NOT MEASUREMENT SENSITIVE
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MILITARY STANDARD

HYDRAULIC SYSTEM COMPONENTS, SHIP

AMSC N/A FSC 4810

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND

Arlington, VA 22242-5160

Hydraulic System Components, Ship

1. This Military 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. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 03R42, 2531 Jefferson Davis Hwy, Arlington, VA 22242-5160 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

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.

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1. SCOPE, PURPOSE AND IMPLEMENTATION GUIDANCE

1.1 Scope. This standard provides general 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 general requirements, including testing, for hydraulic components used in shipboard hydraulic systems. This standard also provides guidance as to when special design and test requirements, such as impulse fatigue, should be applied to shipboard hydraulic components. This standard will be used to provide the general requirements for a number of military specifications for ship hydraulic components and as the basis for general 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 shall 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 HRP 4538 may be used for selecting hydraulic directional control valves. Marine hydraulic system designers should also refer to SAE HIR 4544 for assistance in identifying specifications and standards that are suitable for use in marine hydraulic systems.
(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. REFERENCED DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

QQ-C-320 - Chromium Plating (Electrodeposited).
QQ-N-290 - Nickel Plating (Electrodeposited).
QQ-S-365 - Silver Plating, Electrodeposited: General Requirements for.

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MIL-S-901 - Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for.
MIL-H-6083 - Hydraulic Fluid, Petroleum Base, for Preservation and Operation.
MIL-A-8625 - Anodic Coatings, for Aluminum and Aluminum Alloys.
MIL-R-8791 - Retainer, Packing, Hydraulic, and Pneumatic, Tetrafluorethylene Resin.
MIL-R-8791/1 - Retainer, Packing, Hydraulic and Pneumatic, Polytetrafluoroethylene, single turn
MIL-I-8846 - Inserts, Screw-Thread, Helical Coil.
MIL-T-10727 - Tin Plating; Electrodeposited or Hot-Dipped, for Ferrous and Nonferrous Metals.
MIL-P-15024 - Plates, Tags and Bands for Identification of Equipment.
MIL-H-17672 - Hydraulic Fluid, Petroleum, Inhibited.
MIL-F-18240 - Fastener, Externally Threaded, 250F°, Self-Locking Element for.
MIL-H-19457 - Hydraulic Fluid, Fire-Resistant, Non-Neurotoxic.
MIL-H-22072 - Hydraulic Fluid, Catapult, NATO Code Number H-579.
MIL-C-22751 - Coating System, Epoxy-Polyamide, Chemical and Solvent Resistant: Process for Application of.
MIL-P-24441 - Paint, Epoxy Polyamide, General Specification for.
MIL-P-24441/1 - Paint, Epoxy-Polyamide, Green Primer, Formula 150, Type I.
MIL-P-24441/2 - Paint, Epoxy-Polyamide, Exterior Topcoat, Haze Gray, Formula 151, Type I.
MIL-V-24695 - Valve, And Hose Assembly, Vent and Test, Hydraulic Service, General Specification For. (Metric)
MIL-V-24695/1 - Valve, Vent and Test, Hydraulic Service.
MIL-F-24704 - Hydraulic Flanges, Square, 4-Bolt.
MIL-C-24714 - Connector Tubes, Hydraulic Component General Specification For.
MIL-N-25027 - Nut, Self-Locking, 250F°, 450F°, and 800F°.
MIL-C-26074 - Coatings, Electroless Nickel, Requirements for.
MIL-G-27617 - Grease, Aircraft and Instrument, Fuel and Oxidizer Resistant.
MIL-I-45910 - Insert, Screw Thread-Locked In and Ring Locked, Serrated, General Specification for.
MIL-I-45932 - Insert, Screw Thread, Thin Wall, Locked In: General Specification for.
MIL-S-81733 - Sealing and Coating Compound, Corrosion Inhibitive.

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MIL-R-83248 - Rubber, Fluorocarbon Elastomer, High Temperature, Fluid, and Compression Set Resistant.
MIL-R-83248/1 - Rubber, Fluorocarbon Elastomer, High Temperature, Fluid, and Compression Set Resistant, O-Rings, Class 1, 75 Hardness.
MIL-R-83248/2 - Rubber, Fluorocarbon Elastomer, High Temperature, Fluid, and Compression Set Resistant, O-Rings, Class 2, 90 Hardness.
MIL-R-83485 - Rubber, Fluorocarbon Elastomer, Improved Performance at Low Temperatures.
MIL-R-83485/1 - Rubber, Fluorocarbon Elastomer, Improved (USAF) Performance of Low Temperatures, O-Rings, Sizes and Tolerances.
MIL-C-83982 - Compound, Sealing, Fluid Resistant.

STANDARDS

MILITARY

MIL-STD-100 - Engineering Drawing Practices.
MIL-STD-167-1 - Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II Internally Excited).
MIL-STD-167-2 - Mechanical Vibrations of Shipboard Equipment (Reciprocating Machinery and Propulsion System and Shafting) Types III, IV and V.
MIL-STD-438 - Schedule of Piping, Valves, Fittings, and Associated Piping Components for Submarine Service.
MIL-STD-740-1 - Airborne Sound Measurements and Acceptance Criteria of Shipboard Equipment.
MIL-STD-740-2 - Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment.
MIL-STD-785 - Reliability Program for Systems and Equipment Development and Production.
MIL-STD-777 - Schedule of Piping, Valves, Fittings, and Associated Piping Components for Naval Surface Ships.
MIL-STD-810 - Environmental Test Methods and Engineering Guidelines.
MIL-STD-889 - Dissimilar Metals.
MIL-STD-1251 - Screws and Bolts Preferred for Design, Listing of.
MIL-STD-1598 - Studs Preferred For Design, Listing of.
MIL-STD-1754 - Fastening Devices Preferred for Design, Listing of.
MIL-STD-1759 - Rivets and Rivet Type Fasteners Preferred for Design, Listing of.
MIL-STD-1764 - Washers Preferred for Design, Listing of.
MIL-STD-1903 - Nuts Preferred For Design, Listing of.
MS20995 - Wire, Safety or Lock.
MS21344 - Installation of Flared Tube, Straight Threaded Connectors, Design Standard for.

MILITARY (Continued)

MS24391 - Plug-Bleeder, Tube Precision Type.
MS33540 - Safety Wiring and Cotter Pinning, General Practices for.
MS33547 - Pin, Spring, Functional Limitations of.

(Unless otherwise indicated, copies of federal and military specifications and standards are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DoDISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

B46.1 - Surface Texture, Surface Roughness, Waviness and Lay. (DoD adopted)
Y32.10 - Graphic Symbols for Fluid Power Diagrams. (DoD adopted)

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

B 633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel. (DoD adopted)
E 208 - Standard Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels.
F 303 - Standard Practices for Sampling Aerospace Fluids From Components.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

NATIONAL FLUID POWER ASSOCIATION (NFPA)

T2.6.1 - Method for Verifying the Fatigue and Establishing the Burst Pressure Ratings of the Pressure Containing Envelope of a Metal Fluid Power Component.
T3.9.18 - Method of Establishing the Flow Degradation of Fixed Displacement Hydraulic Fluid Power Pumps When Exposed to Particulate Contaminant.
T2.12.2 - Method of measuring average steady-state pressure. (DoD adopted).
T2.12.10 - Testing general measurement, principles and tolerances. (DoD adopted).

(Application for copies should be addressed to the National Fluid Power Association, Inc., 3333 N. Mayfair Road, Milwaukee, WI 53222.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

J 514 - Hydraulic Tube Fittings. (DoD adopted)
J 518 - Hydraulic Flanged Tube, Pipe, and Hose Connections, 4-Bolt Split Flange.
J 1926 - Straight Threads O-Ring Port.
J 2244/1 - Connections for Fluid Power and General Use - Ports and Stud Ends with ISO261 Threads and O-Ring Sealing Part 1: Port with O-Ring Seal in Truncated Housing, Standard; December 1991 (ISO6149-1).
J 2244/2 - Connections for Fluid Power and General Use - Ports and Studs Ends with ISO261 Threads and O-Ring Sealing Part 2: Heavy Duty (S Series) Stud Ends - Dimensions, Design, Test Methods, and Requirements, Standard; December 1991 (ISO 6149-2).
MA 2010 - Packing, Preformed - O-Ring Seal Standard Sizes & Size Codes, Metric.
MA 2012 - Port Connection Internal, Straight Thread, Metric.
MA 3352 - Packing, Preformed - O-Ring Seal, AMS 7276, Metric.
MA 3445 - Packing, Preformed O-Ring Seal, Fluorocarbon (MIL-R-83485, Type I), Metric.
MAP 3439 - O-Ring Groove Design for Packing Preformed, Elastomeric O-Ring Seals, Static Axial Compression, Metric.
MAP 3440 - O-Ring Groove Design for Packing Preformed, Elastomeric O-Ring Seals, Static Radial Squeeze, Metric.
HRP 4538 - Selection of Hydraulic Directional Control Valves For Marine Vehicle Applications.
HRP 4544 - Specifications and Standards for Marine Hydraulic Systems and Components.
AS 568 - Aerospace Size Standard For O-Rings.
AS 4716 - Gland Design, O-Ring and Other Elastomeric Seals.

(Application for copies should be addressed to the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.)

(Nongovernment standards are generally available for reference from libraries. They are also distributed among nongovernment standards bodies and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

3. DEFINITIONS

Not applicable.

4. GENERAL REQUIREMENTS

4.1 Compatibility. Components shall be compatible with MIL-H-17672 petroleum base, MIL-H-22072 water-glycol, and MIL-H-19457 triaryl phosphate ester hydraulic fluids. Components shall also be compatible with preservation fluid in accordance with MIL-H-6083.

4.2 Materials. Materials used in the manufacture of hydraulic components shall be compatible with the specified fluids and temperatures, and unless otherwise specified in the component specification, 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.

4.3 Environmental conditions. Unless otherwise specified by the component specification, components shall operate continuously in the environments specified herein.

4.3.1 Ambient pressure. The components shall operate throughout an ambient pressure range of 8.25×10^{-1} 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.

4.3.2 Ambient temperature. Unless otherwise specified in the applicable component specification, components shall operate throughout an ambient temperature range of minus 40 to 80 degrees Celsius (C), except components installed within heated spaces shall operate throughout a temperature range of 5 to 80°C.

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.) Low ductility material and high transition temperature material may be used in non-pressure boundary and non-load carrying applications where suitability is proven by high-impact shock tests. Low ductility material is metallic material showing less than 10 percent elongation in a standard tension test. High transition temperature material is material having a nil-ductility transition temperature (NDTT) above the minimum operational temperature. The NDTT shall be as measured by the drop-weight test in accordance with ASTM E 208. Charpy V-notch impact values may be used as criteria when these have been correlated with drop-weight test results.

TABLE I. Metal coatings.

Coating	Applicable specification
Zinc plating	ASTM B 633
Chromium plating	QQ-C-320
Nickel plating	QQ-N-290
Silver plating	QQ-S-365
Tin plating	MIL-T-10727, type I
Electroless nickel	MIL-C-26074

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.

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-P-24441, MIL-P-24441/1 (formula 150), MIL-P-24441/2 (formula 151) or MIL-C-22751.

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-base alloys.
(e) Radioactive materials.
(f) Asbestos.

(g) Cadmium (see 5.1.2.1).
(h) Beryllium (beryllium is acceptable as a small percentage (less than 3 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 DOD-STD-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. The components shall withstand all loads or combinations of loads resulting from hydraulic pressure, vibration, shock, temperature variations, actuation or operation, and 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 ANSI B46.1. The determination of surface finishes shall be made with a profilometer, comparator brush analyzer, or other comparison equipment with an accuracy of plus or minus 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 roughness height rating or finer is specified, the process description shall be in addition to required surface measurements. 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 General. Sufficient clearance shall exist to permit assembly of the components without damage to O-rings or back-up rings where they pass threaded parts or sharp corners. The glands for O-rings, quad-type rings, and T-type rings shall be in accordance with the following:

(a) For static and dynamic sealing applications using SAE AS568 size O-rings at pressures exceeding 100 bar (1450 lb/in^2) utilizing one or two anti-extrusion (backup) rings and applications at pressures under 100 bar (1450 lb/in^2) without backup rings, glands shall be in accordance with SAE AS 4716. The use of shallower depth glands to increase squeeze is permissible, where required, such as for face-type seals.
(b) For metric size static radial seals up to 100 bar (1450 lb/in^2) without backup rings, glands shall be in accordance with SAE MAP 3440.
(c) For metric size dynamic radial seals in applications at pressures exceeding 100 bar (1450 lb/in^2) utilizing one or two anti-extrusion (backup) rings and applications at pressures under 100 bar (1450 lb/in^2) without backup rings, glands shall be designed for SAE MA 2010 O-ring sizes in accordance with the guidelines of SAE AS 4716.
(d) For metric size face-type seals glands shall be in accordance with SAE MAP 3439.
(e) For standard commercial components, the manufacturer's standard glands may be used provided they do not require nonstandard size seals. Similarly, for existing navy designs, the current seal glands are acceptable if they perform satisfactorily when standard size seals are utilized.

T-type rings, quad rings, compression lip seals and other seals which can be used in the standard glands identified above may be used where significant improvement over O-ring performance will be obtained. Use of seals which require glands other than those identified above shall be used only where standard seals will not meet performance requirements.

5.2.8.2 O-rings. O-rings shall be fluorocarbon elastomer in accordance with MIL-R-83485 and MIL-R-83485/1 or MIL-R-83248 and MIL-R-83248/1, except 900 series dash numbers shall be in accordance with MIL-R-83248/2. O-rings in accordance with MIL-R-83485/1 are preferred where temperatures below minus 4°C may be encountered. Metric O-rings shall be in accordance with SAE MA 3445 or MA 3352.

5.2.8.3 Back-up rings. Back-up rings shall be tetrafluorethylene in accordance with MIL-R-8791 and shall conform dimensionally with a military standard for back-up rings when an applicable standard exists. Back-up retainer rings in accordance with MIL-R-8791/1 are preferred for new, non-metric designs.

5.2.9 Fasteners. Screws and bolts shall be selected from the preferred-for-design MIL-STD-1251. Studs shall be selected from the preferred-for-design MIL-STD-1598. Nuts shall be selected from the preferred-for-design MIL-STD-1903. Other fasteners shall be selected from the preferred-for-design MIL-STD-1754. Rivets and washers shall be selected from the preferred-for-design MIL-STD-1759 and MIL-STD-1764, respectively. For applications where the preferred-for-design military standard parts are not adequate, selection shall next be from military and industry specifications which incorporate a standard part numbering system for identifying parts before selecting a nonstandard part.

5.2.9.1 Threaded inserts. Tapped holes larger than 6.4 millimeters (mm) diameter in nonferrous parts to be used for mounting screws or bolts shall incorporate inserts conforming to MIL-I-8846, MIL-I-45910, or MIL-I-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. The insert specifications provide guidance on determining the length of insert required. As a minimum, the insert length selected shall be sufficient for the load developed when the fastener is torqued 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 below:

Bolt diameter	Maximum standard size drill
3/4 inch and smaller	Nominal bolt diameter plus 1/32 inch
Larger than 3/4 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 MS33540 and shall conform to MS20995. 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 MIL-N-25027. Externally threaded self-locking elements shall be in accordance with MIL-F-18240. For component internal fastenings which require disassembly of the component to retighten, loosening shall be prevented by self-locking nuts or lockwires.

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 MS33547.

5.2.12 Function-adjustment screws. Function-adjustment screws, if used, shall maintain adjustment under all the required conditions of vibration, shock, temperature, and 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, provision shall be made for bleeding of entrapped air. Auxiliary bleed ports shall be provided when necessary, and bleed plugs shall conform to MS24391. Valves in accordance with MIL-V-24695/1 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 union as listed in MIL-STD-438 or MIL-STD-777, as applicable. Pipe threads shall not be used.

5.2.14.1 Bosses. Internally threaded bosses for connecting fittings and plugs shall conform to SAE J1926, 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. Metric ports for straight thread connections shall conform to SAE MA 2012 or SAE J2244/1.

5.2.14.2 External tube connections. External male threaded tube connections shall conform to SAE J514, SAE J2244/2 thread dimensions for mating with straight thread O-ring bosses.

5.2.14.3 Flanges. Flanges shall conform to MIL-F-24704 or SAE J518 except that 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 direction of flow shall be indicated.

5.2.14.5 Connector tubes. Internal connecting tubes shall be in accordance with a specification sheet to MIL-C-24714.

5.2.15 Lubrication. Unless otherwise specified by the acquisition specification, if lubrication is necessary during assembly, the lubricant shall conform to MIL-G-27617, type III.

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

5.2.17 Identification of product. Each component shall be identified by means of a nameplate conforming to MIL-P-15024. A faying surface sealant conforming to MIL-C-83982 or MIL-S-81733 shall be used under mechanically fastened nameplates to prevent corrosion.

5.2.17.1 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 ANSI Y32.10. This is not required for small components where compliance is not practical.
(c) Component operational data, if required by the component specification.

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. If not addressed in the component specification, the fluid and temperature requirements herein shall apply.

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 provide 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 tolerances. 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 provide 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.

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 in accordance with MIL-H-17672, 2135-T-H. Pressure drop and leakage tests shall be conducted with the fluid at 40°C.

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) Water
(b) MIL-H-17672, 2135-TH
(c) MIL-H-22072
(d) MIL-H-19457

Critical dimensions shall be measured before immersion and after immersion for 7 days at 70 ± 2°C. 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 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.

5.3.1.8 Parameters measurement. The measurement of average steady-state pressure for first article/qualification testing shall be in accordance with ANSI/(NFPA) T2.12.1. Unless otherwise specified herein or in applicable component specification, the level of accuracy in test parameters measurements for first article/qualification testing shall be in accordance with Class B of ANSI/(NFPA) T.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 specification, a single sample unit shall be subjected to the inspection and tests specified in table II. The recommended test sequence shall be as specified in table II. Quality conformance tests and requirements shall be as specified in the component specification.

TABLE II. Inspection 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 509.2 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. 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/in^2).
(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.

For unbalanced cylinders and other components subjected to pressure multiplication, the proof pressure for ports subjected to pressure multiplication shall be not less than the nominal system pressure times the multiplication factor based on area ratios.

5.3.3.4 Burst pressure. The burst pressure shall be as specified in the component specification and shall not be less than 250% of the rated operating pressure. Components containing air or gas under pressure shall be subject to a burst pressure of at least 400% of the operating pressure. In addition, the minimum burst pressure shall not be less than 150% 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.

The leakage measurement shall begin within 2 minutes after the application of pressure and shall be measured for not less than 1 minute nor more than 10 minutes. The rates of leakage shall not exceed those specified in the component specification. Quality conformance (acceptance) tests shall be the same as described above, except tests need be conducted only at rated operating pressures, except when first article (or qualification) tests have indicated that leakage at other conditions is greater.

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 minus 40°C for 3 hours after the temperature has stabilized at minus 40°C. 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. While the temperature is being raised, the component shall be actuated at maximum increments of 15°C 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 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, 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 MIL-STD-740-1 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-167-2. For type I tests the component shall be tested in each on 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 (as defined in MIL-STD-785).

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-S-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 in accordance with NFPA T3.9.18 or other procedure approved by the Naval Sea System Command (see 6.1.2(d)). The test circuit shall be modified by the addition of a component test loop as shown on figure 2.

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 following particle counts:

Particle size	Particles per 100 ml.
Greater than 15 micrometres	14,000
Greater than 25 micrometres	2,500
Greater than 50 micrometres	400

Unless otherwise specified, 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 MIL-STD-100.

6. NOTES

6.1 Guidance for application of test requirements.

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, i.e. pressure, temperature, speed, environment, etc. the tests for adverse tolerances 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 the DODISS. A contamination sensitivity test procedure for valves is being developed by the National Fluid Power Association. However, contaminant sensitivity test procedures do not specify fail/pass criteria. Accordingly, the fail/pass criteria must be specified in the procurement specification. (NAVSEA 03W16 should be consulted regarding contamination sensitivity test procedures and pass/fail criteria.)
(e) For some tests, guidance on the applicability of the test is identified in the test procedure.

6.2 Subject term (key word) listing.

Adverse tolerance conditions
Cadmium plate
Contamination sensitivity
Hydraulic system components
Zinc plate

Preparing activity:
Navy - SH
(Project 4810-N108)

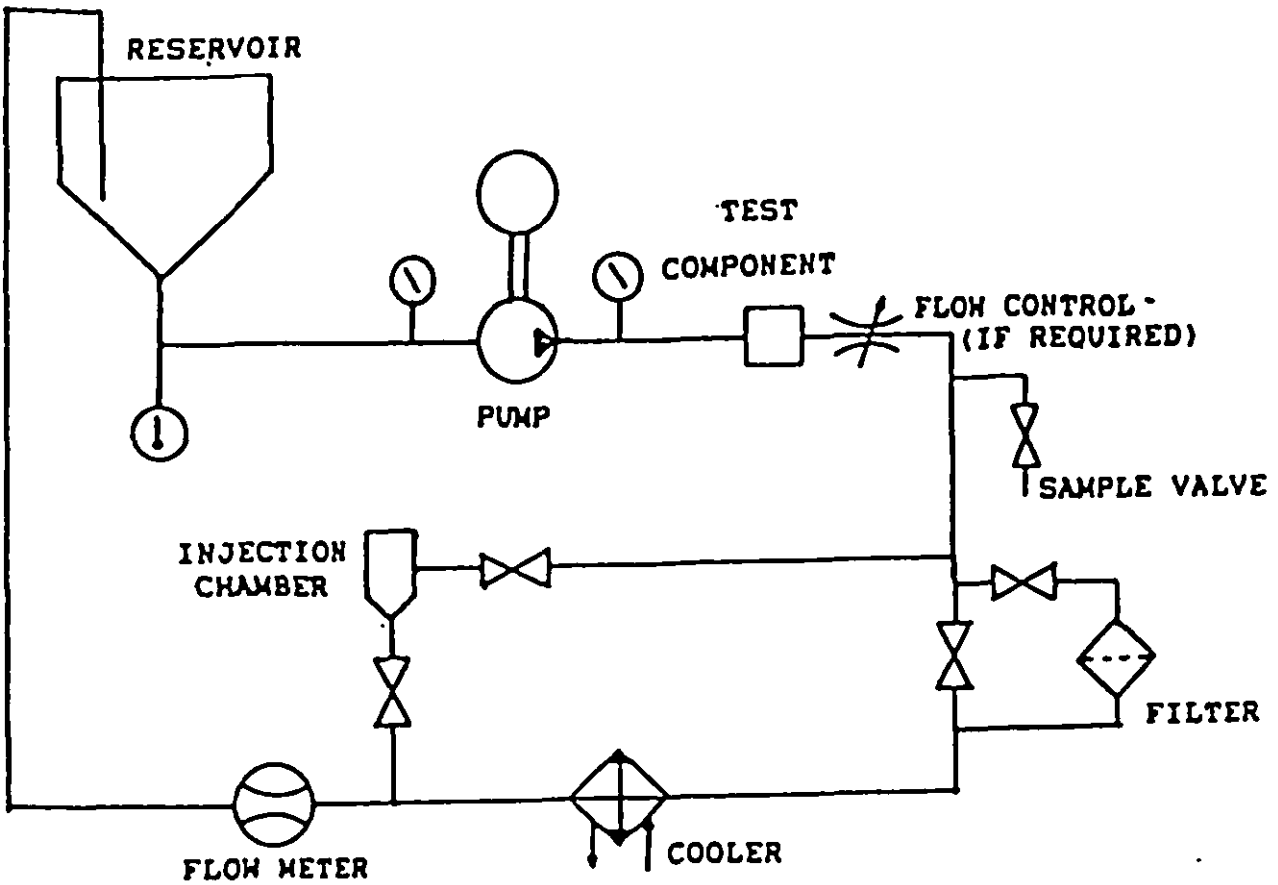

FIGURE 1. Contamination sensitivity test circuit.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-STD-2193B(SH)	2. DOCUMENT DATE (YYMMDD) 21 JUNE 1994

3. DOCUMENT TITLE
HYDRAULIC SYSTEM COMPONENTS, SHIP

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code) -	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME COMMANDER NAVAL SEA SYSTEMS COMMAND (SEA 03R42)	b. TELEPHONE (Include Area Code) (1) Commercial (703) 602-9137 (2) AUTOVON DSN 332-9137
c. ADDRESS (Include Zip Code) 2531 JEFFERSON DAVIS HWY ARLINGTON, VA 22242-5160	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340