NOT MEASUREMENT SENSITIVE

MIL-STD-2193C(SH)
w/CHANGE 1
9 February 2018

SUPERSEDING
MIL-STD-2193C(SH)
30 November 2012

DEPARTMENT OF DEFENSE
DESIGN CRITERIA STANDARD

SHIP HYDRAULIC SYSTEM COMPONENTS

AMSC N/A FSC 4810

FOREWORD

1. This standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. This standard provides general requirements and test procedures for ship hydraulic system components. This standard does not establish configuration requirements, pressure, flow, or performance requirements for any specific component. Such requirements will be identified in military and DoD component specifications and in component acquisition specifications.

3. Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Sea Systems Command, ATTN: SEA 05S, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to CommandStandards@navy mil, with the subject line "Document Comment". Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil.

SUMMARY OF CHANGE 1 MODIFICATIONS

1. Various document IDs, document titles, and source statements throughout Section 2 were updated in accordance with their respective repository's most recently published information. Reference document IDs were updated as appropriate throughout the text of this document.

2. Added the following references to Section 2:

a. ASTM E8/E8M, Standard Method for Tension Testing of Metallic Materials;

b. ISO 3019-1, Hydraulic Fluid Power – Dimensions and Identification Code for Mounting Flanges and Shaft Ends of Displacement Pumps and Motors – Part 1: Inch Series Shown in Metric Units;

c. ISO 3019-2, Hydraulic Fluid Power – Dimensions and Identification Code for Mounting Flanges and Shaft Ends of Displacement Pumps and Motors – Part 2: Metric Series;

d. SAE-J744, Hydraulic Pump and Motor Mounting and Drive Dimensions;

e. NFPA T2.12.1, Hydraulic Fluid Power – Systems and Products – Method of Measuring Average Steady-State Pressure; and

f. SAE-AS83485, O-Ring Molded from AMS7287 Material.

3. Deleted the following references from Section 2:

a. MIL-G-5514, Gland Design; Packings, Hydraulic, General Requirements for;

b. MIL-PRF-17672, Hydraulic Fluid, Petroleum, Inhibited;

c. MIL-H-19457, Hydraulic Fluid, Fire-Resistant, Non-Neurotoxic;

d. MIL-H-22072, Hydraulic Fluid, Catapult, NATO Code Number H-579;

e. NFPA T2.12.2, Hydraulic Fluid Power – Systems and Products – Method of Reporting Traceability of Measurements; and

f. SAE-AMS-R-83485/1, Rubber, Fluorocarbon Elastomer, Improved Performance at Low Temperatures, O-Rings, Sizes and Tolerances.

4. Added biobased materials to recycled, recovered, or environmentally preferable materials in 4.1.

5. Changed the requirement in 4.2 to include end-use hydraulic system fluid and reference to MIL-PRF-6083.

6. Changed the low ductility and high transition temperature material requirement in 5.1.1.

7. Added "(see 6.1.4)" to the end of the last sentence in 5.2.8.1.

8. Deleted all instances of MIL-G-5514 in table II.

9. Changed the first sentence of 5.2.14.3 to state, "Flanges shall conform to MIL-DTL-24704, ISO 3019-1, ISO 3019-2, SAE-J744, or SAE-J518-1 except other flanges…"

10. Changed the pressure drop test fluid requirement in 5.3.1.6.

11. Changed the immersion test requirements in 5.3.1.7.

12. Added new paragraph (6.1.4) to provide technically acceptable allowance for the continued use of MIL-G-5514.

13. Added new acquisition requirement (item d) in 6.2.

14. The following modifications to MIL-STD-2193C(SH) have been made:

Paragraph	Modification	Paragraph	Modification
2.2.1	Changed	5.2.9.1	Changed
2.3	Changed	5.2.14.3	Changed
4.2	Changed	5.3.1.6	Changed
5.1	Changed	5.3.1.7	Changed
5.1.1	Changed	5.3.1.9	Changed
5.2.8.1	Changed	6.1.4	Added
5.2.8.2	Changed	6.2	Changed
Table II	Changed		

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1. SCOPE

1.1 Scope. This standard provides design, construction, and testing requirements that are common to most components used in ship hydraulic (power transmission and control) systems. This standard does not establish configuration requirements, pressure, flow, or performance requirements for any specific component.

1.2 Purpose. The purpose of this standard is to standardize the design, construction, and testing requirements for hydraulic components used in shipboard hydraulic systems, such as valves and actuators. This standard provides the design, construction, and testing requirements for military specifications for ship hydraulic components and the design, construction, and testing requirements in specifications developed by shipbuilders and contractors for the acquisition of ship hydraulic components.

1.3 Implementation guidance. Where suitable for use, the selection of components should be made in the following order:

a. As required by the applicable detail shipbuilding specification or other invoked contractual requirements.

b. As identified in the hydraulic system sections of MIL-STD-438 and MIL-STD-777, as applicable.

c. In accordance with military and industry specifications and standards with configuration control which meet the requirements of this standard. Where no other guidance is available, SAE-J1783 may be used for selecting hydraulic directional control valves.

d. Configurations in accordance with military and industry specifications. (Minor modification such as seal substitution to meet this standard is acceptable.)

e. Previously used components, modified if necessary, to comply with this standard.

f. Commercial components, modified as necessary, to comply with this standard.

g. New components designed in accordance with this standard.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

FEDERAL SPECIFICATIONS

FF-S-86 - Screw, Cap, Socket-Head

FEDERAL STANDARDS

FED-STD-H28 - Screw-Thread Standards for Federal Services

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-901 - Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for

MIL-DTL-1222 - Studs, Bolts, Screws and Nuts for Applications Where a High Degree of Reliability is Required; General Specification for

DELETED

MIL-PRF-6083 - Hydraulic Fluid, Petroleum Base, for Preservation and Operation

MIL-A-8625	-	Anodic Coatings for Aluminum and Aluminum Alloys
MIL-DTL-15024	-	Plates, Tags, and Bands for Identification of Equipment, General Specification for
MIL-PRF-17331	-	Lubricating Oil, Steam Turbine and Gear, Moderate Service
DELETED		
MIL-DTL-18240	-	Fastener Element, Self-Locking, Threaded Fastener, 250 °F Maximum
DELETED		
DELETED		
MIL-DTL-24441	-	Paint, Epoxy-Polyamide, General Specification for
MIL-DTL-24441/20	-	Paint, Epoxy-Polyamide, Green Primer, Formula 150, Type III
MIL-DTL-24441/21	-	Paint, Epoxy-Polyamide, Haze Gray Formula 151, Type III
MIL-DTL-24695/1	-	Valve, Vent and Test Hydraulic Service
MIL-DTL-24704	-	Flanges, Four Bolt Square, Hydraulic General Specification For
MIL-DTL-32258	-	Nut, Self-Locking (Ring Type Non-Metallic Insert), Heavy Hex, Controlled Root Radius, Nickel-Copper Alloy
MIL-DTL-45910	-	Insert, Screw Thread-Locked In and Ring Locked, Serrated, General Specification for
MIL-DTL-45932	-	Insert, Screw Thread, Thin Wall, Locked In: General Specification for
MIL-PRF-81733	-	Sealing and Coating Compound, Corrosion Inhibitive

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-167-1	-	Mechanical Vibrations of Shipboard Equipment (Type I – Environmental and Type II – Internally Excited)
MIL-STD-438	-	Schedule of Piping, Valves, Fittings and Associated Piping Components for Submarine Service
MIL-STD-740-2	-	Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment
MIL-STD-777	-	Schedule of Piping, Valves, Fittings, and Associated Piping Components for Naval Surface Ships
MIL-STD-810	-	Environmental Engineering Considerations and Laboratory Tests
MIL-STD-889	-	Dissimilar Metals
MIL-STD-1474	-	Noise Limits
MS21344	-	Fitting – Installation of Flared Tube, Straight, Threaded Connectors, Design Standard for

(Copies of these documents are available online at http://quicksearch.dla.mil.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AEROSPACE INDUSTRIES ASSOCIATION (AIA)

NAS1351	-	Screw, Cap, Socket Head, Undrilled and Drilled, Plain and Self-Locking, Alloy Steel, Corrosion-Resistant Steel and Heat-Resistant Steel, UNRF-3A
NAS1352	-	Screw, Cap, Socket Head, Undrilled and Drilled, Plain and Self-Locking, Alloy Steel, Corrosion-Resistant Steel and Heat-Resistant Steel, UNRC-3A and UNRC-2A
NASM7838	-	Bolt, Internal Wrenching, 160 KSI FTU
NASM8846	-	Insert, Screw-Thread, Helical Coil
NASM17829	-	Nut, Self-Locking, Hexagon, Regular Height, 250 °F, Non-Metallic Insert, Non-CRES Steel
NASM17830	-	Nut, Self-Locking, Hexagon-Regular, 250 °F and 450 °F, Non-Metallic Insert, 300 Series CRES
NASM20995	-	Wire, Safety or Lock
NASM25027	-	Nut, Self-Locking, 250 °F, 450 °F, and 800 °F
NASM33540	-	Safety Wiring, Safety Cabling, Cotter Pinning, General Practices for
NASM33547	-	Pins, Spring, Functional Limitations of

(Copies of these documents are available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3901 or online at www.aia-aerospace.org.)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B18.2.2	-	Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B18.3	-	Socket Cap, Shoulder, Set Screws, and Hex Keys (Inch Series)
ASME B46.1	-	Surface Texture (Surface Roughness, Waviness, and Lay)
ASME Y14.100	-	Engineering Drawing Practices

(Copies of these documents are available from the American Society of Mechanical Engineers, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007-2900 or online at www.asme.org.)

ASTM INTERNATIONAL

ASTM A193/A193M	-	Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194/A194M	-	Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A563	-	Standard Specification for Carbons and Alloy Steel Nuts
ASTM A564/A564M	-	Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes

ASTM A574 - Standard Specification for Alloy Steel Socket-Head Cap Screws

ASTM B446 - Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625), Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219), and Nickel-Chromium-Molybdenum-Tungsten Alloy (UNS N06650) Rod and Bar

ASTM B545 - Standard Specification for Electrodeposited Coatings of Tin

ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel

ASTM B700 - Standard Specification for Electrodeposited Coatings of Silver for Engineering Use

ASTM E8/E8M - Standard Test Methods for Tension Testing of Metallic Materials

ASTM E208 - Standard Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels

ASTM F303 - Standard Practices for Sampling for Particles in Aerospace Fluids and Components

ASTM F467 - Standard Specification for Nonferrous Nuts for General Use

ASTM F468 - Standard Specification for Nonferrous Bolts, Hex Cap Screws, Socket Head Cap Screws, and Studs for General Use

ASTM F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

ASTM F594 - Standard Specification for Stainless Steel Nuts

(Copies of these documents are available from ASTM International, 100 Barr Harbor Dr., P.O. Box C700, West Conshohocken, PA 19428-2959 or online at www.astm.org.)

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 3019-1 - Hydraulic Fluid Power – Dimensions and Identification Code for Mounting Flanges and Shaft Ends of Displacement Pumps and Motors – Part 1: Inch Series Shown in Metric Units

ISO 3019-2 - Hydraulic Fluid Power – Dimensions and Identification Code for Mounting Flanges and Shaft Ends for Displacement Pumps and Motors – Part 2: Metric Series

(Copies of these documents are available online at www.iso.org.)

NATIONAL FLUID POWER ASSOCIATION (NFPA)

NFPA T2.6.1 - Fluid power components – Method for verifying the fatigue and establishing the burst pressure ratings of the pressure containing envelope of a metal fluid power component

DELETED

NFPA T2.12.1 - Hydraulic fluid power – Systems and products – Method of measuring average steady-state pressure

NFPA T2.12.10 - Hydraulic fluid power – Systems and products – Testing general measurement principles and techniques

(Copies of these documents are available from the National Fluid Power Association (NFPA), 3333 North Mayfair Road, Suite 211, Milwaukee, WI 53222-3219 or online at www.nfpa.com.)

SAE INTERNATIONAL

SAE-AMS2404	-	Plating, Electroless Nickel
SAE-AMS2460	-	Plating, Chromium
SAE-AMS-QQ-N-290	-	Nickel Plating (Electrodeposited)
SAE-ARP1234	-	Gland Design, Elastomeric O-Ring Seals, Static Axial, Without Back-Up Rings
SAE-AS1290	-	Graphic Symbols for Aircraft Hydraulic and Pneumatic Systems
SAE-AS3209	-	Packing, Preformed – AMS 7276, "O" Ring
SAE-AS3581	-	Packing, Preformed – O-Ring Seal AMS7259
SAE-AS4716	-	Gland Design, O-Ring and Other Elastomeric Seals
SAE-AS5169	-	Fitting, Port Plug and Bleeder
SAE-AS5781	-	Retainers (Backup Rings), Hydraulic and Pneumatic, Polytetrafluoroethylene Resin, Single Turn, Scarf-Cut, for Use in AS4716 Glands
SAE-AS5782	-	Retainers (Backup Rings), Hydraulic and Pneumatic, Polytetrafluoroethylene Resin, Solid, Un-Cut, for Use in AS4716 Glands
SAE-AS5857	-	Gland Design, O-Ring and Other Elastomeric Seals, Static Applications
SAE-AS5860	-	Retainers, (Back-Up Rings), Hydraulic and Pneumatic, Polytetrafluoroethylene Resin, Single Turn, Static Gland
SAE-AS5861	-	Retainers, (Back-Up Rings), Hydraulic and Pneumatic, Polytetrafluoroethylene Resin, Solid, Static Gland
SAE-AS83485		O-Ring Molded from AMS7287 Material
SAE-AS8791	-	Hydraulic and Pneumatic Retainers (Back-Up Rings), Polytetrafluoroethylene (PTFE) Resin
SAE-J429	-	Mechanical and Material Requirements For Externally Threaded Fasteners
DELETED		
SAE-J518/1	-	Hydraulic Flanged Tube, Pipe, and Hose Connections, 4-Screw Flange Connection Part 1: 3.5 MPa to 35 MPa (Code 61)
SAE-J744	-	Hydraulic Pump and Motor Mounting and Drive Dimensions
SAE-J995	-	Mechanical and Material Requirements for Steel Nuts
SAE-J1926/1	-	Connections for General Use and Fluid Power – Ports and Stud Ends with ASME B1.1 Threads and O-Ring Sealing – Part 1: Threaded Port with O-Ring Seal in Truncated Housing
SAE-J1926/2	-	Connections for General Use and Fluid Power – Ports and Stud Ends with ASME B1.1 Threads and O-Ring Sealing – Part 2: Heavy-Duty (S Series) Stud Ends

SAE-J1926/3	-	Connections for General Use and Fluid Power – Ports and Stud Ends with ASME B1.1 Threads and O-Ring Sealing – Part 3: Light-Duty (L Series) Stud Ends
SAE-J2655	-	Fastener Part Standard – Washers and Lockwashers (Inch Dimensioned)
SAE-J24714	-	Fluid Systems – Connector Tubes – General Specification and Part Standard

(Copies of these documents are available from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or online at www.sae.org.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the 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.

3. DEFINITIONS

3.1 Radial static external seal. A radial static seal that is located at the outermost pressure boundary of the component (i.e., prevents leakage outside of the component).

3.2 Radial static internal seal. A radial static seal that is not located at the outermost pressure boundary of the component (i.e., only prevents leakage inside of the component).

4. GENERAL REQUIREMENTS

4.1 Recycled, recovered, environmentally preferable, or biobased materials. Recycled, recovered, environmentally preferable, or biobased materials should be used to the maximum extent possible, provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

4.2 Compatibility. Components shall be compatible with the end-use hydraulic system fluid (see 6.2) or as specified in the applicable component specification. Components in applications that come into contact with water under normal operating conditions shall be compatible with water. Components intended for use in systems with hydrocarbon base fluids shall be compatible with preservation fluid in accordance with MIL-PRF-6083.

4.3 Materials. Materials used in the manufacture of hydraulic components shall be compatible with the specified fluids and temperatures. Unless otherwise specified in the component specification, materials shall conform to the applicable reference documents cited herein. Material conforming to contractor's specifications may be used provided it can be demonstrated that they are at least equivalent to the applicable military specifications and standards with respect to performance characteristics.

4.4 Environmental conditions. This standard does not anticipate all potential component operational environments; therefore, component acquisition specifications must specify those applicable operational environments that differ from those provided herein. Unless otherwise specified by the component specification, components shall operate continuously in the environments specified herein.

4.4.1 Ambient pressure. The components shall operate throughout an ambient pressure range of 0.825 to 1.25 bars [12 to 18 pounds per square inch (lb/in^2)] absolute and shall operate to the requirements of this standard and the applicable component specification.

4.4.2 Ambient temperature. Unless otherwise specified in the applicable component specification, components shall operate throughout an ambient temperature range of -29 to 80 °C (-20.2 to 176 °F), except components installed within heated spaces shall operate throughout a temperature range of 5 to 80 °C (41 to 176 °F).

5. DETAILED REQUIREMENTS

5.1 Materials.

5.1.1 Metals. Metals shall be compatible with the intended temperature, function, service, and storage conditions to which the components will be exposed. The metals shall possess corrosion-resistant characteristics or shall be protected by anodizing or the use of coatings to resist corrosion which may result from such conditions as dissimilar metal combinations, moisture, salt spray, and high temperature deterioration, as applicable. Dissimilar metals are defined in MIL-STD-889. Low ductility material or high transition temperature material shall not be used in pressure-containing boundaries of components. (Control valve slides and sleeves are exempt where suitability is proven by high-impact shock tests.) Unless otherwise specified in the applicable component specification, low ductility material and high transition temperature material shall be shock qualified in accordance with MIL-DTL-901 prior to use. Low ductility material is metallic material showing less than 10 percent elongation in a standard tension test in accordance with ASTM E8/E8M. High transition temperature material is material having a Nil-Ductility Transition Temperature (NDTT) above the minimum operational temperature. The NDTT shall be measured by the drop-weight test in accordance with ASTM E208. Charpy V-notch impact values may be used as criteria when these have been correlated with drop-weight test results.

5.1.2 Plated coatings. Plated coatings and materials used in the component shall be only those suitable for the intended service and shall be in accordance with table I or provide equivalent protection as determined by the contracting activity. Where not indicated, class or type is at the option of the manufacturer.

TABLE I. Metal coatings.

Coating	Applicable specification
Zinc plating	ASTM B633
Chromium plating	SAE-AMS2460
Nickel plating	SAE-AMS-QQ-N-290
Silver plating	ASTM B700
Tin plating	ASTM B545
Electroless nickel plating	SAE-AMS2404

5.1.2.1 Cadmium and zinc plating. Cadmium and zinc plating shall not be used for internal parts or on internal surfaces in contact with hydraulic fluid. This restriction does not prohibit the use of zinc or cadmium-plated standard parts such as nuts, bolts, and screws in locations that are external to the system if there is no danger of fluid contamination.

5.1.2.2 Aluminum alloys. Aluminum alloys shall be anodized in accordance with MIL-A-8625 and shall be resistant to stress corrosion cracking.

5.1.2.3 Ferrous alloys. External surfaces of ferrous alloys with a chromium content of less than 12 percent shall be protected against corrosion by the use of one of the platings or coatings listed in table I or by painting with a two-component system epoxy-polyamide coating. The coating shall be in accordance with MIL-DTL-24441, MIL-DTL-24441/20 (formula 150), or MIL-DTL-24441/21 (formula 151).

5.1.3 Plastic parts. Synthetic materials for use as seals, guides, wipers, and so forth shall conform to the applicable specifications for these parts. Other nonmetallic parts may be used subject to the limitations of the applicable detail specification when verified to be compatible with all fluids in accordance with the immersion test of 5.3.1.7.

5.1.4 Prohibited materials. The following materials shall not be used unless specifically permitted herein:

a. Toxic materials.

b. Zinc or zinc-plated materials (see 5.1.2.1).

c. Mercury (see 5.1.5).

d. Magnesium or magnesium-based alloys.

e. Radioactive materials.

f. Asbestos.

g. Cadmium (see 5.1.2.1).

h. Beryllium [beryllium is acceptable as a small percentage (less than three percent) alloying material].

5.1.5 Mercury contamination. The component or any component parts shall not come in direct contact with mercury, mercury compounds, or mercury bearing instruments or devices employing only a single boundary of containment during manufacture, tests, or inspections. No mercury or mercury bearing parts shall be installed or used in the component.

5.2 Construction.

5.2.1 Standard parts. Standard parts (per approved Government and industry specifications and standards) shall be used whenever suitable for the purpose and shall be identified and numbered in accordance with the requirements of ASME Y14.100. Where permitted by the component specification, commercial utility parts, such as screws, bolts, nuts, and cotter pins may be used, provided they possess equivalent properties and are replaceable by the standard parts without alteration, and provided that both the commercial parts and the corresponding standard part numbers are included on the drawings required by the component specification. For standard commercial components, this can be accomplished with a cross reference between commercial utility parts and standard parts.

5.2.2 Reverse installation. When internal parts can be reversed or rotated and, as a consequence, the component is subject to malfunction, a method of verifying proper assembly shall be provided. This shall consist of a functional test which shall be identified on the component assembly drawing specified in the component specification, or by keying, directional arrow, indexing, or other method of identifying direction of installation.

5.2.3 Structural strength. Components shall withstand, without damage, the following types of loads or combinations of loads resulting from:

a. hydraulic pressure,

b. vibration,

c. shock,

d. temperature variations,

e. actuation,

f. operation,

g. fastener installation, or

h. torque loads for connection of tube fittings in accordance with MS21344

5.2.4 Weight. System components shall be designed for minimum weight consistent with the requirements of this standard.

5.2.5 Surface roughness. Surface roughness finishes for all moving and mating parts shall be identified in accordance with ASME B46.1. The determination of surface finishes shall be made with a profilometer, comparator brush analyzer, or other comparison equipment with an accuracy of ±15 percent at the level being measured. If surface defects are unacceptable, either all imperfections shall be within stated limits or special inspection procedures shall be identified. Where a surface of 16-microinch Ra or finer is specified, the process description shall be in addition to required surface measurement. When necessary for assembly or proper operation, waviness and lay shall be specified.

5.2.6 Alignment. Plungers, poppets, balls, pistons and so forth, shall be accurately guided to prevent misalignment or chattering.

5.2.7 Orifices. Where orifices less than 500 micrometers in diameter are used internally in the component, the orifice shall be removable for system flushing and shall be protected by a strainer-type element. Orifices and strainers shall withstand 110 percent of operating pressure, including no-flow conditions, without rupture. Strainers protecting the orifices shall have openings no larger than 40 percent of the orifice diameter.

5.2.8 Seals.

5.2.8.1 Gland design and related requirements. Components shall be designed so that no damage to the seals would be incurred from assembly of the component or from installation of the seals passing over threads or other sharp corners (see 6.1.3). The glands for O-rings or other elastomeric seals for radial, face, or boss applications shall be in accordance with an established technical standard or specification that conforms to the standard sized seals. See table II for guidance on O-ring gland design options based on established technical standards or specifications. Radial seal gland designs other than those specified in table II may be used for O-rings and other elastomeric seals when use of alternate gland designs (a) supports performance, installation, or other requirements, (b) permits the use of standard sized seals and (c) is also allowed by the component acquisition specification. Similarly, for existing Navy designs at the assembly or part level, the existing seal glands and associated backup rings are acceptable if they perform satisfactorily when standard size seals are utilized (see 6.1.4).

TABLE II. Guidance on O-ring gland design options.

Gland Design	**Radial**	**Static (External)**	SAE-AS5857 [1/]	**Associated Back-up Rings**	SAE-AS5860 or SAE-AS5861
			SAE-AS4716		SAE-AS5781 or SAE-AS5782
			DELETED		SAE-AS8791
		Static (Internal)	SAE-AS4716		SAE-AS5781 or SAE-AS5782
			DELETED		SAE-AS8791
		Dynamic	SAE-AS4716		SAE-AS5781 or SAE-AS5782
			DELETED		SAE-AS8791
	Face		SAE-ARP1234		
	Boss		SAE-J1926/1		

NOTE:

[1/] SAE-AS5857 is preferred in low temperature or low seal swell applications compared to SAE-AS4716 for radial static external seal gland design.

5.2.8.2 O-rings. O-rings shall be in accordance with table III for applications within the temperature range of 28.8 to 260 °C (-20 to 500 °F). O-rings shall be in accordance with SAE-AS83485 for lower temperature applications [below 28.8 °C (-20 °F)]. Alternate O-ring requirements documents for existing Navy designs are acceptable if they provide equivalent material, dimensional, and part numbering requirements.

TABLE III. O-ring requirements.

O-Rings	**Radial**	**Static**	SAE-AS3209 or Dash no. -001 to -475 of SAE-AS3581
		Dynamic	
	Axial Compression or Face		
	Boss		Dash no. -901 to -932 of SAE-AS3581

5.2.8.3 Elastomeric seals other than O-rings. Elastomeric seals not classified as O-rings are acceptable if improved performance over O-rings is achievable.

5.2.8.4 Back-up rings. Guidance on the selection of back-up rings is shown in table II based on gland design.

5.2.9 Fasteners. Fasteners shall be in accordance with table IV.

TABLE IV. Options for selection of hydraulic component fasteners. [1/]

Application	Fastener Type	Specification	Material
Inboard applications not in contact with seawater. Inboard applications not in bilge regions or trunks.	Bolts, hex head capscrews, and studs	MIL-DTL-1222	Grade 5 or 8
		SAE-J429	Grade 5 or 8
		NASM7838	Alloy steel
		ASTM A193/A193M	Grade B7 or B16
		ASTM F593	Group 1 or 2
	Socket head capscrews	MIL-DTL-1222	Grades A574, 4340, or 630
		NAS 1351/1352	Alloy steel, corrosion-resistant steel, or heat-resistant steel
		FF-S-86	Type VI, alloy steel [2/], corrosion-resistant steel, or heat- and corrosion-resistant steel
		ASTM A574	Alloy steel [2/]
		ASME 18.3	ASTM A564/A564M, Type 630, Condition H 1150
	Nuts	MIL-DTL-1222	Grade 4, 5, 7, or 8
		ASTM A563	Grades C, D, or DH
		SAE-J995	Grade 5 or 8
		ASTM A194/A194M	Grade 4 or 7
	Self locking nuts	NASM17829	Alloy steel
		NASM17830	CRES
Outboard applications. Inboard applications in contact with seawater. Inboard applications in bilge regions or trunks.	Bolts, hex head capscrews, and studs	MIL-DTL-1222	Grade 400, 500, or 625
		ASTM F468	Alloy 400, 405, or 625 [3/]
	Socket head capscrews	MIL-DTL-1222	Grade 500 or 625
		FF-S-86	Nickel copper alloy
		ANSI B18.3	ASTM B446 UNS N06625 Grade 1
	Nuts	MIL-DTL-1222	Grades 400, 405, or 625
		ASTM F467	Alloy 400 or 405
		ASTM F594	Group 1 or 2
		ASME B18.2.2	ASTM B446 UNS N06625 Grade 1
	Self-locking nuts	NASM17828	Ni-Cu
		NASM17830	CRES
		MIL-DTL-32258	Ni-Cu

NOTES:

1/ Proper material selection shall be followed when selecting alloys from this table, and selection shall be consistent with applicable detail shipbuilding specifications or other invoked contractual requirements. Some material combinations (MIL-DTL-1222 Grade 500 bolts with MIL-DTL-1222 Grade 625 nuts) are incompatible.

2/ FF-S-86, alloy steel, and ASTM A574 fasteners shall require a manufacturer mark as size permits.

3/ Nickel-copper alloy bolting ⅞-inch diameter or greater shall be in accordance with MIL-DTL-1222 for all applications, since the mechanical properties of ASTM F468 for those sizes are less than MIL-DTL-1222.

5.2.9.1 Threaded inserts. Tapped holes larger than 6.4 millimeters (mm) (0.25 inch) diameter in nonferrous parts to be used for mounting screws or bolts shall incorporate inserts conforming to NASM8846, MIL-DTL-45910, or MIL-DTL-45932. For high shear strength materials (above 345 MPa, 50,000 lb/in^2), inserts are not required when adequacy of design is verified by calculations in accordance with FED-STD-H28. The insert specifications provide guidance on determining the length of insert required. As a minimum, the insert length selected shall not result in shear tear out in the parent or tapped material if the fastener is tightened to 135 percent of the torque value indicated on the component drawing.

5.2.9.2 Bolt hole diameter. Hole diameters for mounting bolts shall not exceed those diameters produced using standard size drills as identified in table V.

TABLE V. Bolt hole diameters.

Bolt diameter	Maximum standard size drill
¾ inch and smaller	Nominal bolt diameter plus 1/32 inch
Larger than ¾ inch	Nominal bolt diameter plus 1/16 inch
20 mm and smaller	Nominal bolt diameter plus 1 mm
Larger than 20 mm	Nominal bolt diameter plus 1.5 mm

5.2.9.3 Safety. Hand-adjustable threaded parts subject to tampering shall be securely locked by safety wiring, self-locking nuts, or other methods specified in the component specification. Safety wire shall be applied in accordance with NASM33540 and shall conform to NASM20995. Star washers, lock washers, and jam nuts shall not be used as locking devices, except that jam nuts may be used on function-adjustment screws as specified in 5.2.12.

5.2.9.4 Self-locking devices. Self-locking nuts used with through-bolting shall be in accordance with NASM25027. Externally threaded self-locking elements shall be in accordance with MIL-DTL-18240. For component internal fastenings which require disassembly of the component to retighten, loosening shall be prevented by self-locking nuts or self-locking externally threaded fasteners.

5.2.9.5 Washers. Washers shall be used, as necessary, to provide load distribution, a hardened bearing surface, locking assistance, or some combination of these functions. Washer material shall be compatible with the assembled parts. Selection of washers shall be in accordance with SAE-J2655.

5.2.10 Retainer rings. Retainer rings or snap rings shall not be used unless the requirements of 5.2.10.1 through 5.2.10.3 are met.

5.2.10.1 Load limitation. Hydraulic, structural, mechanical, or any other form of loads, or combinations thereof, including vibration, shock loads, expansion, or contraction due to thermal changes, and so forth, which may cause axial displacement or failure of the ring, shall not be exerted on the ring.

5.2.10.2 Installation clearances and tolerances. Retainer rings or snap rings shall not be used where buildup of clearances and manufacturing tolerances will allow destructive end play in the assembly that may cause, or contribute to, failure of packings or gaskets brinelling, or fatigue failure of parts.

5.2.10.3 Installation and removal. The retainer rings or snap rings shall be installed and removed with standard pin-type pliers or other standard tools developed for use with the rings.

5.2.11 Spring pins. Unless approved by the contracting activity, spring pins shall not be used in any applications that conflict with NASM33547.

5.2.12 Function-adjustment screws. Function-adjustment screws, if used, shall maintain adjustment under all the required conditions of vibration, shock, temperature, and end operation. Friction-type locking devices shall be kept to a minimum and shall be subject to the approval of the contracting activity. If friction-type locking devices are used, the adjustment screws shall maintain their setting after adjusting through the full range 15 times, or as specified in the component specification, and then vibration tested as specified in 5.3.8. The adjustment screws shall be adjusted and locked with a standard wrench or screwdriver. Where practicable, the adjustment screws shall adjust under full system pressure with negligible loss of fluid. The means of adjustment shall be either internal or protected from tampering by a cover or similar device.

5.2.13 Bleeding and sampling. The configuration of components shall minimize the potential for air pockets; however, when required, provisions shall be made for bleeding of entrapped air. Auxiliary bleed ports shall be provided when necessary, and bleed plugs shall conform to SAE-AS5169. Valves in accordance with MIL-DTL-24695/l may be used for bleeding and venting and shall be used where sampling of fluid is required or where a pressure test station is required.

5.2.14 Fluid connections. Fluid connections shall be static O-ring seal bosses, flanges, quills, or O-ring unions as listed in MIL-STD-438 or MIL-STD-777, as applicable. Tapered pipe threads shall not be used.

5.2.14.1 Bosses. Internally threaded bosses for connecting fittings and plugs shall conform to table II, straight thread O-ring boss. Bosses shall be deep enough, or shall incorporate fitting stops, to prevent damage to internal mechanism or restriction of fluid flow when universal fittings are screwed into the bosses to excessive depths.

5.2.14.2 External tube connections. External male threaded tube connections shall conform to SAE-J1926/2 or SAE-J1926/3 thread dimensions for mating with straight thread O-ring bosses.

5.2.14.3 Flanges. Flanges shall conform to MIL-DTL-24704, ISO 3019-1, ISO 3019-2, SAE-J744, or SAE-J518/1 except other flanges identified in the applicable hydraulic sections of MIL-STD-438 and MIL-STD-777 or in component specifications referenced therein may also be used when applicable.

5.2.14.4 Fluid connection marking. Ports shall be clearly and permanently marked to indicate the connections to be made using standard nomenclature. Where applicable, the directions of flow shall be indicated.

5.2.14.5 Connector tubes. Internal connecting tubes shall be in accordance with SAE-J24714.

5.2.15 Lifting and handling attachments. Attachments for lifting eyes or handles shall be provided when the weight of the component exceeds 23 kilograms (50 pounds).

5.2.16 Identification of product. Each component shall be identified by means of a nameplate conforming to MIL-DTL-15024. A faying surface sealant conforming to MIL-PRF-81733 Type IV shall be used under mechanically fastened nameplates to prevent corrosion.

5.2.16.1 Marking. A nameplate shall be installed on the component to identify:

a. Standard part number or specification number, if applicable, manufacturer's name, and part number.

b. Fluid power symbol in accordance with SAE-AS1290. This is not required for small components where compliance is not practical.

c. Component operational data, if required by the component specification.

5.2.17 Lubrication. Unless otherwise specified by the acquisition component specification or applicable detail shipbuilding specification, if lubrication is necessary during assembly, the lubricant shall facilitate adequate fastener preload during installation and, if the fastener is in contact with the system fluid, shall be compatible with the system fluid.

5.3 Test procedures. The hydraulic components shall be tested in accordance with the applicable component specification. The specific test procedures identified herein should be included as applicable in the component specification (see 6.1).

5.3.1 Test conditions. The applicable test conditions shall be specified in the component specification. The specific test procedures identified herein should be included as applicable in the component specification (see 6.1).

5.3.1.1 Adverse tolerance conditions. The component shall function when assembled with adverse tolerance parts without degradation in component performance or life. Unless otherwise specified in the applicable component specification, compliance to this requirement shall be made by either mathematical analysis or by testing of minimum and maximum clearance samples.

5.3.1.2 Minimum clearance specimen. One specimen shall be assembled from parts which have been selected to ensure that the clearance with regard to linear and diametrical tolerances between moving and nonmoving members, conducive to malfunctioning at extreme temperatures, will not exceed 110 percent of the minimum clearance. For sliding parts where packing friction will influence the performance of the component, such as pistons operated by spring, the maximum packing friction shall be induced in the test specimen. O-ring packing glands shall provide maximum O-ring squeeze, including the effect of adverse O-ring cross section tolerance. This specimen shall be marked "MIN".

5.3.1.3 Maximum clearance specimen. The second specimen shall be assembled from parts which have been selected to ensure that the clearance with regard to linear and diametrical tolerances between moving members, conducive to malfunctioning as a result of wear associated with prolonged operation, will be not less than 90 percent of the maximum clearance. This specimen shall be marked "MAX".

5.3.1.4 Tolerance considerations. In machining these specimens, surface finishes shall be no finer than the surface finishes produced on production units. Where friction is not a factor, packing glands may be fabricated to nominal dimensions. Lapped or selectively fitted parts need not be made to adverse limits. In order to fabricate specimens with adverse tolerance, it is permissible to produce one of the mating parts required with the critical clearance outside of drawing tolerances, provided that the clearance, as fabricated, falls within the established design range.

5.3.1.5 Temperature. Unless otherwise specified herein or in the applicable component specification, the tests shall be conducted at a room temperature of 15 to 30 °C (59 to 89 °F).

5.3.1.6 Test fluid and fluid temperature. Unless otherwise specified herein or in the applicable component specification, the fluid used for pressure drop tests shall be the end-use hydraulic system fluid (see 6.2) or MIL-PRF-6083. Pressure drop and leakage tests shall be conducted with the fluid at 40 °C (104 °F), unless otherwise specified in the applicable component specification.

5.3.1.7 Immersion. This test shall be conducted on all nonmetallic materials not specifically identified in this standard which may be in contact with the fluid or fluid leakage for which shrinkage or swelling could affect performance. Each material shall be subject to an immersion test in each of the following fluids:

a. End-use hydraulic system fluid (see 6.2) or MIL-PRF-17331
b. Water (applications that come into contact with water under normal operating conditions only)
c. MIL-PRF-6083 (components for use in systems with hydrocarbon base fluids only)
d. DELETED

5.3.1.8 Additional testing requirements for material shrinkage. Critical dimensions shall be measured before immersion and after immersion for 7 days at 70±2 °C (158±35.6 °F). Material subject to shrinkage or swelling shall not be used unless additional testing establishes that the shrinkage or swelling does not affect performance or operability. As a minimum, the additional testing shall include subjecting the material in the assembled component to the fluid causing the most adverse effect for a period of 7 days at 70±2 °C (158±35.6 °F) prior to conducting first article or qualification tests. After the immersion at elevated temperature, the equipment shall remain in the fluid at room temperature until just prior to testing. Flushing of the immersion fluid just prior to an operational test will be permitted. The internal parts shall not be exposed to air for any appreciable length of time until operability and performance is verified.

5.3.1.9 Parameter measurement. The measurement of average steady-state pressure for first article/qualification testing shall be in accordance with NFPA T2.12.1 and NFPA T2.12.10. Unless otherwise specified herein or in applicable component specification, the level of accuracy in test parameter measurements for first article/qualification testing shall be in accordance with Class B of NFPA T2.12.10.

5.3.2 Inspection routine. The component specification shall identify the required inspections and tests using the guidance herein for their selection. Unless otherwise specified in the applicable component specifications, a single sample unit shall be subjected to the inspection and tests specified in table VI. Conformance tests and requirements shall be as specified in the component specification.

TABLE VI. Inspections sequence.

Tests	Test paragraph
Salt fog	5.3.3.2
Proof pressure	5.3.3.3
External leakage	5.3.3.5.1
Internal leakage	5.3.3.5.2
Extreme temperature	5.3.4
Shock	5.3.11
Vibration	5.3.8
Endurance	5.3.5
Reliability	5.3.9
Maintainability	5.3.10
Contamination sensitivity	5.3.12
Fatigue	5.3.6
Noise	5.3.7
Burst pressure	5.3.3.4

5.3.3 Test methods.

5.3.3.1 Operation. Each component shall be subjected to at least 10 normal operating cycles at the rated pressure specified in the applicable component specification without any sign of external leakage or other malfunction.

5.3.3.2 Salt fog. Unless otherwise specified in the component specification, the components shall be subjected to the salt fog test procedures specified in MIL-STD-810, Method 509.5 for 48 hours. After completion of testing and cleaning, the base metal of the component shall not be visible through the coating or finish, nor shall there be any evidence of blistering, softening, separation from the base metal corrosion products, or other coating failures. When more than one design is developed by the same contractor who uses the same method of surface preservation for all designs, only one representative unit shall require this test, provided the same materials are used. Unless otherwise specified in the component specification, test data on similar equipment with the same base and coating materials and equivalent coating thickness may be used to meet this requirement.

5.3.3.3 Proof pressure. Unless otherwise specified in the applicable component specification, a proof pressure of 150 percent of the system-rated operating pressure shall be applied to the components. The rated operating pressure of a component is the maximum safe operating or working pressure based on an established number of fatigue cycles, and does not preclude use in applications subject to infrequent higher transient pressures. For parts not covered by a specification or standard, the contracting activity shall specify the required proof pressure. For unbalanced cylinders and other components subjected to pressure multiplication, the proof pressure for ports subjected to pressure multiplication shall not be less than the nominal system pressure times the multiplication factor based on area ratios. The following additional guidance shall be used in determining the minimum proof pressure:

a. Suction ports. At least 135 percent of the maximum suction pressure, but not less than 2 bars (29 lb/in²).

b. Pressure and cylinder ports. The proof pressure shall not be less than the maximum calculated pressure developed under conditions of hydraulic shock considering, but not necessarily limited to, such factors as rapid valve closing, overhauling and suddenly applied loads, and relief valve full flow settings and response time.

c. Return ports. At least 135 percent of the maximum calculated return line pressure considering maximum flow rates and minimum fluid temperatures. If a stop valve is installed in a return line, the requirements for pressure and cylinder ports shall also apply upstream of the stop valve and the proof pressure must be at least equal to that developed with full flow through any relief valve protecting the return line.

5.3.3.4 Burst pressure. The burst pressure shall be as specified in the component specification and shall not be less than 250 percent of the rated operating pressure. Components containing air or gas under pressure shall be subject to a burst pressure of at least 400 percent of the operating pressure. In addition, the minimum burst pressure shall not be less than 150 percent of the proof pressure. The component shall not rupture under this pressure. The pressure may be increased above that specified in order to secure data on actual rupture pressure. If required, this shall be the last test performed because of its destructive nature. Components that require different test pressures in different elements shall have these pressures applied either separately or simultaneously, whichever is the most critical. 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, whichever is most adverse. The burst pressure test is not required if the specified component is subjected to the fatigue test specified in 5.3.6.

5.3.3.5 Leakage tests.

5.3.3.5.1 External leakage. During the course of all of the tests specified in this standard (with the exception of shock, endurance, and fatigue), external leakage, other than a slight wetting insufficient to form a drop through static seals, shall be cause for rejection. Where external, dynamic seals are utilized, permissible leakage past such seals shall be not greater than that specified in the applicable component specification. During shock and endurance testing, allowable leakage shall not exceed that specified in the component specification.

5.3.3.5.2 Internal leakage. Unless otherwise specified in the component specification, internal leakage tests shall be conducted by applying 0.35 bar (5 lb/in²), 50 percent of rated operating pressure, and operating pressure in the positions identified below:

a. Valves. Leakage tests shall be conducted for all positions in which the valve blocks flow.

b. Cylinders, actuators. Leakage tests shall be conducted at the two end positions of travel.

c. Other components. Leakage tests shall be conducted with component held in the position most conducive to leakage.

5.3.3.5.3 Leakage measuring requirements. The leakage measurement shall begin within 2 minutes after the application of pressure and shall be measured for not less than 1 minute and no more than 10 minutes. The rates of leakage shall not exceed those specified in the component specification. Conformance (acceptance) tests for external leakage shall be conducted at rated operating pressures.

5.3.4 Extreme temperature functioning. When this test is specified in the applicable component specification, it shall be conducted as follows:

5.3.4.1 Low temperature. The component shall be connected to the rated operating pressure specified in the applicable component specification. Unless otherwise specified in the applicable component specification, this arrangement shall be maintained at a temperature not warmer than -28.8 °C (-20 °F) for 3 hours after the temperature has stabilized at -28.8 °C (-20 °F). After this period, the component shall be actuated at least two times. Variation of actuating forces or regulation, as applicable, shall not exceed that specified in the component specification. The leakage tests in 5.3.3.5.1 and 5.3.3.5.2 shall be performed after each actuation to determine conformance to the requirements of the applicable component specification. Use of low viscosity fluids will be permitted during this test.

5.3.4.2 Intermediate temperature. Unless otherwise specified in the applicable component specification, immediately following the low temperature test (see 5.3.4.1), the test arrangement shall be warmed rapidly to 80 °C (176 °F). While the temperature is being raised, the component shall be actuated at maximum increments of 15 °C (59 °F) to determine satisfactory operation throughout the temperature range. These tests shall be performed without waiting for the temperature of the entire component to stabilize.

5.3.4.3 High temperature. The component shall be maintained at 80 °C (176 °F) for a length of time sufficient to allow all parts to attain this temperature. The component shall then be actuated at least two times. In the case of pressure actuation or regulation, the variation of actuating forces or regulation shall not exceed that specified in the applicable component specification. The leakage test (see 5.3.3.5.2) shall be performed after each actuation and the leakage requirements of the applicable component specification shall be met.

5.3.5 Endurance. Components shall be designed for a 30-year service life which may be equated to 150,000 hours of operation. Compliance with the service life requirement shall be demonstrated for components not subject to qualification or first article testing under a military specification. Unless otherwise specified in the acquisition specification, this shall be done either by a first article cyclic operation endurance test, or based on data representing at least 5 years of continuous operating experience. Unless otherwise specified (see 6.2), the endurance test can be limited to 2,000,000 cycles or 500 hours operating time for continuously operating components and other components where testing for the number of cycles equivalent to 30 years operation is impractical. During the endurance test, individual parts carried on board for logistic support, such as seals, may be replaced at intervals equivalent to not less than 20,000 hours or 200,000 cycles of operation, whichever is less. Disposable type filter elements in components may be replaced when required. At the conclusion of the endurance test, the component shall operate satisfactorily and meet endurance performance requirements specified in the applicable component specification. If specific endurance requirements are not specified in the component specification, then an internal leakage test shall be conducted and the leakage shall not exceed 300 percent of that specified for a new component.

5.3.6 Fatigue. Valves, pressure containers, and similar components (except hose assemblies) which have an expected service life of one million or more pressure cycles, with a magnitude in excess of 50 percent of their rated operating pressure, shall be fatigue tested to 90 percent assurance and 90 percent confidence levels in accordance with NFPA T2.6.1.

5.3.7 Noise. When tested in accordance with the Shipboard Equipment Noise requirement section of MIL-STD-1474 and MIL-STD-740-2, the component shall perform in accordance with the requirements specified in the applicable component specification. The noise test shall be either airborne or structureborne as specified in the applicable component specification. The noise test shall be performed after all other tests have been completed, with the exception of the burst pressure test.

5.3.8 Vibration. Components shall operate when subjected to Type I (environmental vibration) vibration tests in accordance with MIL-STD-167-1. In addition, rotating machinery such as pumps and motors shall meet the Type II (internally excited vibration) requirements of MIL-STD-167-1. For Type I tests, the component shall be tested in each of three mutually perpendicular axes. However, if a component is symmetrical about a principal axis, vibration testing need only be accomplished along two orthogonal axes, one of which shall be the principal axis of symmetry. The vibration test shall be run early in the component test program or various tests repeated after vibration testing to assure that vibration has not had an adverse effect on performance. Any of the following conditions resulting from vibration are considered unacceptable:

a. Damage to parts.

b. Loosening of parts.

c. Degradation of operational performance (including leakage) below specification requirements.

5.3.9 Reliability. When specified in the component specification, each component shall meet a specified quantitative reliability requirement in terms of Mean-Time-Between Failure (MTBF) or its equivalent. Reliability tests shall demonstrate conformance with the reliability requirements and confidence factors as specified in the applicable component specification for critical components.

5.3.10 Maintainability. The component shall demonstrate the ability to meet the allowed time for maintenance actions identified in the component specification. The elapsed time and man-hours required to replace each of the on board repair parts and the elapsed time and man-hours to perform each proposed preventive maintenance task shall be recorded. The average cumulative number of hours per week needed to perform both preventive and corrective maintenance tasks shall not exceed the requirements of the applicable component specification. Fault correction time for corrective maintenance tasks and servicing time for preventive maintenance tasks shall be recorded separately.

5.3.11 Shock. The components shall perform as specified herein and in the applicable component specification after being subjected to the high-impact shock test, Grade A, Class I as specified in MIL-DTL-901. The components shall be cycled after each blow during the test to determine that no damage has occurred as a result of the impact. A momentary interruption of the component function during shock testing shall not be interpreted as a failure. Post-shock test inspection shall include all functional and operational tests to demonstrate that the specified requirements are met.

5.3.12 Contamination sensitivity. When required by the component specification, the components shall meet the requirements of the applicable component specification when subjected to a contamination sensitivity test procedure approved by the Naval Sea System Command (NAVSEA) (see 6.1.2.d). The test circuit shall be modified by the addition of a component test loop as shown on figure 1.

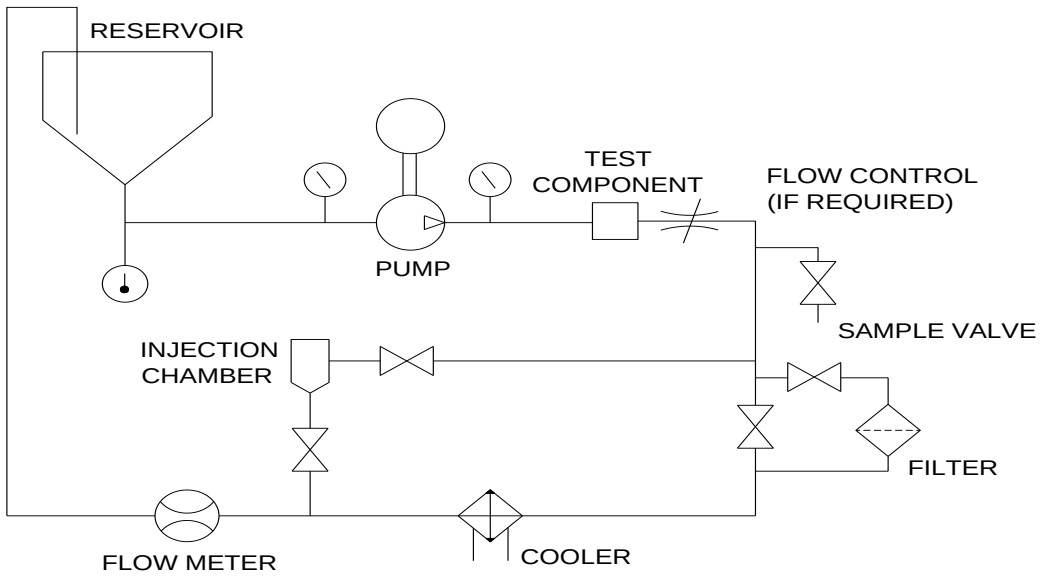

FIGURE 1. Contamination sensitivity test circuit.

5.3.13 Component cleanliness. Component cleanliness levels shall be as identified in the procurement specification. Where the procurement specification invokes this military standard but does not identify a specific cleanliness level, the fluid sampled from the component shall not exceed the particle counts identified in table VII.

TABLE VII. Component cleanliness.

Particle size	Particles per 100 mL
Greater than 15 micrometers	14,000
Greater than 25 micrometers	2,500
Greater than 50 micrometers	400
NOTE: Unless otherwise specified (see 6.2), the above counts apply to samples taken in accordance with practice A of ASTM F303.	

5.4 Drawing practices. Engineering drawing practices for hydraulic component drawings shall be in accordance with ASME Y14.100.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use.

6.1.1 Components to military specifications. When a component is procured to military specification, the tests in this standard apply only to the extent identified in the component military specification.

6.1.2 Commercial components and components to shipbuilder prepared specifications. Every test need not be applied to each component. The procuring activity has the responsibility for determining if any of the tests may be deleted based on the following guidance:

a. For standard commercial components being used within the applicable design parameters (e.g., pressure, temperature, speed, environment, etc.), the tests for adverse tolerance and extreme temperature functioning are not required.

b. Reliability and maintainability requirements need be included in the component specification only when required by the shipbuilding or other higher level specification.

c. High-impact shock requirements need not be applied if the components are used solely in a system not subject to these requirements.

d. The contamination sensitivity test may be limited to those electro-hydraulic servo valves, electric driven motors, and hydraulic pumps not in accordance with a military or industry specification listed in Acquisition Streamlining and Standardization Information System (ASSIST) Online. However, contaminant sensitivity test procedures do not specify fail/pass criteria. Accordingly, the fail/pass criteria may be specified in the procurement specification. (NAVSEA Hydraulics TWH, SEA 05Z4, should be consulted regarding contamination sensitivity test procedures and fail/pass criteria.)

e. For some tests, guidance on the applicability of the test is identified in the test procedure.

6.1.3 Design and installation guidance for O-ring assembly. SAE-AS4716 and SAE-AS5857 provide design features and installation methods to prevent damage to seals on O-ring assembly.

6.1.4 Seal gland design. For existing Navy hydraulic component designs, continued use of seal gland designs in accordance with MIL-G-5514 is technically acceptable. All new component designs are to conform to the seal gland design requirements specified herein.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this standard.

b. When specific endurance testing is required (see 5.3.5).

c. When specific component cleanliness is required (see table VII).

d. End-use hydraulic system fluid. If exact system fluid is not yet determined, specify the hydraulic system fluid type (e.g., petroleum base, synthetic hydrocarbon, phosphate ester) (see 4.2, 5.3.1.6, and 5.3.1.7).

6.3 Subject term (key word) listing.

Adverse tolerance conditions

Cadmium plate

Contamination sensitivity

Zinc plate

6.4 Change notations. The margins of this standard are marked with vertical lines to indicate modifications generated by this change. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations.

CONCLUDING MATERIAL

Preparing activity:
Navy – SH
(Project 4810-2018-001)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.