specifically directed herein, testing to demonstrate compliance with these requirements shall not be mandatory.

NOTE: Although RTCA/DO-160 is referred throughout this document for environmental requirements, MIL-STD-810 may alternatively be used.

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3.4.1 Altitude: The component performance shall not be significantly affected by change of altitude from sea level to the maximum altitude specified in the Procurement Specification or vice versa.

3.4.2 Ambient Temperature: The Procurement Specification shall state the minimum and maximum ambient operating and non-derangement temperatures.

Care shall be taken in specifying the temperature range to take into account:

- a. Cold soak conditions that will occur when the aircraft is parked in very cold weather conditions or, during flight at high altitude, if the component is installed in an unpressurized zone.
- b. Hot soak conditions that will occur when the aircraft is parked in very hot weather conditions or if the component is installed in a zone which is subject to local high ambient temperatures, for example, in an engine nacelle.

Typical ambient temperature ranges are:

- a. Operating temperature: -65 °F (-54 °C) to +158 °F (+70 °C).
- b. Non-derangement temperature: -80 °F (-62 °C) to +230 °F (110 °C).

3.4.3 Vibration: Components shall be capable of withstanding vibrations excited by the driving means. All components shall be designed to withstand the applicable vibration levels as stated in RTCA/DO-160, Section 8, unless otherwise specified in the Procurement Specification. For design and test purposes, torsional vibration excited by the driving means shall be considered negligible. As part of the qualification tests, all component models shall be subjected to the vibration tests specified in 6.11.

3.4.4 Operational Shocks and Crash Safety: All components shall be designed to withstand sustained accelerations in accordance with RTCA/DO-160, Section 7 requirements unless otherwise specified in the Procurement Specification.

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- 3.4.5 Environmental Conditions: The component shall be designed to comply with the following sections of RTCA/DO-160, unless otherwise specified in the Procurement Specification:
- a. Section 6 - Humidity. The Procurement Specification shall specify the applicable Category for the component.
 - b. Section 10 - Water resistance. The Procurement Specification shall specify the applicable Category for the component.
 - c. Section 11 - Fluids susceptibility. The Procurement Specification shall identify the relevant fluids that have to be considered.
 - d. Section 12 - Sand and dust. This requirement only applies if the component is subject to blowing sand and dust in the course of normal aircraft operations.
 - e. Section 13 - Fungus. The Procurement Specification shall specify the applicable Category for the component.
 - f. Section 14 - Salt spray. This requirement only applies if the component is mounted in an unpressurized part of the aircraft.
 - g. Section 24 - Icing. The Procurement Specification shall specify the applicable Category for the component.
- 3.4.6 Fire Resistance: The component shall be designed to comply with the FAR/JAR 25.863, FAR/JAR 25.1183 and FAR/JAR 25.1435(c) requirements if it is installed in an area which is subjected to engine fire conditions (for example, an engine driven pump). The Procurement Specification must state the flow rate and direction of flow through the component that will occur during engine fire conditions. This is to enable the necessary precautions to be incorporated into the component in order for it to comply fully with these requirements.
- 3.4.7 Explosion Proofness: The Procurement Specification shall state if the component is to be installed in an environment where the potential exists for explosions to occur. The category for the environment shall be stated in accordance with the requirements of RTCA/DO-160, Section 9. If it is determined that there is the likelihood of an explosion, the component shall be suitably designed to minimize the possibility of this event occurring.
- 3.4.8 Acoustic Fatigue: The component shall not be adversely affected or prematurely failed due to external noises as defined in the Procurement Specification.

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3.5 Installation Requirements:

3.5.1 General: The Purchaser and the Supplier shall directly liaise with each other to ensure that the component is designed so that it is only possible to install it properly. Means shall be provided to ensure that it is not possible to:

- a. Have the wrong tubes connected to it or reverse the component's installation (see 3.8.14).
- b. Install the wrong electrical wires to the component.
- c. Connect the wrong cables or mechanisms to the component.

Ideally, the Purchaser shall provide the Supplier with the relevant drawings in order to ensure compliance with this requirement.

3.5.2 Dimensions: Dimensions and tolerances pertinent to the installation of the component in the aircraft shall be specified on the Supplier's installation drawing or in the Procurement Specification.

3.5.3 Orientation: Generally, the component shall meet the requirements of this specification and the Procurement Specification while mounted in any orientation. However, if the component is specifically attitude susceptible, the installation limitations shall be agreed upon between the Purchaser and the Supplier and it shall be stated on the component installation drawings.

3.5.4 Weight: The wet and dry weight of the completely assembled component shall be stated on the component's installation drawing and shall not exceed that stated in the Procurement Specification.

3.5.5 Ports: Each port configuration shall be in accordance with MS33649 unless otherwise specified in the Procurement Specification. The spacing of ports for connecting fittings shall be adequate for wrench clearance, as specified in MS21343.

3.5.5.1 Wrench Torque Loads: The structural design of the ports and of the affected sections of the component shall withstand the application of torque 2.5 times the maximum value specified in the Procurement Specification or MS33566, as applicable. There shall be no permanent distortion or impairment of function.

3.6 Detail Requirements:

FAR/JAR 25.603 requirements state that the materials and processes used in the manufacture of components shall be of high quality, suitable for the purpose and shall conform to the applicable specifications. Materials conforming to the Supplier's material specifications may be used provided the specifications are acceptable to the Purchaser and contain provisions for adequate tests.

The use of the Supplier's specifications shall not constitute the waiver of other applicable specifications. The choice of materials and the assumed strength of the materials shall comply with FAR/JAR 25.613 regulations.

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- 3.6.1 Metals: All metals shall be compatible with the fluid, temperature, function, service, and storage conditions to which the components will be exposed. The metals shall possess adequate corrosion resisting characteristics, or be suitably protected in accordance with 3.6.2. Magnesium shall not be used.
- 3.6.2 Corrosion Protection: Metals which do not inherently possess adequate corrosion resisting characteristics or are not submerged in hydraulic fluid, shall be suitably protected, in accordance with the following sub paragraphs, to resist corrosion which may result from such conditions as:
- Dissimilar metal combinations (reference MIL-STD-889).
 - Moisture.
 - Salt spray.
 - High temperature.

Ferrous alloys requiring corrosion preventive treatment, and all copper alloys, except for parts having bearing surfaces, shall have a suitable electro-deposited metallic coating selected from Table 1. Tin, cadmium, and zinc plating may not be used for internal parts or on internal surfaces in contact with hydraulic fluid or exposed to its vapors and not where parts are subject to abrasion. Where not indicated, the class and type are at the option of the manufacturer.

Unless otherwise authorized, all aluminium alloys shall be anodized in accordance with MIL-A-8625 Type II or Type III coating. However, in the absence of abrasive conditions, they may be coated in accordance with MIL-A-8625 Type I or with a chemical film in accordance with MIL-C-5541. The exceptions noted shall be subject to the approval of the Purchaser.

TABLE 1 - Metallic Coatings

Coatings	Specification
Cadmium plating	QQ-P-416, Type II, class 2
Chromium plating	AMS 2406
Electroless Nickel plating	AMS 2404, AMS 2405, AMS 2433
Nickel plating	AMS 2403, AMS 2423, AMS 2424
Silver plating	AMS 2410, AMS 2411, AMS 2412, AMS 2413
Tin plating	AMS 2409, ASTM B 339, ASTM B 545
Zinc plating	ASTM B 633

Other metallic or non-metallic coatings or treatments may be used if acceptable to the Purchaser.

The use of cadmium shall be minimized. Environmental concerns shall be addressed when selecting the coatings.

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- 3.6.3 Castings: Castings shall be of high quality, clean, sound, and free from cracks, blow holes, and excessive porosity and other defects. Defects not materially affecting the suitability of the castings may be repaired at the foundry or during machining by peening, impregnation, welding, or other methods acceptable to the Purchaser.

Inspection and repair of castings shall be governed by quality control techniques and standards that are satisfactory to the Purchaser. When impregnation castings are used, they shall be in accordance with impregnation procedures and inspection requirements of MIL-STD-276.

Corrosion and heat resistant alloys shall have their surfaces treated in accordance with MIL-S-5002 and shall be cleaned by acid etching, electropolishing or by mechanical means to remove contamination, oxides, etc.

The use of castings in components subject to high pressure (3000 psi (20,690 kPa) or greater) shall be subject to the approval of the Purchaser.

The casting factors assumed in the design of the components shall comply with FAR/JAR 25.621 regulations.

- 3.6.4 Residual Magnetism: Parts made of material that is capable of retaining residual magnetism, but are not intended to function as magnets, shall be demagnetized sufficiently to prevent system or component malfunction, including malfunction due to the accumulation of magnetic contaminants. If a component or system is vulnerable to malfunction due to residual magnetism, the Procurement Specification shall specify the maximum allowable flux density.

- 3.6.5 Magnets: Permanent magnets and electromagnets shall be shielded where required to prevent system or component malfunction. The Procurement Specification shall specify the maximum allowable flux density outside the shield.

- 3.6.6 Plastic Parts: The use of plastic parts shall be subject to the approval of the Purchaser.

- 3.6.7 Glands and Seals:

- 3.6.7.1 General: Components shall be designed so that, in the assembly of parts, sufficient clearance exists to permit assembly of the components without damage to O-rings or backup rings where they pass threaded parts or sharp corners.

- 3.6.7.2 Glands: The configuration and dimensions of seal glands shall conform to the requirements of AS4716. Non-standard glands for specialized seal assemblies shall only be used with the approval of the Purchaser.

Care shall be taken to prevent binding and interference at the most adverse temperature extremes.

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- 3.6.7.3 Seals: Wherever possible, ethylene propylene rubber O-rings shall conform to NAS1611 and NAS1612 dimensional requirements. All other elastomer seals shall dimensionally conform to AS568. When non-standard 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.

Smaller cross section O-ring seals (0.070 in (1.778 mm) diameter or less) or their equivalent proprietary seals, shall only be used in exceptional circumstances (such as space critical applications) and shall have the approval of the Purchaser.

Components designed for operation with fluids per AS1241 shall use sealing elastomers conforming to NAS1613.

Components designed for operation with fluids per MIL-H-5606 or MIL-H-87257 shall use nitrile-sealing elastomers conforming to MIL-P-25732 or MIL-P-83461. Components designed for operation with fluids per MIL-H-83282 shall use nitrile-sealing elements conforming to the requirements of MIL-P-83461. If the temperature of MIL-H-5606 or MIL-H-83282 fluids are expected to exceed 250 °F (121 °C), fluorocarbon elastomers conforming to MIL-R-83248 or MIL-R-83485 should be used. Of the two elastomers, MIL-R-83485 materials have better low temperature properties. However, fluorocarbon elastomers cannot meet the -65 °F (-54 °C) requirement and caution should be exercised when using these materials in systems that have low temperature requirements.

- 3.6.7.4 Backup Rings: Backup rings shall conform to MS27595. Backup rings conforming to MIL-R-8791/1 may be used on dynamic applications where minimum seal friction is required for satisfactory operation or where access to the gland prevents installation of MS27595 backup rings. If MS27595 continuous 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 component.

- 3.6.7.5 Scrapers: Components with internal diameter seals that may be exposed to water, dirt or ice shall have a scraper using a gland in accordance with AS4088.

- 3.6.8 Standard Parts: Aerospace standard parts (Military or Commercial) shall be used whenever they are suitable for the purpose, and shall be identified on the drawings by their standard part identifying numbers.

- 3.6.9 Marking:

- 3.6.9.1 Identification of the Product: FAR/JAR 25.1301 requirements state that the component must be marked for identification in accordance with standard practices and the Purchaser's requirements.

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3.6.9.2 Nameplate: Whenever possible, a nameplate containing the following information legibly filled in shall be securely attached to the component:

NOTE: The use of drive screws is prohibited.

- a. Component type.
- b. Procurement Specification number.
- c. Supplier's part number.
- d. Supplier's name or trademark.
- e. Serial number.
- f. Fluid (Identify in accordance with ARP1288 or ISO3323).
- g. Date of manufacture.
- h. Inspection stamp.
- i. Modification status.

Any additional nameplate data requirements shall be specified in the Procurement Specification.

If there is insufficient space for a nameplate on the component, indelible marking on the component is acceptable. The following, as a minimum, shall be provided:

- a. Supplier's part number.
- b. Serial number.

3.7 Strength Requirements:

3.7.1 Pressure Loads: FAR 25.1435(a)(1) requires the components to be designed to withstand design operating loads in combination with limit structural loads which may be imposed. No permanent or temporary deformation of the component is permitted under these conditions that would prevent it from performing its intended function.

The design operating pressure is defined in FAR 25.1435(a)(1) regulations as the maximum normal operating pressure, excluding any transient pressures. The equivalent JAR 25.1435(a)(1) requirement is identical to the FAR 25 regulation except that "working pressure" is used instead of "design operating pressure" for components other than pressure vessels. The working pressure is equivalent to the maximum steady state pressure of the system.

For pressure vessels (for example, accumulators), the term "limit pressure" is used in JAR 25.1435(a)(1), which is defined as the anticipated maximum pressure in service, including tolerances and possible pressure variations in normal operating modes, but excluding transient pressures.

The Procurement Specification for the component shall define the design operating pressure or working pressure (as applicable) for the high and low pressure parts of the component. If applicable, the Procurement Specification shall define the limit structural load.

3.7.2 Proof and Ultimate Pressure Requirements:

- 3.7.2.1 Proof Pressure Requirements: FAR 25.1435(a)(1) and JAR 25.1435(a)(2) requirements state that each component must withstand, without rupture, the design operating pressure or working pressure loads (as applicable) multiplied by 1.5 in conjunction with ultimate structural loads that can reasonably occur simultaneously.

In addition, JAR 25.1435(a)(10) requirement (no equivalent FAR 25 regulation) states that each component must withstand the loads due to the working pressure multiplied by 1.5, without leakage or permanent distortion. Pressure vessels must withstand the loads due to the limit pressure multiplied by either 1.5 or 3.0 for at least 3 minutes. In order to use the lower factor, a full fatigue endurance test has to be conducted on a test specimen (from which a permissible fatigue life is declared) and the proof test is subsequently carried out on the same test specimen.

- 3.7.2.2 Ultimate Pressure Requirements: JAR 25.1435(a)(10) requirement states that each component must withstand the loads due to the working pressure multiplied by 2.0, without rupture. Pressure vessels must withstand the loads due to the limit pressure multiplied by either 2.0 or 4.0 for at least 1 minute. In order to use the lower factor, a full fatigue endurance test has to be conducted on a test specimen (from which a permissible fatigue life is declared) and the ultimate pressure test is subsequently carried out on the same test specimen.

For applications that are required to comply with FAR 25 regulations, there is no formal ultimate pressure requirement. However, the Procurement Specification may stipulate a value that matches system requirements.

- 3.7.3 Impulse (Fatigue) Requirements: JAR 25.1435(a)(11) requirement states that an adequate allowance must be made for fatigue for any part of the hydraulic system which is subject to fluctuating or repeated internal and external loads. Although there is no equivalent FAR 25 regulation, the Procurement Specification for each component should state:

- a. An overall predicted duty cycle for the high and low pressure sides of the component, and the external loads applied to the component (where applicable), throughout the lifetime of its application.
- b. The scatter factor that is to be applied for analysis or fatigue (Pressure impulse) testing.

In addition, when defining the duty cycle for the impulse testing, the following should be considered:

- a. The pressure variations due to flow demands in the hydraulic system.
- b. The peak transient pressure generated by the component as it is operating (for example, a fast operating solenoid valve).

Refer to 6.17.2 for details of the impulse testing requirements.

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3.8 Design and Construction:

- 3.8.1 Minimum Weight: The component shall be designed with emphasis placed on ensuring that its weight is as low as possible, consistent with the requirements of this Specification and the Procurement Specification.
- 3.8.2 Lubrication: Except where it is necessary to lubricate drive couplings, the components shall be self-lubricating with no provisions for lubrication other than the fluid circulating within the component.
- 3.8.3 Leakage: External leakage of sufficient magnitude to form a drop shall not be permitted from the component housing or from any static seal. For those components which have dynamic seals (for example, pumps, motors, actuators), every effort shall be made to minimize amount of external leakage over the lifetime of the component. The permissible external leakage shall be stated in the Procurement Specification.
- 3.8.4 External Tube Connections: External threaded tube connections, when used shall conform to drawing MS33514 or MS33515, unless otherwise required in the Procurement Specification. External threaded tube fittings shall be fabricated from steel or titanium if the system pressure is 3000 psi (20,690 kPa) or higher.
- 3.8.5 Interchangeability: All parts having the same Supplier's part number shall be directly and completely interchangeable with each other with respect to installation and performance. Changes in the Supplier's part numbers shall be governed by the Purchaser's requirements. Sub-assemblies composed of selected mating parts must be interchangeable as assembled units, and shall be so indicated on the Supplier's drawings. The individual parts of such assemblies need not be interchangeable.
- 3.8.5.1 Adverse Tolerance Conditions: The Supplier shall verify that the component shall be capable of functioning when assembled with adverse tolerance parts without any degradation of component performance or life. Compliance with this requirement shall be by mathematical analysis or testing.
- 3.8.6 Bolts: Bolts smaller than 0.25 in (6.35 mm) shall not be used in primary tension applications. Bolts smaller than 0.188 in (4.763 mm) shall not be used in primary structural applications. Bolts having minimum tensile strengths more than 160 ksi shall be forged body design and have rolled head-to-shank fillet radii.

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3.8.7 Function Adjustment Screws: Function adjustment screws, when used, shall be so designed and constructed as to maintain adjustment under all the required conditions of vibration, shock, temperature and adjustment. Friction type locking devices shall be kept to a minimum and shall be subject to the approval of the Purchaser. If a friction type is used, the adjustment screws shall maintain their setting after adjusting through the full range 15 times, or as allowed in the Procurement Specification, and then vibration tested.

It shall be possible to adjust and lock the adjustable screws with a standard wrench or screwdriver. Where possible, it shall be possible to adjust under full system pressure with negligible loss of fluid. The adjustment screws shall be sealed, where practicable. If a component is subject to multiple settings, the seal shall be marked with the settings. The means of adjustment shall be either internal or protected from tampering with a cover or similar device.

3.8.8 Plugs: Permanently installed plugs conforming to AS3121 to AS3132 should be used. However, if it is necessary to use a removable plug with an elastomeric seal, then either the following shall be used:

- a. A MS24391 type plug, with an elastomeric seal, wire locked in position.
- b. A ring locked fluid connection type per AS1300.

3.8.9 Alignment: All plungers, poppets, balls, pistons, etc., shall be accurately guided to prevent misalignment or chattering on their seats.

3.8.10 Threads: Straight threads shall conform to AS8879, Unified Fine Thread Series, classes UNJF3A and UNJF3B. Other type threads shall be subject to the approval of the Purchaser. Pipe threads shall not be used.

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3.8.11 Safetying: All threaded parts shall be securely locked or safetied by self-locking nuts or other approved methods. Star washers and jam nuts shall not be used as locking devices.

Lock washers may be used to prevent loosening of threaded fasteners under the following conditions:

- a. When a self-locking feature cannot be provided in an externally or internally threaded part.
or
- b. When a cotter pin cannot be use to prevent rotation of an internally threaded part with respect to an externally threaded part.
or
- c. When lock wire cannot be used to prevent loosening of threaded parts.
- d. When loosening of threaded parts would not endanger the safety of the aircraft or personnel.
- e. When corrosion, encouraged by the gouging of aluminium alloys by the edges of teeth on tooth locked washers, would not cause malfunctioning of parts being fastened together. Installing washers with wet primer may reduce corrosion of dissimilar metals.

3.8.11.1 Safetying Internal Parts of Fluid Chambers: Permanently deformed safetying devices, such as safety wire or cotter pins, that are subject to breaking off, shall not be used internally in fluid chambers.

3.8.11.2 Threaded Inserts: All threaded holes in non-ferrous parts to be used for mounting screws or bolts, shall incorporate straight threaded inserts if locking wire or other locking methods are used on the fasteners. Otherwise, self-locking inserts conforming to MS21209 shall be used.

3.8.12 Retainer Rings: Retainer rings or snap rings shall not be used unless specifically authorized by the Purchaser. When retainer rings are permitted, the following requirements are applicable.

3.8.12.1 Displacement: Displacement of the ring or fragmentation thereof, and associated hardware (for example, washers, lock wire, etc.) shall not cause, or contribute to, loss of fluid from the component or system, or cause malfunction of any component in the aircraft.

3.8.12.2 Load Limitation: Hydraulic, structural, mechanical, or any other form of loads, or combination thereof, including vibration, shock loads, expansion or contraction due to temperature changes, etc., shall not be exerted on the ring that may cause axial displacement and/or failure of the ring.

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- 3.8.12.3 Installation Clearances and Tolerances: Retainer rings or snap rings shall not be used where build-up of clearances and manufacturing tolerances will allow destructive end play in the assembly that may cause, or contribute to, failure of seals or gaskets, brinelling, or fatigue failure of parts.
- 3.8.12.4 Installation and Removal: The retainer rings or snap rings shall be capable of being removed with standard pin type pliers or other standard tools developed for use with the rings.
- 3.8.13 Spring Pins: The use of spring pins is undesirable and they shall not be used in any applications that conflict with the intent of MS33547, unless specifically approved by the Purchaser.
- 3.8.14 Reverse Installation: All components shall be designed such that reverse or incorrect installation in the aircraft or sub-assembly cannot be made. Internal parts which are subject to malfunction or failure due to reversed or rotated assembly shall be designed to render improper assembly impossible or such that any incorrectly installed assembly can be detected during the Production Acceptance Tests.
- 3.8.15 Robustness: Where a manually operated control lever is part of the component, the lever, mechanism and stops shall be capable of withstanding a limit torque of 75 lb-in (864 kg mm) for a radii of greater than 0.8 in (20.3 mm). In the case of components that incorporate stops but do not have an integral control means, the stops shall be capable of withstanding a limit torque of 1800 lb-in (20,738 kg mm).
- 3.8.16 Fixed Orifices: Orifices larger than 0.005 in (0.127 mm) but smaller than 0.070 in (1.778 mm) diameter shall be protected by adjacent secondary filters having screen openings one-third to two-thirds of the diameter being protected. Orifices that are subjected to reversing flow are exempt from this requirement. Orifices smaller than 0.005 in (0.127 mm) diameter shall not be used.
- Multiple orifice fixed restrictors shall be used as a means of increasing the orifice diameter and allowing the use of coarser strainer elements.
- Orifices and secondary filter elements shall be strong enough to absorb system design flow and pressure without rupture or permanent deformation.
- 3.8.17 Internal Locks: If it is required to retain the position of an actuator with no hydraulic system pressure available, then either positive over center locks or internal hydraulic lock devices (such as hydraulically operated mechanical or finger type locks) should be used. Internal locks that solely rely on friction of wetted surfaces shall not be used.

3.9 Electrical Requirements:

3.9.1 Voltage Range: Electrically operated components shall be designed to operate in aircraft electrical systems having characteristics as specified in RTCA/DO-160 Section 16. The components shall be designed to operate under simultaneous extremes of temperature, fluid pressure and voltage. The effect of the following factors shall be considered in determining the most detrimental voltage as defined in RTCA/DO-160 Section 16:

- a. Over and under voltage.
- b. Distortion (ripple).
- c. Surge.
- d. Emergency mode operation.

NOTE: MIL-STD-704 may be used in place of RTCA/DO-160.

3.9.2 Solenoid Operated Components: The solenoids shall be of compact design and of sufficiently rugged construction to withstand the mechanical shocks and stresses incident to their use in aircraft and performance under the environmental conditions specified in 3.4.

Solenoids shall be designed for continuous or intermittent duty and shall be supplied with single or multiple coil windings. The solenoids shall be totally enclosed in order to prevent moisture from coming in contact with the electrical windings. The coil(s) shall be firmly fixed in the frame to prevent ultimate failure of leads caused by vibration. Potting compounds used in the electrical components shall be subject to approval from the Purchaser.

Solenoids shall operate within the time specified in the Procurement Specification.

The drop out or pull in voltage (as appropriate) for solenoid operated components shall be greater than 10% of the nominal operating voltage and less than the minimum activation voltage and at the ambient temperature extremes as specified in the Procurement Specification.

3.9.3 Electric Motor Operated Components: The characteristics of electric motors for operating hydraulic components shall conform generally to MIL-M-8609 for DC operated units, MIL-M-7969 for AC operated units, and the Procurement Specification, including hydraulic fluid proof and explosion proof requirements.

3.9.4 Clutches or Brakes: On assemblies using clutches or brakes to limit overtravel, the design shall be such as to prevent overtravel sufficient to cause malfunctioning of the component, even with oil on the clutch or brake surfaces. Positive mechanical stops shall be incorporated to ensure accurate positioning.

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- 3.9.5 Electromagnetic Interference: In order to demonstrate compliance with FAR/JAR 25.1353(a) and FAR/JAR 25.1431(c), the Procurement Specification, for electrically operated components that might be affected by electromagnetic interference, shall specify EMC testing in accordance with RTCA/DO-160, Sections 20 and 21.

NOTE: MIL-STD-461, MIL-STD-462 and IEEE C63.14 may be used in place of RTCA/DO-160.

- 3.9.6 Electro-Conductive Bonding: FAR/JAR 25.581 and JAR 25.X899 requirements states that the aircraft must be protected against catastrophic effects resulting from a lightning strike. In order to meet this regulation, each component must have the capability of being effectively bonded to the aircraft. This is achieved either by having an effective continuity of bonding across the tube connections' ports or by the provision of a facility to enable the component to be bonded to the aircraft. The method of bonding should be stated in the Procurement Specification. The resistance measured shall not exceed the limits as called out in ARP1870, unless otherwise specified in the Procurement Specification. MIL-STD-464 may be used as an alternative to ARP1870.

- 3.9.7 Connectors: The electrical connectors shall be in accordance with MIL-C-38999 or NAS1599 unless otherwise specified in the Procurement Specification.

3.10 Maintainability Requirements:

- 3.10.1 Maintenance Concept: The required maintenance concept shall be stated in the Procurement Specification, for example, "On Condition".

- 3.10.2 Useful Life and Storage Conditions: The requirements together with the appropriate definitions shall stated in the Procurement Specification and shall consist of:

- a. Life before it has to be overhauled (if applicable).
- b. Storage life.
- c. Life before it has to be scrapped.

Care shall be given in defining the life of a component. A requirement for a "low life" component will not take advantage of the available technologies. However, if the life is too high, then it might result in component qualification problems.

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3.10.3 Maintainability Features: The component shall incorporate the following features in order to minimize its cost of ownership and the possibility of incorrect assembly:

- a. All wear surfaces shall be replaceable or repairable.
- b. Electrical sockets and connections, mounting and wiring provisions shall be designed to prevent erroneous connections.
- c. Components that are not functionally interchangeable shall not be physically interchangeable. Line replacement of the component or any module of the component shall be conducted using standard tools only.
- d. Special or unique equipment is kept to a strict minimum for shop repair, overhaul and maintenance checks.

3.11 Reliability Requirements:

3.11.1 Design for Reliability: As part of the design process, every effort shall be made to achieve the best achievable reliability for the component. This should be conducted by:

- a. Using the minimum number of parts.
- b. Using materials and processes that have been shown to have an excellent in-service history.
- c. Reviewing the in-service history of similar components and consulting AIR4543 to determine the lessons that can be learned and thereby minimize the possibility of in-service problems.

3.11.2 Mean Time before Unscheduled Removals: The Procurement Specification shall state the requirements for the justified unscheduled removal rate per 1000 flight hours. This shall include the removal of the component due to external leakage.

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3.11.3 Data Requirements: The supplier shall provide the following data:

- a. The defect rate.
- b. The failure rate.
- c. The safety rate (if applicable).
- d. The failure mode and effects analysis (FMEA).

This is required in order to:

- a. Enable analysis to be conducted to demonstrate compliance with the safety requirements of FAR/JAR 25.1309.
- b. Plan integrated logistics support requirements.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

Unless otherwise specified in the contract or order, the Supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the Supplier may use his own facilities or the services of any industrial laboratory that has the necessary approvals.

The Purchaser reserves the right to perform any of the inspections contained in this Standard where such inspections are deemed necessary to ensure that the supplies and the services conform to the stipulated requirements.

4.2 First Article Inspection:

The first delivered production article shall have a detailed external dimensioning inspection along with the production acceptance testing to show compliance with the applicable interface or source control drawing/specification. The actual measured dimensions and interface standards shall be recorded for comparison with the applicable requirement document. A later serial numbered component may be used for first article inspection with the concurrence of the Purchaser and the Supplier.

4.3 Classification of Tests:

For the purpose of demonstrating compliance of components with this Standard and the applicable Procurement Specification, two distinct test programs shall be conducted, hereinafter referred to as Acceptance Tests and Qualification Tests.

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4.4 Test Stand Requirements:

For the test stands that are employed for the acceptance tests and the qualification tests, the following limits are set for the required steady state operating conditions, unless otherwise agreed to between the Supplier and the Purchaser:

Pressure:

- a. Up to 100 psi (689 kPa): $\pm 2\%$ but not less than ± 5 psi (± 34 kPa).
- b. Up to 1000 psi (6895 kPa): $\pm 2\%$ but not less than ± 15 psi (± 103 kPa).
- c. Greater than 1000 psi (6895 kPa): $\pm 2\%$ but not less than ± 60 psi (± 414 kPa).

Temperature:

- a. Between -70 and $+110$ °F, within ± 5 °F (-57 to $+43$ °C, within ± 3 °C).
- b. Between $+110$ and $+225$ °F, within ± 8 °F ($+43$ to $+107$ °C, within ± 4 °C).

Component shaft speed (where applicable): Within $\pm 2\%$.

Flow: Within $\pm 5\%$.

The accuracy of the instrumentation shall be consistent with the measurement tolerances required.

The test stands shall use sufficient filtration to maintain the cleanliness of the fluid to AS4059 or NAS1638, Class 6 or better, except for the qualification endurance testing (see 6.9).

5. ACCEPTANCE TESTS:

Each hydraulic component submitted for delivery under a procurement contract shall be subjected to the following acceptance test requirements:

- a. Visual and dimensional examinations.
- b. A test program to determine product conformance to the dimensional, workmanship, functional and performance requirements of this Specification and the Procurement Specification. The test program is specified in 5.1. Unless otherwise specified in the Procurement Specification, the fluid and ambient temperatures shall be between 70 °F (21 °C) and 120 °F (49 °C).

5.1 Test Program and Inspection Methods:

Starting with 5.1.1, the hydraulic fluid in the test circuit shall be as specified in the Procurement Specification. If, at any phase of testing, working parts require replacement, the entire acceptance test procedure shall be repeated.

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- 5.1.1 Weight: Unless the dry weight of the component is required by the Procurement Specification, the component shall be filled with fluid and all the air bled from it. It shall then be weighed to check that it is no greater than that stated in the component's installation drawing.
- 5.1.2 External Leakage: Throughout the test program, there shall be no external leakage past the static seals or the housing except where external dynamic seals are utilized; the permissible leakage past such seals shall be no greater than that specified in the Procurement Specification.
- 5.1.3 Proof Pressure Tests: These tests may be conducted at normal operating temperature, either statically or with the component in operation. The proof pressure shall be 1.5 times the working pressure or as specified in the Procurement Specification and shall be held for at least 3 minutes.

The rate of pressure rise shall not exceed 25,000 psi (172,366 kPa) per minute. There shall be no evidence of:

- a. External leakage other than a slight wetting at seals insufficient to form a drop except for dynamic rotating seals that may leak at the rate specified in the Procurement Specification.
- b. Excessive distortion.
- c. Permanent set.

Components that require a varying test pressure in different elements may have these pressures applied either separately or simultaneously, as specified in the Procurement Specification. Components which are subject to pressure in the reverse direction such as check valves, shut off valves or accumulators shall be pressurized in both directions, either separately or simultaneously as specified in the Procurement Specification.

- 5.1.4 Pressure Drop: When applicable, the pressure drop across the component at the rated flow specified in the Procurement Specification shall be measured. The value observed shall not exceed that permitted by the Procurement Specification. This test shall be performed on 10% of the components in a production lot, unless otherwise agreed between the Supplier and the Purchaser.

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- 5.1.5 Function Tests: The Supplier shall undertake a series of function tests to demonstrate that the component complies with the technical requirements that are specified in the Procurement Specification. The Supplier shall propose the function test program and submit it for approval to the Purchaser. The test program shall incorporate tests to determine the correct operation of the component, such as:
- a. Correct movement of the component when selected.
 - b. Correct rate of operation.
 - c. Correct power generated.
 - d. Loads to operate the component or that the component has to overcome.
 - e. Internal leakage check.
 - f. Checks of position indication (when applicable).
 - g. Electrical checks such as current draw at minimum and maximum voltage levels, solenoid drop out voltage, insulation and dielectric tests.

- 5.1.6 Electro-Conductive Bonding: The electrical resistance between specified points on the component shall be measured. It shall not be greater than the value stated in the Procurement Specification.

5.2 Preparation for Shipment:

After testing, small components shall be drained and filled to approximately 85% of their full volume with fresh, hydraulic fluid to a cleanliness standard of AS4059 or NAS1638, Class 6 or better. Larger components shall be filled with enough fluid to wet all the surfaces.

The fluid used shall be either the specified hydraulic system fluid or a compatible preservative fluid.

A shipping tag shall be provided that states the fluid that has been used for shipping.

5.3 Storage and Packing:

The method of storage and packing shall be defined in the Procurement Specification or procurement contract.

6. QUALIFICATION TESTS:

Qualification tests, for the purposes of checking whether the component design conforms to the requirements of this Standard and the Procurement Specification, shall consist of the tests specified herein. The Supplier shall compile a detailed test schedule for the qualification test program that shall be agreed to by the Purchaser and by the Airworthiness Authorities, when applicable, before the test program commences.

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6.1 Qualification Procedure:

6.1.1 Qualification by Similarity: All or some of the qualification tests may be waived if the following conditions are met:

- a. The component incorporates the same or essentially the same configuration, operation and materials as a component which was previously qualified.
- b. The service requirements for the previous application for which the component was qualified was equivalent to or greater than the service requirements for this application.

and

- c. The production facility shall be the same and/or all the production processes are the same or better.

A report substantiated by drawings and test data showing the similarity with the qualified component shall be submitted instead of carrying out actual tests.

6.1.2 Component Qualification Test Report: A report of the tests performed and the test results shall be compiled. This report shall include a full assessment of the extent to which the tested components comply with the specified requirements.

The report shall include full descriptions of the manner in which the tests were performed, including instrumentation description, schematic diagrams, photographs, as appropriate, and copies of the test data sheets. Hydraulic test circuits shall be described in complete detail for each test. A set of parts lists of the component shall accompany the report.

6.1.3 Test Components Requirements: The qualification tests shall be conducted on components that are to the production standard. The number of components to be used during the qualification testing shall be agreed between the Supplier and the Purchaser, as well as the tests that shall be conducted on each test specimen.

6.1.4 Notification of Test Failures: Whenever a failure is encountered in the qualification test program, the Supplier shall notify the Purchaser within 24 hours of the failure. The Supplier shall obtain concurrence of the corrective action from the Purchaser before restarting the testing.

6.2 Range of Qualification Tests:

The qualification tests to be carried out shall include the following:

- a. Acceptance tests (see 6.3).
- b. Function tests (see 6.4).
- c. Fluid immersion test (see 6.5).
- d. Actuation above system pressure test (see 6.6).
- e. Drop out voltage test (see 6.7).
- f. Temperature rise test (see 6.8).
- g. Endurance testing (see 6.9).
- h. Extreme temperature functioning tests (see 6.10).
- i. Vibration test (see 6.11).
- j. Electromagnetic interference test (see 6.12).
- k. Explosion proofness test (see 6.13).
- l. Fire resistance test (see 6.14).
- m. Environmental tests (see 6.15).
- n. Solenoid tests (see 6.16).
- o. Structural tests (see 6.17).
- p. Any additional tests required by the Procurement Specification.

6.3 Acceptance Tests:

Those acceptance tests which are included in the design approval test program, shall be performed exactly as specified in 5.1, except that:

- a. The tests shall be extended to check the correct operation of the component for the complete fluid temperature range as specified in 3.3.2.
- b. The pressure drop test shall be carried out with flow rates of 25%, 50%, 75%, 100% and 110% of rated flow or as specified in the Procurement Specification. The pressure drop across the component shall be recorded at each of these flow rates. In addition, the pressure drop may be also measured at these flow rates with the fluid at different temperatures.
- c. External leakage is allowed to degrade to a maximum stipulated in the Procurement Specification. This shall be throughout the duration of the qualification program.

6.4 Function Tests:

The test program shall include a series of detailed function tests that will enable the Purchaser to determine that the component fully complies with the Procurement Specification and the applicable airworthiness requirements. These tests may be more comprehensive than those conducted in the Acceptance Test schedule. In addition, tests may be conducted which investigate the effects of failure modes within the component or the aircraft hydraulic system.