



AEROSPACE STANDARD	AS4941	REV. B
	Issued 1998-05 Revised 2015-03	
	Superseding AS4941A	

(R) Aerospace - General Requirements for Commercial Aircraft Hydraulic Components

RATIONALE

The changes to AS4941 at Revision B include:

- a. Additional technical requirements including removing all references to JAR airworthiness regulations
- b. Editorial changes including re-organizing some of the sections and updating the references

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1. SCOPE

This SAE Aerospace Standard (AS) provides general requirements for components that are used in commercial aircraft hydraulic systems. It also includes the 14 CFR Part 25/CS 25 regulations that apply to hydraulic components.

It also provides information to be included in the Procurement Specification in Appendix A and a checklist for design reviews in Appendix B.

It does not provide requirements for distribution elements such as hoses, pipe fittings and general tubing.

1.1 Field of Application

It is recommended that this document should be used in conjunction with the Procurement Specification for a hydraulic component.

2. REFERENCES

2.1 Applicable Documents

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

2.1.1 SAE Publications

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

AIR4543	Aerospace Hydraulics and Actuation Lessons Learned
ARP210	Definition of Commonly Used Day Types (Atmospheric Ambient Temperature Characteristics Versus Pressure Altitude)
ARP1288	Placarding of Aircraft Hydraulic Equipment to Identify Phosphate Ester Fluid Compatibility
ARP1383	Aerospace - Impulse Testing of Hydraulic Components
ARP1870	Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety
ARP4727	Gland Design, Computation of Seal Squeeze and Gland Volume
ARP4754	Guidelines for Development of Civil Aircraft and Systems
ARP5935	Use of HVOF Thermal Spray Coatings for Hard Chrome Replacement in Landing Gear Applications
AS567	Safety Cable, Safety Wire, Key Washers, and Cotter Pins for Propulsion Systems, General Practices for Use of
AS568	Aerospace Size Standard for O-rings
AS1241	Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft
AS1290	Graphic Symbols for Aircraft Hydraulic and Pneumatic Systems
AS1300	Port - Ring Locked Fluid Connection Type, Standard Dimensions for

AS3121	Plug, Expansion - Aluminum, 2024-T4 and 2024-T351, Long; Std and .010 Oversize Diameters (UNS A92024)
AS3122	Pin, Expansion - Aluminum, 2024-T4 and 2024-T351, Long (UNS A92024)
AS3123	Plug, Expansion - Aluminum, 2024-T4 and 2024-T351, Short; Std and .010 Oversize Diameters, UNS A92024
AS3124	Pin, Expansion - Aluminum, 2024-T4 and 2024-T351, Short, UNS A92024
AS3125	Plug, Expansion - CRES, 416 or 416SE, Long; Std and .010 Oversize Diameters, UNS S41600/UNS S41623
AS3126	Pin, Expansion - CRES, 416 or 416SE, Long, UNS S41600/UNS S41623
AS3127	Plug, Expansion - CRES, 416 or 416SE, Short; Std and .010 Oversize Diameters, UNS S41600/UNS S41623
AS3128	Pin, Expansion - CRES, 416 or 416SE, Short, UNS S41600/UNS S41623
AS3129	Plug, Expansion - CRES, 303, Long; Std and .010 Oversize Diameters, UNS S30300
AS3130	Pin, Expansion - CRES, 303, Long, UNS S30300
AS3131	Plug, Expansion - CRES, 303, Short; Std and .010 Oversize Diameters, UNS S30300
AS3132	Pin, Expansion - CRES, 303, Short, UNS S30300
AS3208	Packing, Preformed - AMS 7276 - Seal
AS3209	Packing, Preformed - AMS 7276, 'O' Ring
AS3581	Packing, Preformed - O-Ring Seal, AMS7259
AS4052	Gland Design: Scraper, Landing Gear, Installation
AS4059	Aerospace Fluid Power - Cleanliness Classification for Hydraulic Fluids
AS4088	Aerospace Rod Scraper Gland Design Standard
AS4273	Fire Testing of Fluid Handling Components for Aircraft Engines and Aircraft Engine Installations
AS4716	Gland Design, O-ring and Other Elastomeric Seals
AS5169	Fitting, Port Plug and Bleeder
AS5202	Port or Fitting End, Internal Straight Thread, Design Standard
AS5729	O-Ring Molded From AMS7379 (Fluorocarbon) Material
AS5857	Gland Design, O-ring and Other Elastomeric Seals, Static Applications
AS6235	Face Seal Gland Design, Static, O-ring and Other Seals for Aerospace Hydraulic and Pneumatic Applications
AS8879	Screw Threads - UNJ Profile, Inch Controlled Radius Root with Increased Minor Diameter

AS33566	Fittings, Installation of Flareless Tube, Straight-Threaded Connectors
AS83461/1	Packing, Preformed M83461 O-Ring
AS83461/2	O-Ring M83461 Straight Thread Tube Fitting Boss
MA2010	Packing, Preformed - O-Ring Seal, Standard Sizes and Size Codes, Metric
AMS2403	Plating, Nickel, General Purpose
AMS2404	Plating, Electroless Nickel
AMS2405	Electroless Nickel Plating Low Phosphorus
AMS2406	Plating, Chromium Hard Deposit
AMS2409	Plating, Immersion Tin for Aluminum Alloys
AMS2410	Plating, Silver, Nickel Strike, High Bake
AMS2411	Plating, Silver for High Temperature Applications
AMS2412	Plating, Silver Copper Strike, Low Bake
AMS2413	Plating, Silver-Rhodium
AMS2423	Plating, Nickel Hard Deposit
AMS2424	Plating, Nickel Low-Stressed Deposit
AMS2433	Plating, Nickel-Thallium-Boron or Nickel-Boron Electroless Deposition
AMS2447	Coating, Thermal Spray High Velocity Oxygen/Fuel Process
AMS2448	Application of Tungsten Carbide Coatings on Ultra High Strength Steels, High Velocity Oxygen/Fuel Process
AMS2449	Grinding of HVOF Sprayed Tungsten Carbide Coatings Applied to High Strength Steels
AMS7259	Rubber: Fluorocarbon (FKM), High Temperature/Fluid Resistant, Low Compression Set/85 to 95 Hardness, For Seals in Fuel Systems and Specific Engine Oil Systems
AMS7276	Rubber: Fluorocarbon (FKM), High-Temperature-Fluid Resistant, Low Compression Set, for Seals in Fuel Systems and Specific Engine Oil Systems
AMS7287	Fluorocarbon Elastomer (FKM) High Temperature / HTS Oil Resistant / Fuel Resistant Low Compression Set / 70 to 80 Hardness, Low Temperature Tg -22 °F (-30 °C) For Seals in Oil / Fuel / Specific Hydraulic Systems
AMS7379	Rubber: Fluorocarbon Elastomer (FKM) 70 to 80 Hardness, Low Temperature Sealing Tg -40 °F (-40 °C) For Elastomeric Seals in Aircraft Engine Oil, Fuel and Hydraulics Systems
AMS-A-8625	Anodic Coatings for Aluminum and Aluminum Alloys
AMS-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
AMS-P-83461	Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Improved Performance at 275°F (135°C)

- AMS-QQ-P-416 Plating, Cadmium (Electrodeposited)
- AMS-R-83485 Rubber, Fluorocarbon Elastomer, Improved Performance at Low Temperatures
- AMS-R-83485/1 Rubber, Fluorocarbon Elastomer, Improved Performance At Low Temperatures, O-Rings, Sizes and Tolerances

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

- ASTM B339 Standard Specification for Pig Tin
- ASTM B545 Standard Specification for Electrodeposited Coatings of Tin
- ASTM B633 Zinc Coating, Electrodeposited, Requirements for

2.1.3 EASA Publications

Available from European Aviation Safety Agency, Postfach 10 12 53, D-50452 Köln, Germany, Tel: +49 (0) 221-8999-000, www.easa.eu.int.

- CS-25 Certification Specifications for Large Aeroplanes

2.1.4 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

- 14 CFR Part 25 Code of Federal Regulations, CFR1.1, Part 25 Airworthiness Standards, Transport Category Airplanes

2.1.5 IEEE Publications

Available from Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08855-1331, Tel: 732-981-0060, www.ieee.org.

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

2.1.6 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

or, if using the Switzerland address:

Available from International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland, Tel: +41-22-749-01-11, www.iso.org.

- ISO 3601 Fluid power systems - O-rings - Part 1 Inside diameters, cross-sections, tolerances and size identification code
- ISO 16889 Hydraulic fluid power - Filters - Multi-pass method for evaluating filtration performance of a filter element

2.1.7 NAS Publications

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

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
NASM21209	Insert, Screw Thread, Coarse and Fine, Screw Locking, Helical Coil, CRES
NASM33547	Pin, Spring, Functional Limitations of

2.1.8 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

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

2.1.9 U.S. Government Publications

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

MIL-DTL-5002	Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapon Systems
MIL-DTL-38999	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded and Breech Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for
MIL-HDBK-454	Electronic Equipment, General Guidelines for
MIL-PRF-5606	Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordnance (Inactive for new design)
MIL-PRF-83282	Hydraulic Fluid, Fire Resistant Synthetic Hydrocarbon Base, Aircraft
MIL-PRF-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-464	Electromagnetic Environmental Effects Requirements Interference Standard
MIL-STD-704	Electrical Power, Aircraft, Characteristics and Utilization of
MIL-STD-810	Environmental Engineering Considerations and Laboratory Tests
MIL-STD-889	Dissimilar Metals

2.2 Related Publications

The following publication is provided for information purposes only and is not a required part of this SAE Aerospace Technical Report.

AS8775 Hydraulic System Components, Aircraft and Missiles, General Specification for

2.3 Definitions

COMPONENT: A component is a part that provides a function to the hydraulic system when it is operated, such as a valve, actuator, accumulator, filter, reservoir, pump, manifolds, or a similar device. It is not a fluid conveyance device in a hydraulic system such as a fitting, pipe, hose, etc.

DESIGN OPERATING PRESSURE: The design operating pressure (DOP) is the normal maximum steady pressure. Excluded are:

- a. Reasonable tolerances and transient pressure effects such as may arise from acceptable pump ripple, or
- b. Reactions to system functioning or demands that may affect fatigue

NON-DERANGEMENT TEMPERATURE: The 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.

RATED TEMPERATURE: The rated temperature of the component is the maximum continuous fluid temperature that the component is subjected to, and is expected to function without any degradation in performance.

TURN ON VOLTAGE: Turn on voltage is the minimum applied voltage that will cause the component to provide correctly its electrically commanded function.

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

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, Tier 1 system supplier or a modification center. The Purchaser is responsible for compiling the Procurement Specification.

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

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

- a. Technical requirements
- b. Acceptance and qualification test requirements
- c. Reliability requirements
- d. Packaging requirements

HIGH VELOCITY OXYGENATED FUEL (HVOF): HVOF is a combustion process in which the combustion gases are accelerated through a nozzle to supersonic velocities. Gas/particle temperatures can reach 4500 °F (2482 °C) with a particle velocity up to 2500 feet per second (762 m/s).

THERMAL SPRAY: Thermal spray is a process in which thermal energy is used to create an aerosol of finely divided materials to be deposited in a molten or semi molten condition on to a prepared substrate to form a new surface deposit. Thermal spray processes include combustion, plasma and arc/wire.

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 or issue of the standards and/or related documents that are cited in the Specification.

3.1 General

In the case of a conflict between the requirements of AS4941 and the Procurement Specification, the latter shall take precedence.

3.1.1 System Characteristics

The Procurement Specification shall include the characteristics of the hydraulic system, or the various parts of the system where it may be used that are relevant to the design of the component.

NOTE: An example of this is an application where, infrequently, a significantly high flow rate may be induced through the component and which the Supplier can confirm in his preliminary tests that such will not cause damage.

3.1.2 Graphical Symbols

Graphical symbols in accordance with AS1290 shall be used:

- a. To provide a complete functional symbol for the component including adjustability elements
- b. In, where possible, any schematic diagrams that are provided in test circuit's requirements and test reports

3.1.3 Airworthiness Regulations

The hydraulic component shall comply with 14 CFR Part 25 (for US certified aircraft) or the Certification Standards for Large Aeroplanes CS-25 (for European certified aircraft).

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

25.301	Loads
25.303	Factor of safety
25.581	Lightning protection
25.603	Materials
25.607	Fasteners
25.613	Material strength properties and design values
25.621	Casting values
25.863	Flammable fluid fire protection
25.899	Electrical bonding and protection against static electricity (CS 25 only)
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

14 CFR Part 25/CS 25.1301 regulations state that each item of installed equipment shall be:

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

In order to demonstrate compliance with this regulation, each hydraulic component shall be qualified in order 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 Pressure

The Procurement Specification shall state the applicable Design Operating Pressure (DOP) that will be applied to the various parts of the component, for example:

- a. System Pressure
- b. Return Pressure
- c. Reservoir Pressure

NOTE: The DOP for the return pressure may be artificially high for stressing purposes only. DOPs of 1000 psi (6895 kPa) or 1500 psi (10 342 kPa) have been specified in Procurement Specifications whereas the typical average return pressure may be 100 psi (690 kPa) or less.

3.3.2 Fluid Temperature

3.3.2.1 Rated Temperature

The Procurement Specification shall state the rated temperature.

3.3.2.2 Minimum Continuous Fluid Temperature

A minimum continuous fluid temperature at the supply port of the component at which the component is expected to function may be specified in the Procurement Specification.

3.3.3 Hydraulic Fluid

The Procurement Specification shall specify the applicable hydraulic fluid.

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

Each component should generally be designed to offer the minimum restriction to flow consistent with the other requirements of this specification. The pressure drop at rated flow shall not exceed the values specified in the Procurement Specification or the applicable detail drawing.

However, those components intended to provide restriction to flow shall be designed for specific range of pressure drop at rated flow as in the values specified in the Procurement Specification or the applicable detail drawing.

3.3.6 Actuation above System Pressure

Each component shall be designed to be capable of actuation or de-actuation 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, at the worst case operating temperature, neither the turn on voltage nor the turn on current shall exceed the maximum values specified in the Procurement Specification.

3.4 Environmental Requirements

14 CFR Part 25/CS 25.1435 (a)(5) requires all components to perform as intended under all environmental conditions for which the airplane is certificated. Therefore, each component shall be designed to operate under the environmental conditions specified below without:

- a. Any time limitation
- b. Any impairment of function or change of adjustment

NOTES:

1. Although RTCA/DO-160 is referred to throughout this document for environmental requirements, MIL-STD-810 may alternatively be used if approved by the procurement specification.
2. Environmental conditions relating to temperature and pressure are defined in ARP210 and should be utilized by the Purchaser.

The component shall be designed to comply with the following sections of RTCA/DO-160, unless otherwise specified in the Procurement Specification:

- a. Section 4 - Temperature and altitude - refer to 3.4.1 and 3.4.2 respectively.
- b. Section 5 - Temperature variation - the Procurement Specification shall specify the applicable category.
- c. Section 6 - Humidity - the Procurement Specification shall specify the applicable category.
- d. Section 7 - Operational shocks and crash safety - refer to 3.10.7.
- e. Section 8 - Vibration - refer to 3.10.6.
- f. Section 9 - Explosive atmosphere - refer to 3.6.
- g. Section 10 - Waterproofness - the Procurement Specification shall specify the applicable category.

- h. Section 11 - Fluids susceptibility - the Procurement Specification shall identify the relevant fluids that have to be considered.
- i. 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.
- j. Section 13 - Fungus resistance - the Procurement Specification shall specify the applicable category.
- k. Section 14 - Salt fog - this requirement only applies if the component is mounted in an unpressurized part of the aircraft.
- l. Section 24 - Icing - the Procurement Specification shall specify the applicable Category.

3.4.1 Altitude

The performance of each component should not be 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.

The following shall be noted in the Procurement Specification:

- 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:

1. Operating temperature: -65 °F (-54 °C) to +160 °F (+71 °C)
2. Non-derangement temperature: -80 °F (-62 °C) to +230 °F (110 °C)

3.4.3 Combined Altitude and Humidity

If the component contains sealed cavities, the design shall take into account the effect of the combination of the variation of the aircraft altitude and humidity in order to ensure that the cavity sealing arrangement is adequate and is in accordance with the aircraft operation. The Procurement Specification shall provide the specific altitude/humidity combinations that are to be considered in the design.

NOTE: The effectiveness of the design can be demonstrated by the successful completion of the icing test (refer to 6.7.10)

3.5 Fire Resistance

If the component is installed in an area that is subjected to engine fire conditions (for example, an engine driven pump), it shall be designed to comply with the 14 CFR Part 25/CS 25.863, 14 CFR Part 25/CS 25.1183 and 14 CFR Part 25/CS 25.1435(b)(4) requirements. The Procurement Specification shall 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.

3.6 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 possibility of an explosion, the component shall be suitably designed to minimize the possibility of this event occurring.

3.7 Acoustic Fatigue

The component shall not prematurely fail due to external noises as defined in the Procurement Specification.

3.8 Installation Requirements

3.8.1 General

Each component shall be designed such that reverse or incorrect installation in the aircraft or sub-assembly cannot be made. 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
- b. Install the wrong electrical wires to the component
- c. Connect the wrong cables or mechanisms to the component
- d. Equipment electrical connectors shall be located such that they are not positioned under hydraulic pipes, when the component is installed in the aircraft

Ideally, the Supplier should work with the Purchaser's installation team in order to achieve the optimum installation of the component. The Purchaser should provide the Supplier with the relevant drawings in order to ensure compliance with this requirement. For some components of a complex configuration, additional data should be provided in the Procurement Specification.

3.8.2 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.

3.8.3 Orientation

Generally, each 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, then the installation limitations shall be agreed upon between the Purchaser and the Supplier and it shall be stated on the component installation drawings.

3.8.4 Ports

Each port configuration shall be in accordance with AS1300 or AS5202 unless otherwise specified in the Procurement Specification. The spacing of ports for connecting fittings shall be adequate for wrench clearance.

3.8.5 Wrench Torque Loads

The structural design of the ports and of the affected sections of each component shall withstand the application of torque 2.5 times the maximum value specified in the Procurement Specification or AS33566, as applicable. There shall be no permanent distortion or impairment of function.

3.9 Detail Requirements

14 CFR Part 25/CS 25.603 requirement states 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 14 CFR Part 25/CS 25.613 regulations.

3.9.1 Metals

All metals shall be compatible with the fluid, temperature, function, service, and storage conditions to which the components will be exposed.

Magnesium shall not be used.

3.9.2 Corrosion Protection

Metals which do not inherently possess 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:

- a. Dissimilar metal combinations (reference MIL-STD-889)
- b. Moisture
- c. Salt spray
- d. High temperature

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

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

3.9.2.1 Ferrous Alloys

Ferrous alloys requiring corrosion preventive treatment, and all copper alloys, except for parts having bearing surfaces, shall have an 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.

Table 1 - Metallic coatings

Coatings	Specification
Cadmium plating	AMS-QQ-P-416, Type II, class 2
Chromium plating	AMS2406
Electroless Nickel plating	AMS2404, AMS2405, AMS2433
Nickel plating	AMS2403, AMS2423, AMS2424
Silver plating	AMS2410, AMS2411, AMS2412, AMS2413
Tin plating	AMS2409, ASTM B339, ASTM B545
Zinc plating	ASTM B633

3.9.2.2 Aluminum Alloys

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

3.9.3 High Velocity Oxygen Fuel (HVOF) Thermal Spray Coatings

HVOF coatings shall be in accordance with AMS2447 or AMS2448, as applicable. Grinding of the coatings to obtain the required finish shall be in accordance with AMS2449.

NOTES:

1. ARP5935 provides guidelines for the use of HVOF coatings.
2. The use of HVOF coatings as a bearing surface or rubbing surface in areas of components where there are surface discontinuities and sharp corners should be avoided.

3.9.4 Castings

Castings shall be clean, sound, and free from cracks, blowholes, excessive porosity and other defects that would affect their strength. 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.

Quality control techniques and standards that are satisfactory to the Purchaser shall govern the inspection and repair of castings. 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-DTL-5002 and shall be cleaned by acid etching, electro-polishing or by mechanical means to remove contamination, oxides, etc.

The use of castings in components subject to high pressure (3000 psi (20 684 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 14 CFR Part 25/CS 25.621 regulations.

3.9.5 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.

3.9.6 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.

3.9.7 Plastic Parts

The use of plastic parts shall be subject to the approval of the Purchaser.

3.9.8 Glands and Seals

3.9.8.1 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, backup rings or seals where they pass threaded parts or sharp corners. Sharp corners local to sealing components should be avoided and smooth radii should be used wherever practical to avoid seal damage during assembly.

3.9.8.2 Gland Design

The configuration and dimensions of seal glands for radial sealing shall conform to the requirements of AS4716 for dynamic applications and internal static applications. For external static sealing (sealing to atmosphere downstream of the seal) seal glands to AS5857 may be used. AS5857 provides increased squeeze compared to AS4716 and it should be noted that there may be differences in the bore diameters of AS4716 and AS5857 and differences in rod diameters of AS4716 and AS5857.

NOTE: It may be necessary to conduct a detailed design review to check that it is possible to get a component for an AS4716 seal gland past an AS5857 seal gland.

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

For static face sealing (internal and external pressure applications), seal glands to AS6235 shall be used.

Care shall also be taken to prevent binding and interference at the most adverse temperature extremes, appropriate seal squeeze. AS4716 provides a minimum of 0.005 inch (1.27 mm) or 5%, whichever is the larger, at ambient temperature and extremes of tolerance and eccentricity.

3.9.8.3 Seals

Small cross section O-ring seals (smaller than 0.103 inch (2.616 mm)) nominal cross section or their equivalent proprietary seals shall only be used in external seals or critical internal seals in exceptional circumstances (such as very space critical applications) and shall have the written approval of the Purchaser for each installation. O-rings with cross-sectional diameters of 0.070 or less, or their equivalent proprietary seals, shall not be used as external seals.

Seals should conform to the appropriate required specification.

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

Table 2 should be used when selecting seal materials for the specific hydraulic fluid.

Table 2 - Seal material and O-ring standards

Fluid	Seal Material	O-ring Standard	Application
AS1241	NAS1613	NAS1611, NAS1612	General
MIL-PRF-83282 & MIL-PRF-87257	AMS-P-83461	AS83461/1 AS83461/2	General
MIL-PRF-5606, MIL-PRF-83282 & MIL-PRF-87257	AMS7276	AS3208, AS3209	See Notes
	AMS7259	AS3581	
	AMS7287	No part numbers yet	
	AMS7379	AS5729	
	AMS-R-83485	AMS-R-83485/1	

NOTES:

1. For the high temperature elastomers, AMS7379 materials have better low temperature properties (TG: -40 °F (-40 °C)). However, fluorocarbon elastomers cannot currently meet the low temperature requirement of TG of -65 °F (-54 °C) requirement and AMS7379 material should be tested in the systems that have low temperature requirements below -40 °F (-40 °C) before specifying it into the applications.
2. These materials are to be used for applications where high fluid temperatures may be routinely encountered (up to or greater than 275 °F (135 °C)) or if a margin of seal integrity may be required and the maximum fluid temperature is less than 275 °F (135 °C)).

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

O-rings not covered by a specification should conform to AS568, MA2010, or ISO 3601 for dimensions and tolerances. 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.

3.9.8.4 Backup Rings

Backup rings shall be installed on all O-ring installations where operating pressures are above 1500 psi (10 342 kPa). Backup rings with greater extrusion resistant compounds should be used in systems operating at pressures above 3000 psi (20 684 kPa) and/or in locations where continuous operation at high temperature limits is required by the Procurement Specification. The backup rings shall be dimensioned to function properly in the specific gland in which they are installed. If continuous backup rings are used on dynamic piston applications, friction due to pressure entrapment between the backup rings should be considered in the design of the component.

At low temperatures, scarf-cut single turn backup rings should be designed to ensure that a lap of at least 50% of the scarf cut is maintained. Additionally, for piston and rod type backups, at low temperature and at full cylinder breathing due to pressure, the 50% minimum lap requirement should be maintained.

3.9.8.5 Scrapers

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

3.9.9 Standard Parts

Standard parts should be used whenever possible, and shall be identified on the drawings by their standard part identifying numbers.

3.9.10 Marking

3.9.10.1 Identification of the Product

14 CFR Part 25/CS 25.1301 requirement states that each component must be marked for identification in accordance with standard practices and the Purchaser's requirements.

3.9.10.2 Nameplate

The nameplate should contain the following information:

- a. Component type
- b. Procurement Specification number (include standard part numbers when available)

- c. Supplier's part number
- d. Supplier's name or trademark
- e. Serial number
- f. Fluid (Identify in accordance with ARP1288)
- 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:

- j. Supplier's part number
- k. Serial number

The above information shall be legibly filled in on the nameplate.

The nameplate shall be securely attached to the component:

NOTES:

1. The use of drive screws is undesirable and should be avoided.
2. Bonding as the only attachment method of nameplates should be avoided.

3.10 Strength Requirements

3.10.1 General

If applicable, the Procurement Specification shall define the limit structural load.

3.10.2 Pressure Loads

14 CFR Part 25/CS 25.1435(a)(2) requires the components to be designed to withstand design operating loads in combination with limit structural loads that 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 limit structural loads are defined in 14 CFR Part 25/CS 25.301(a). These include, but are not limited to:

- a. Flight and ground maneuvers
- b. Gust and turbulence conditions

The loads arising in these conditions should be combined with the maximum hydraulic pressures, including transients that could occur simultaneously. Where appropriate, thermal effects should also be accounted for in the strength justification.

For hydraulic actuators equipped with hydraulic or mechanical locking features, such as flight control actuators and power steering actuators, the actuators and other loaded elements should be designed for the most severe combination of internal and external loads that may occur in use. For hydraulic actuators that are free to move with external loads, i.e., do not have locking features, the structural loads are the same as the loads produced by the hydraulic actuators.

At limit load, seal leakage exceeding the allowed maximum in-service rate is permitted.

3.10.3 Proof and Ultimate Pressure Requirements

14 CFR Part 25/CS 25.1435(a)(1) defines the factors that are to be applied to the DOP for Proof and Ultimate Pressures. These are provided in Table 3.

Table 3 - Factors to be applied for proof and ultimate pressures

Element	Proof (x DOP)	Ultimate (x DOP)
Pressure vessels containing gas		
High pressure (e.g., accumulators)	3.0	4.0
Low pressure (e.g., reservoirs)	1.5	3.0
All other elements	1.5	2.0

NOTE: The term 'pressure vessels' is not intended to include small volume elements such as pressure gauges.

3.10.3.1 Proof Pressure Requirement

14 CFR Part 25/CS 25.1435(a)(1) requirement states that each component must withstand the proof pressure without permanent deformation that would prevent it from performing its intended function.

3.10.3.2 Ultimate Pressure Requirements

14 CFR Part 25/CS 25.1435(a)(1) requirement states that each component must withstand the ultimate pressure without rupture.

3.10.4 Combined Pressure and Load Requirements

3.10.4.1 Combined Design Operating Pressure and Limit Structural Load

14 CFR Part 25/CS 25.1435(a)(2) requires that each component shall withstand, without deformation that would prevent it from performing its intended function, the design operating pressure in combination with limit structural loads that may be imposed.

Limit structural loads are defined in 14 CFR Part 25/CS 25.301(a). The loading conditions of 14 CFR Part 25/CS-25, subpart C to be considered include, but are not limited to flight and ground maneuvers, and gust and turbulence conditions. The loads arising in these conditions should be combined with the maximum hydraulic pressures, including transients that could occur simultaneously. Where appropriate, thermal effects should also be accounted for in the strength justification.

For hydraulic actuators equipped with hydraulic or mechanical locking features, such as flight control actuators and power steering actuators, the actuators and other loaded elements shall be designed for the most severe combination of internal and external loads that may occur in use. For hydraulic actuators that are free to move with external loads, i.e., do not have locking features, the structural loads are the same as the loads produced by the hydraulic actuators.

At limit load, seal leakage not exceeding the allowed maximum in-service rate is permitted.

3.10.4.2 Combined Proof and Ultimate Structural Load

14 CFR Part 25/CS 25.1435(a)(3) requires that each component shall withstand, without rupture, the design operating pressure multiplied by a factor of 1.5 in combination with ultimate structural load that can reasonably occur simultaneously.

For compliance with this requirement, the combined effects of the ultimate structural load(s) as defined in 14 CFR Part 25/CS 25.301 and 25.303 and the DOP, which can reasonably occur simultaneously, should be taken into account with a factor of 1.5 applied to the DOP. In this case the overall structural integrity of the element should be maintained. However, it may be permissible for this element to suffer leakage, permanent deformation, operational/functional failure or any combination of these conditions. Where appropriate, thermal effects should also be accounted for in the strength justification.

3.10.5 Fatigue (Pressure Impulse) Requirements

14 CFR Part 25/CS 25.1435(a)(4) requirement states that each component must withstand the fatigue effects of all cyclic pressures, including transient pressures and associated externally induced loads, taking into account the consequences of element failure.

In addition to endurance requirements listed in 3.11.1 for each component, the Procurement Specification shall state the scatter factor that is to be applied for the analysis and/or the fatigue (pressure impulse) testing.

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

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

NOTE: The impulse fatigue pressure shall be applied to stress all modes of operation of the component.

3.10.6 Vibration

Each component shall be capable of withstanding vibrations excited by the driving means and under functional vibration levels, the component shall maintain its functionality (for example, switches shall not change state, or spools change position).

Each component shall be designed to withstand the applicable vibration levels as stated in RTCA/DO-160, Section 8, unless otherwise specified in the Procurement Specification. In addition, the vibrational effects of engine windmilling with engine fan blade out and tire burst should be considered.

For design and test purposes, any torsional vibration excited by the driving means should be considered to be negligible.

3.10.7 Operational Shocks and Crash Safety

Each component shall be designed to withstand sustained accelerations in accordance with RTCA/DO-160, Section 7 requirements unless otherwise specified in the Procurement Specification. The Procurement Specification shall state the applicable equipment category.

When subjected to the required operational shocks levels, each component shall maintain its functionality (for example, switches shall not change state, or spools change position).

NOTE: Hydraulic components are not normally required to comply with the crash safety requirements. If they are, then the Procurement Specification shall state the applicable test category.

3.10.8 Bench Handling

Each component shall be designed such that it will continue to function normally after being exposed to shocks that are generated due to it being dropped when tested in accordance with the bench handling test defined in 6.11.8.

3.11 Design and Construction

3.11.1 Endurance

Each component shall be designed such that it will operate satisfactory throughout its operational lifetime.

The Procurement Specification shall state the endurance requirements for each component. It shall define the predicted operation of the component over the life that has been declared for it including the following:

- a. The number of cycles of operation that it will be subjected to
- b. The overall predicted duty cycle for the high and low pressure sides of the component
- c. The rate of operation (i.e., flow rates through the component) for each cycle
- d. The input and output strokes of the component (where applicable)
- e. Any external loads that the component may be subjected to
- f. The expected environmental temperatures during the component's life
- g. The fluid cleanliness levels.

A factor may be introduced on the duty cycle to allow for different kinds of operation for the same aircraft type. For example, one airline might use the aircraft for one or two long flights per day, whereas another operator may use the aircraft for more than 10 flights per day.

3.11.2 Weight

Each component should 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. The wet and dry weight of the completely assembled component shall be stated on the component's installation drawing.

3.11.3 Lubrication

Except where it is necessary to lubricate drive couplings, each component shall be self-lubricating with no provisions for lubrication other than the fluid circulating within the component.

3.11.4 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 that 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.

3.11.5 External Tube Connections

The Procurement Specification shall specify the external threaded tube connections.

NOTE: External threaded tube fittings shall be fabricated from steel or titanium if the system pressure is 3000 psi (20 684 kPa) or higher.

3.11.6 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 shall 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.

3.11.6.1 Adverse Tolerance Conditions

The Supplier shall verify that each 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.

3.11.7 Fasteners

Fasteners (bolts, screws and studs) that are smaller than 0.25 inch (6 mm) diameter shall not be used in primary tension applications. Fasteners that are smaller than 0.188 inch (5 mm) diameter shall not be used in primary structural applications. Bolts and screws having minimum tensile strength more than 160 ksi shall be a forged body design and have rolled head-to-shank fillet radii.

The use and installation of fasteners shall comply with 14 CFR Part 25/CS 25.607 regulations.

3.11.8 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 should 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. It should be possible to adjust the screws 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 cover or similar device.

3.11.9 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. An AS5169 type plug, with an elastomeric seal, wire locked in position
- b. A ring locked fluid connection type per AS1300

3.11.10 Alignment

All plungers, poppets, balls, pistons, etc., shall be-guided to prevent misalignment or chattering on their seats.

3.11.11 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.

3.11.12 Safetying

All threaded parts shall be securely locked or safetyed by self-locking nuts, safety wire or cable or other methods identified in AS567. Internal and external tooth (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 used to prevent rotation of an internally threaded part with respect to an externally threaded part

or

c. When safety wire or safety cable 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 aluminum 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

3.11.12.1 Safetying Internal Parts of Fluid Chambers

Permanently deformed safetying devices, such as safety wire or cotter pins, which are subject to breaking off, shall not be used internally in fluid chambers.

3.11.12.2 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 NASM21209 shall be used.

3.11.13 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.

3.11.13.1 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.

3.11.13.2 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.

3.11.13.3 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.

3.11.13.4 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.

3.11.14 Spring Pins

Spring pins shall not be used in any applications that conflict with the intent of NASM33547, unless specifically approved by the Purchaser.

3.11.15 Internal Parts

Internal parts that 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.

3.11.16 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 pound-inch (8.47 Newton-meter) for radii of greater than 0.8 inch (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 pound-inch (203.4 Newton-meter).

3.11.17 Fixed Orifices

Orifices larger than 0.005 inch (0.127 mm) but smaller than 0.070 inch (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 inch (0.127 mm) diameter shall not be used.

Multiple orifice fixed restrictors should 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.

Each orifice shall be analyzed and tested to assure that it does not cause two phase flow (air and bubbles) instead of single phase flow (fluid only) during any phase of operation of the component.

3.11.18 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.

3.11.19 Heat Rejection

The Procurement Specification shall specify the predicted heat generation from a component and the means of cooling the component if it is required for the specific application (for example an electric motor driving a hydraulic pump).

The predicted heat rejection should be defined for a new component and for a component at the end of its intended life.

If ambient air is the chosen cooling medium, then means shall be provided to ensure that there is no risk of blockage of the air entry or exit ports.

If the hydraulic system fluid is the chosen cooling medium, then:

- The Supplier should provide sufficient information to enable the Purchaser to define the requirements for an oil cooler (if required)
- Means shall be provided to ensure that there is no possibility of fluid ingress into parts of the component that will either cause the motor to malfunction and/or affect the electrical power supply

3.12 Electrical Requirements

If the component has an electrical interface, then it shall be designed to comply with the following sections of RTCA/DO-160 listed below, unless otherwise specified in the Procurement Specification:

- a. Section 15 - Magnetic effect - when applicable, the procurement specification shall identify the applicable category
- b. Section 16 - Power input - refer to 3.12.3
- c. Section 17 - Voltage spike - refer to 3.12.3
- d. Section 18 - Audio frequency conducted susceptibility - power inputs
- e. Section 19 - Induced signal susceptibility
- f. Section 20 - Radio frequency susceptibility (radiated and conducted) - refer to 3.12.6
- g. Section 21 - Emission of radio frequency energy - refer to 3.12.6
- h. Section 22 - Lightning induced transient susceptibility - when applicable, the procurement specification shall list the waveforms and levels, and the pass/fail criteria for equipment performance for the test procedure
- i. Section 25 - Electrostatic discharge (ESD) - this is only applicable if the component contains electronic equipment

3.12.1 Turn on Voltage and Current

The maximum turn on voltage and current at the worst case environmental and operating conditions shall be defined in the Procurement Specification. The maximum allowed turn on voltage shall not exceed 80% of the nominal or 100% of the minimum supplied voltage.

3.12.2 Rated Current

The Procurement Specification shall define the maximum continuous and intermittent current to be drawn by the component at the maximum supply voltage under the worst case environmental and operating conditions.

3.12.3 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 if required by the Procurement Specification.

Electrical components shall not be affected when subjected to a voltage spike as defined in RTCA/DO-160 Section 17.

3.12.4 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 as specified in the Procurement Specification. 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.

If required, the Procurement Specification shall define the means to suppress arcs such as an internal arc suppression diode or bi-directional transorb. This is in order to suppress transient induced voltages when the solenoid is de-energized.

3.12.4.1 Dielectric Strength

The solenoids shall be capable of passing a dielectric test following a humidity test or salt fog test. The solenoids shall be capable of being baked for 6 hours at the maximum ambient temperature as specified in the Procurement Specification prior to being subjected to the dielectric test. All solenoids shall then be capable of being subjected to a 60 hertz alternating test voltage between terminals and case for 1 minute at the following root mean square amplitude:

- a. 1500 volts at room temperature and pressure
- b. 1000 volts at maximum operating temperature and altitude

The leakage current shall not exceed 1 mA during these tests.

3.12.5 Electric Motor Operated Components

3.12.5.1 General

The Procurement Specification shall provide the characteristics of electric motors for operating hydraulic components.

The Procurement Specification shall state whether the motor is intended for continuous or intermittent operation.

3.12.5.2 Thermal Protection

The Procurement Specification shall specify the means of protecting the motor in the event of a thermal runaway due to, for example, a locked rotor.

3.12.5.3 AC Electric Motors

3.12.5.3.1 Operation on Two Phases

If required by the Procurement Specification, the electric motor shall be capable of running with one of the electrical phases missing. The Procurement Specification shall define the accepted reduction in motor performance as a result of the loss of the electrical phase.

3.12.5.4 DC Electric Motors

3.12.5.4.1 Motor Type

The Procurement Specification shall state whether the DC motor is a brushed or brushless motor.

If the motor is a brushless type, the Procurement Specification shall state the means of controlling the motor.

If the motor is a brushed type, the Procurement Specification shall state if the brushes are intended for aircraft life or if they are replaceable.

3.12.5.5 Clutches or Brakes

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

3.12.6 Electromagnetic Interference

In order to demonstrate compliance with 14 CFR Part 25/CS 25.1353(a) and 14 CFR Part 25/CS 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 and IEEE C63.14 may be used in place of RTCA/DO-160 if required by the Procurement Specification.

3.12.7 Protection against Lightning Strikes

14 CFR Part 25/CS 25.581 and CS 25.899 requirements state that the aircraft must be protected against catastrophic effects resulting from a lightning strike.

3.12.7.1 Bonding Requirements

In order to meet this regulation, each component shall 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 if required by the Procurement Specification.

3.12.7.2 Protection of Sensitive Electronic Components

If the component includes electrical or electronic parts that could be damaged by a lightning strike, then a protective device such as a transorb should be included in the component.

It should be noted that the failure of a lightning protection device may result in it being a dormant failure during the life of the unit. One option to minimize this dormant failure latency is to conduct an additional test at each removal of the unit.

3.12.8 General Protection of Electrical or Electronic Parts

The Purchaser and the Supplier shall agree the means of protecting electrical and/or electronic parts (if fitted) in the component. Typical protective means include:

- a. Hermetic sealing of the housing that contains the electrical and/or electronic parts
- b. Using a robust sealing method of the electrical and/or electronic parts to protect against any moisture ingress into the component
- c. Proper manufacturing and shipping procedures shall be followed for assemblies sensitive to electrostatic discharge (ESD)

3.12.9 Connectors

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

3.13 Maintainability Requirements

3.13.1 Maintenance Concept

The required maintenance concept shall be stated in the Procurement Specification, for example, "On Condition".

3.13.2 Useful Life and Storage Conditions

The requirements together with the appropriate definitions shall be 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 should 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.

Care should also be given in the choice of electronic components (for example, capacitor) in relation to the storage period. When applicable, there shall be a requirement to define a minimum of years that the unit is capable of being stored in its original packaging without retest prior to use.

NOTE: The choice of the technology of some electronic components can depend on this requirement.

3.13.3 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.

3.14 Reliability Requirements

3.14.1 Design for Reliability

As part of the design process, every effort should 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

3.14.2 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.

3.14.3 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:

1. Enable analysis to be conducted to demonstrate compliance with the requirements of 14 CFR Part 25/CS 25.1309
2. Plan integrated logistics support requirements

4. QUALITY ASSURANCE REQUIREMENTS

4.1 Test Conditions

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 tests contained in this Standard where such tests 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 purpose of demonstrating compliance with this Standard, the Procurement Specification and the applicable airworthiness requirements, there shall be two types of tests:

- a. Acceptance Tests (Section 5)
- b. Qualification Tests (Section 6)

NOTE: Other types of test such as Pre-production or Production Monitoring Tests may be required by the Purchaser and should be noted in the Procurement Specification

4.4 Test Stand Requirements

4.4.1 Steady State Operating Conditions

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:

- 4.4.1.1 Input Signal: $\pm 2\%$
- 4.4.1.2 Flow: $\pm 2\%$
- 4.4.1.3 Leakage Flow: $\pm 2\%$
- 4.4.1.4 Pressure:
 - a. Below atmosphere or within 15 psi (103 kPa) above: ± 0.25 psi (1.72 kPa)
 - b. Over 15 psi (103 kPa): $\pm 2\%$
- 4.4.1.5 Differential Pressure: $\pm 4\%$
- 4.4.1.6 Temperature: ± 4 °F (± 2 °C)
- 4.4.1.7 Torque: $\pm 2\%$
- 4.4.1.8 Speed: $\pm 1\%$
- 4.4.1.9 Time: $\pm 2\%$
- 4.4.1.10 Force: $\pm 2\%$
- 4.4.1.11 Linear Distance: $\pm 2\%$

NOTE: The percentage basis is in terms of the maximum measured value or units of measure as indicated.

4.4.2 Instrumentation/Measurement Accuracy

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

4.4.3 Hydraulic Requirements

4.4.3.1 Hydraulic Fluid

The hydraulic fluid in the test stands shall be as specified in the Procurement Specification.

4.4.3.2 Filtration Requirements

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

4.4.4 Fluid and Ambient Temperatures

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. ACCEPTANCE TESTS

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

- a. Examination of product (5.1)
- b. Weight (5.2)
- b. Proof pressure (5.3)
- c. Pressure drop (5.4)
- d. Functional test program (5.5)
- e. Electro-conductive bonding (5.6)
- f. Sealing performance of electrical and electronic parts (if any) (5.7)
- g. Lightning protection device test (when applicable) (5.8)

Throughout the test program, there shall be no external leakage past the static seals or the housing (i.e., insufficient to form a drop). Where external dynamic seals are utilized; the permissible leakage past such seals shall be no greater than that specified in the Procurement Specification.

If, at any phase of testing, working parts require replacement, the entire acceptance test procedure shall be repeated.

5.1 Examination of Product

A visual and dimensional examination to determine product conformance to the relevant installation drawing requirements, with respect to:

- a. Dimensions
- b. Nameplate information
- c. Marking
- d. Finish
- e. Workmanship

NOTES:

1. Particular attention should be paid to surface treatments for signs of damage.
2. The Procurement Specification shall state if each component is to be inspected or only a percentage of the components in a production lot (for example 10%).

5.2 Weight

The component shall be weighed to check that it is no greater than that stated in the component's installation drawing.

NOTE: The Procurement Specification shall state if each component is to be weighed or only a percentage of the components in a production lot (for example, 10%).

If the Procurement Specification requires the weight of the component to include the mass of fluid contained within component, the component shall be filled with fluid and all the air bled from it prior to being weighed.

5.3 Proof Pressure

This test may be conducted at normal operating temperature, either statically or with the component in operation. The proof pressure shall be the factor appropriate to the component type (Table 3) stated for the component, and the pressure shall be held for at least 2 minutes.

The rate of pressure rise shall not exceed 25 000 psi (172 369 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. Permanent distortion that would prevent the component from performing its intended functions
- 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 that 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.

5.4 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.

5.5 Functional Test Program

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

- g. Heat rejection check
- h. Electrical checks such as current draw at minimum and maximum voltage levels, solenoid drop out voltage, insulation and dielectric tests

The program may review these tests as production develops in selected batches to reduce these tests to a minimum yet maintain assurance the production units will be identical to the qualification units.

5.6 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.

5.7 Sealing Performance of Electrical and/or Electronic Parts

When applicable, the sealing performance of each component containing electrical and/or electronic parts (for example, solenoids, position sensors, electronic modules, etc.) shall be measured. It shall be not greater than the value stated in the procurement specification.

5.8 Lightning Protection Device Test

When applicable, a non-destructive test shall be performed in order to check the ability of the lightning protection device to operate. The test program shall incorporate tests to determine the correct operation of the component. The level of the test voltage and the associated time shall be in accordance with the values stated in the Procurement Specification.

5.9 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 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.

5.10 Storage and Packing

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

6. QUALIFICATION TESTS

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.

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
- 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 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.

6.1.3.1 Selection of Components for Qualification

Qualification items shall be selected on a random basis from a production run as agreed between the Purchaser and Supplier and where production processes and tooling have been completed.

6.1.4 Test Failures

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. Expanded acceptance tests (6.3)
- b. Function tests (6.4)
- c. Fluid immersion test (6.5)
- d. Actuation above system pressure test (6.6)
- e. Environmental tests (6.7)
- f. Electrical tests (6.8)
- g. Functional endurance test (6.9)
- h. Fire resistance test (6.10)
- i. Structural tests (6.11)
- j. Any additional tests required by the Procurement Specification

6.3 Expanded Acceptance Tests

These tests shall be performed as specified in Section 5, except that:

- a. Critical tolerances such as lapped fits as used in a servovalve shall have diametral clearances checked by an appropriate means such as air-gaging or two measurements of spool and sleeve 90 degrees apart in four places in the lapped length

- b. 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. 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.
- c. 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 if required by the Procurement Specification.
- d. 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

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.

6.5 Fluid Immersion Test

6.5.1 Electrical Components

Where electrical components are part of the component assembly, and are in contact with the system hydraulic fluid (partially or completely), they shall be separately subjected to a fluid immersion test prior to the start of the qualification test. This will consist of continuous immersion for 72 hours in the hydraulic fluid at rated temperature. After the soak period, the component shall remain in the fluid at the normal temperature until ready for further tests.

6.5.2 Nonmetallic Parts

Components containing nonmetallic parts other than plastic parts or standard seals in standard glands shall be immersed in the system hydraulic fluid for seven days at the rated temperature prior to conducting the tests specified in this document or in the Procurement Specification. All internal parts shall be in contact with fluid during this period.

In this test, the seal compound and hydraulic fluid used shall be that which, when combined, has the highest swell if this test is necessary as a result of:

- a. The use of non-standard sealing installations
- b. If the seals pass over holes, ports, stop diameters, threads, etc.
- c. If the inside diameter, outside diameter, or sides of the seal are unrestrained during any part of their normal operation

After this immersion test, the component shall remain in the high swell fluid at normal room temperature until ready for test. The component shall not be exposed to air for any appreciable length of time during the tests.

6.6 Actuation above System Pressure Test

Each component shall be tested for correct operation when subjected to a system pressure that is equal to the aircraft's hydraulic system relief valve or thermal relief valve maximum setting. This test shall be conducted as specified in the Procurement Specification.

Checks shall be made to determine that there is no seizing or excessive force input. For electrically operated components, the voltage shall not be greater than the maximum turn on voltage or the current greater than maximum rated current.

6.7 Environmental Tests

Tests shall be carried out on the complete component assembly or the relevant parts of the component if it cannot be demonstrated by analogy or analysis that the component complies with the environmental conditions' requirements of 3.4.

NOTE: The Procurement Specification shall state the environmental tests when the test unit is be operated and functioned.

6.7.1 Extreme Temperature Functioning Tests

6.7.1.1 Low Temperature

Each component shall be connected to a static head of 1 to 3 feet (0.3 to 0.9 m) of the test fluid or working pressure, whichever is the more critical condition. This arrangement shall be maintained at a temperature less than the minimum temperature specified in the Procurement Specification. After this time, the component shall be actuated at least two times. The variation of actuating forces or regulation, as applicable, shall not exceed that which is permitted by the Procurement Specification. The Acceptance Tests for leakage shall be performed after each actuation and the requirements of the Procurement Specification shall be satisfied.

6.7.1.2 Intermediate Temperature

Immediately following the low temperature test, the test arrangement shall be rapidly warmed to a temperature of 160 °F (71 °C). While the temperature is being raised, the component shall be actuated at maximum increments of 36 °F (20 °C) to determine the satisfactory operation of the component throughout the temperature range. These check tests shall be made without waiting for the temperature of the entire component to stabilize. For complex components, the 36 °F (20 °C) increments may be increased in the Procurement Specification to allow time to perform functional tests.

6.7.1.3 High Temperature

The temperature shall be maintained at the maximum temperature specified in the Procurement Specification. The component shall be actuated at least two times. In the case of pressure regulation or actuation, the variation from room temperature actuation or regulation shall not exceed that permitted by the Procurement Specification. The quality conformance test for leakage (5.5 e) shall be performed after each actuation and the requirements of the Procurement Specification satisfied.

6.7.1.4 Differential Temperature

Those components utilizing fluid from two independent hydraulic systems shall be operated with the fluid temperature maintained at a differential temperature of 275 °F (135 °C) between the systems or as specified in the Procurement Specification (as the maximum differential possible for the system). The component shall be actuated at least two times. Variation of actuating forces or regulation, as applicable, shall not exceed that permitted in the Procurement Specification for the differential temperature condition.

6.7.1.5 Non Derangement Temperature

If required, tests shall be specified in the Procurement Specification.

6.7.2 Temperature Variation

A temperature variation test shall be conducted on components that are subjected to temperature variation conditions during their in-service operation. During this test, the component shall be actuated as necessary to determine that it will operate satisfactorily during a worst case temperature variation application. The test shall be in accordance with the requirements of RTCA/DO-160, Section 5.

6.7.3 Humidity

Moisture resistance shall be established by the humidity test procedure of RTCA/DO-160, Section 6. At the conclusion of this test, the component shall operate normally through 25 cycles at rated pressure. If electrical devices are incorporated in the component, they shall operate at rated voltage. Solenoids shall be subjected to the dielectric test specified in 6.8.1.1.

6.7.4 Explosion Proofness Test

The Procurement Specification shall define the category of the environment for the installation of the component in accordance with RTCA/DO-160, Section 9. Those components with a potential source of ignition shall be subjected to an explosion proof test in accordance with the test procedure of RTCA/DO-160, Section 9.

6.7.5 Water Proofness

If this test is required, it shall be conducted in accordance with RTCA/DO-160, Section 10.

6.7.6 Fluids Susceptibility

The component shall be subjected to the fluid susceptibility test as detailed in RTCA/DO-160, Section 11. The Supplier and the Purchaser shall agree the fluids to be tested.

6.7.7 Sand and Dust

The component shall be subjected to the dust test procedure of RTCA/DO-160, Section 12. This test may be omitted if all the moving parts are exposed only to internal fluid. If required by the Procurement Specification, the test unit shall be operated during the test (for example, if moving parts of a component are exposed to sand and dust in real life).

6.7.8 Fungus Resistance

Components that include materials that are not classified as fungus inert by MIL-HDBK-454, Guideline 4, shall be subjected to the fungus resistance test of RTCA/DO-160, Section 13.

6.7.9 Salt Fog

Each component shall be subjected to the salt fog procedures of RTCA/DO-160, Section 14 unless it is agreed by the Purchaser that this test is not required.

6.7.10 Icing

Each component shall be subjected to an icing test if its design is such that accumulation of ice on external surfaces or inside of vent holes may cause malfunction. When required, this test shall be performed in accordance with the icing test of RTCA/DO-160, Section 24, unless otherwise specified in the Procurement Specification. If required by the Procurement Specification, the test unit shall be operated during the test (for example, if moving parts of a component are exposed to ice in real life).

6.8 Electrical Tests

If the component has an electrical interface, then it shall be subjected to the tests in this section, unless otherwise specified in the Procurement Specification.

6.8.1 Solenoid Tests

Components that include solenoid-operated devices shall have the following test conducted on the solenoid assemblies.

6.8.1.1 Dielectric Strength Tests

The solenoids shall be tested to demonstrate compliance with the requirements of 3.12.4.1.

Subsequent dielectric tests on the assembled hydraulic component or after environmental tests on the solenoid shall be performed at 75% of the above voltages for 1 minute. Flashover or leakage current greater than 1 mA shall constitute a failure. There shall be no distinction between the test voltage on prototype and production units.

6.8.1.2 Drop Out Voltage Test

Solenoid operated components shall be tested for drop out voltage by applying nominal activation voltage and slowly reducing the applied voltage to 10% of the nominal activation voltage. The dropout voltage shall be greater than 10% of the nominal operating voltage and less than the minimum activation voltage specified in the Procurement Specification.

6.8.1.3 Solenoid Temperature Limits

Solenoids shall be subjected to the high and low temperature test procedures of RTCA/DO-160, Sections 4 and 5, unless otherwise specified in the Procurement Specification.

6.8.1.4 Temperature Rise Test

DC components shall be tested at 29 volts and AC components shall be tested at 122 volts, at the frequency stated in the Procurement Specification. The DC test source shall be used to measure coil resistance before and immediately after operation at 122 V AC. The DC resistance measurements shall be used to determine the temperature rise.

6.8.2 Magnetic Effect Test

Each component shall be subjected to a magnetic effect test if it is located such that it could affect the aircraft's navigational systems. When required, this test shall be performed in accordance with the magnetic effect test of RTCA/DO-160, Section 15, unless otherwise specified in the Procurement Specification.

6.8.3 Power Input Test

Each component shall be subjected to the power input test in accordance with RTCA/DO-160, Section 16, unless otherwise specified in the Procurement Specification.

6.8.4 Voltage Spike Test

Each component shall be subjected to the voltage spike test in accordance with RTCA/DO-160, Section 17, unless otherwise specified in the Procurement Specification.

6.8.5 Audio Frequency Conducted Susceptibility - Power Inputs Test

When applicable, the component shall be subjected to the audio frequency conducted susceptibility - power inputs test in accordance with RTCA/DO-160, Section 18, unless otherwise specified in the Procurement Specification.

6.8.6 Induced Signal Susceptibility Test

When applicable, the component shall be subjected to induced signal susceptibility tests in accordance with RTCA/DO-160, Section 19, unless otherwise specified in the Procurement Specification.

6.8.7 Electromagnetic Interference Test

When applicable, the component shall be subjected to the electromagnetic interference test in accordance with RTCA/DO-160, Sections 20 or 21 respectively, unless otherwise specified in the Procurement Specification.

NOTE: MIL-STD-461 and IEE C63.14 may alternatively be used in place of RTCA/DO-160 if required by the Procurement Specification.

6.8.8 Lightning Induced Transient Susceptibility Test

When applicable, the component shall be subjected to the lightning induced transient susceptibility tests in accordance with RTCA/DO-160, Section 22, unless otherwise specified in the Procurement Specification.

6.8.9 Electrostatic Discharge (ESD) Test

When applicable, the component shall be subjected to the electrostatic discharge tests in accordance with RTCA/DO-160, Section 25, unless otherwise specified in the Procurement Specification.

6.9 Functional Endurance Test

Each component shall undergo a functional endurance test to determine that the component will operate satisfactory throughout its operational lifetime. The hydraulic fluid used in the endurance test shall be that specified in the Procurement Specification.

The endurance test shall comprise the simulation of the operation of the component over the life that has been declared for it. The test shall replicate, as closely as possible, the endurance requirements in 3.11.1 and shall include variations in ambient and fluid temperatures (this can include operation at minimum and maximum temperatures).

The operation of the component shall use the same type of power or energy as used in the aircraft application.

6.9.1 Dimensional Check

Before the start of the qualification test, the critical wear dimensions shall be checked and recorded. These dimensions shall be checked again for the purposes of comparison once the qualification tests have been completed.

6.9.2 Filtration for Endurance Test

For qualification testing, the test fluid shall be continuously filtered through filter elements with a filtration ratio equivalent to the filtration ratio of the filter element used in the application. The filtration ratio shall be determined at the particle size specified for the application filter. If this is not known, the filtration ratio shall be determined at a particle size between 5 and 15 micrometers based on the ISO 16889 multipass test method.

6.9.3 Intermediate Checks

During the endurance test program, the component shall be subjected to the Acceptance Test program (5.5) at 25, 50, 75, and 100% of the number of cycles.

6.9.4 Failure of Parts

If, during the endurance test program, the test is terminated because of a part failure, the component shall be replaced or repaired using a redesigned part. However, in the case of faulty material or workmanship, the installation of a part of the original design and without the defect may be authorized. This part of the qualification test program shall be considered complete when all parts within the component have fulfilled, without failure, the requirements of the endurance testing.

Should component tests be continued from the point of failure with repaired or replaced part(s), the subsequent failure of parts that have successfully fulfilled the total endurance requirement shall not be considered as cause for rejection.

6.9.5 Teardown Inspection

After completion of the endurance test program, dismantle the component, inspect all parts visually and prepare a dimensional statement of the working parts. The general condition of the parts shall be reported.

6.10 Fire Resistance Test

The component shall be installed in a test apparatus that allows the component to function at conditions representative of those existing during the occurrence of a fire. This shall be as stipulated in the Procurement Specification.

Subject the component to a 5 minute fire test in accordance with AS4273, or to alternative requirements. Unless otherwise stated in the Procurement Specification, the component shall be operating with the flame being applied at a temperature of $2000\text{ }^{\circ}\text{F} \pm 150\text{ }^{\circ}\text{F}$ ($1093\text{ }^{\circ}\text{C} \pm 83\text{ }^{\circ}\text{C}$).

The component is not expected to meet the functional performance requirements during or after the test.

The component shall pass this test with no evidence of a failure that would cause external fluid leakage.

6.11 Structural Tests

6.11.1 Proof Pressure Test

Each component shall be subjected to a pressure test as defined in 5.3, but with the following additions

The component shall be filled with hydraulic fluid to 90% of the total fluid volume of the component. The ports shall then be capped and the component placed in a heating chamber in which the ambient temperature is maintained at the highest fluid or ambient temperature stated in the Procurement Specification. The component shall be held at this ambient temperature for a period of 72 hours.

The component shall be completely filled with fluid and then tested with the ambient and fluid temperatures at their rated values.

6.11.2 Fatigue (Pressure Impulse) Test

Each component shall be subjected to a pressure impulse test. The method of testing shall follow the requirements of ARP1383. The number of cycles and the pressure levels in each part of the test specimen shall be stipulated in the Procurement Specification, but shall be at least 100 000 cycles of nominal return line pressure to design operating pressure to nominal return line pressure.

A permanent record of the dynamic pressure/time history of the pressure impulse test shall be made. Unless otherwise agreed between the Purchaser and the Supplier, this shall be repeated at every 15 000 cycles to ensure that the pressure/time history of the impulse is maintained.

No evidence of cracks in any part of the component shall occur.

6.11.3 Vibration Tests

The Procurement Specification shall provide a functional vibration spectrum (the component maintains its correct functionality) and a fatigue (structural) spectrum (the component does not break or permanently deform, etc.).

6.11.3.1 Mounting of the Component

Mount the test component on a vibration generating mechanism in at least three positions selected to be the most sensitive to causing material damage or component performance anomalies.

Carry out all of the testing specified in each of the mounting positions.

6.11.3.2 Resonant Frequency Vibration Test

Conduct the search for resonant frequencies in accordance with RTCA/DO-160, Section 8 requirements or to an agreed alternative procedure. The applicable procedures and test values shall be specified in the Procurement Specification.