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MILITARY STANDARD

CLEANING AND PROTECTING

PIPING, TUBING, AND FITTINGS

FOR HYDRAULIC POWER

TRANSMISSION EQUIPMENT



FSC MISC

MIL-STD-00419B(SHIPS)
24 February 1975

DEPARTMENT OF THE NAVY
NAVAL SHIP ENGINEERING CENTER
HYATTSVILLE, MARYLAND 20782

Cleaning and Protecting Piping, Tubing, and Fittings
for Hydraulic Power Transmission Equipment

MIL-STD-00419B(SHIPS)

1. This Military Standard is approved for use by all activities under the cognizance of the Naval Sea Systems Command.

2. Recommended corrections, additions, or deletions should be addressed to the Commander, Naval Ship Engineering Center, Department of the Navy, Center Building, Prince George's Center, Hyattsville, Maryland 20782.

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1. SCOPE

1.1 This standard covers the requirements governing the basic methods of cleaning and protecting nonferrous and ferrous metal and alloyed pipe, tubing, and fittings prior to installation and after hydraulic tests in hydraulic power transmission applications. This standard is applicable to hydraulic components used in systems filled with either petroleum oil or a phosphate ester type fluid.

2. REFERENCED DOCUMENTS

2.1 The issues of the following documents in effect on the date of invitation for bids form a part of this standard to the extent specified herein.

GOVERNMENTAL

SPECIFICATIONS

O-H-765 - Hydrochloric Acid, Technical.
 O-H-795 - Hydrofluoric Acid, Technical.
 O-I-501 - Inhibitors, Pickling (for Use with Sulfuric Acid).
 O-N-350 - Nitric Acid, Technical.
 O-S-571 - Sodium Carbonate, Anhydrous, Technical.
 O-S-588 - Sodium Chromate, Anhydrous, Technical.
 O-S-595 - Sodium Dichromate, Dihydrate, Technical.
 O-S-598 - Sodium Hydroxide, Technical.
 O-S-642 - Sodium Phosphate, Tribasic, Technical; Anhydrous, Dodecahydrate, and Monohydrate.
 O-S-809 - Sulfuric Acid, Technical.
 PPP-T-60 - Tape: Packaging, Waterproof.
 MIL-P-116 - Preservation-Packaging, Methods of.
 MIL-C-5501 - Caps and Plugs, Protective, Dust and Moisture Seal, General Specification For.
 MIL-H-6083 - Hydraulic Fluid, Petroleum Base, For Preservation and Operation.
 MIL-C-15348 - Cleaning Oil, Turbine (Compounded).
 MIL-C-16173 - Corrosion Preventive Compound, Solvent Cutback, Cold-Application.
 MIL-P-16232 - Phosphate Coatings, Heavy, Manganese or Zinc Base (For Ferrous Metals).
 MIL-D-16791 - Detergents, General Purpose (Liquid, Nonionic).
 MIL-L-17331 - Lubricating Oil, Steam Turbine (Noncorrosive).
 MIL-L-17672 - Lubricating Oil, Hydraulic and Light Turbine, Non-corrosive.
 MIL-H-19457 - Hydraulic Fluid, Fire Resistant.
 MIL-C-23112 - Corrosion Preventive, Fire Resistant.
 MIL-F-24402 - Filter and Filter Elements, 25 Micrometre Absolute, Ship Hydraulic Systems.
 MIL-C-81302 - Cleaning Compound, Solvent, Trichlorotrifluoroethane.

PUBLICATIONS

MILITARY

MIL-HDBK-406 - Contamination Control Technology, Cleaning Materials - Clean Room and Work Stations.
 MIL-HDBK-407 - Contamination Control Technology - Methods and Procedures.
 NAVSHIPS 0901-003-0001 - Naval Ships Technical Manual, Chapter 9003, Materials Allowances Surveys.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

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NONGOVERNMENTAL

NATIONAL STANDARDS ASSOCIATION (NSA)
NAS 1638 - Cleanliness of Parts Used in Hydraulic Systems.

(Application for copies should be addressed to the National Standards Association, Inc., 1321 Fourteenth Street, N.W., Washington D. C. 20005.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)
ARP 598 - The Determination of Particulate Contamination in
Liquids by the Particle Count Method.

(Application for copies should be addressed to the Society of Automotive Engineers, Inc., 2 Pennsylvania Plaza, New York, NY 10001.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
D 1744 - Water in Liquid Petroleum Products by Karl Fischer Reagent.

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

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)
Occupational Safety and Health Standards, Parts 1910 and
1926, Title 29, USC.

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D. C. 20402.)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
B93.28 - Method for Calibration of Liquid Automatic Particle
Counters Using "AC" Fine Test Dust.

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

3. DEFINITIONS (Not applicable).

4. GENERAL REQUIREMENTS

- # 4.1 Pipe tubing and fittings related to the hydraulic power transmission equipment shall be thoroughly cleaned and pickled as necessary prior to installation (see 5.2). They shall be free from scale and foreign matter which could be detrimental to operation of hydraulic equipment such as pumps, motors, valves, rams, and accumulators.
- # 4.2 Pipe required to complete a hydraulic installation shall be fabricated in a shop where adequate facilities exist. However, shipboard or vehicle fabrication is allowed, provided adequate provisions exist to allow cleanliness controls and preclude damage to equipment. Subassemblies shall be used to the maximum extent practicable. After fabrication and bending operations are completed, the fabricated and bent pipe, tubing, and fittings shall be cleaned and pickled in accordance with the procedures specified herein. Hydraulic components which may be constructed of materials not compatible with the pickling solution shall not be immersed in the cleaning or pickling baths. Complex components, such as pumps, valves, and rams, which may be compatible with the pickling solution but will require disassembly to remove residual fluids, shall not be immersed in the cleaning or pickling baths.
- # 4.3 Sand, shot, or other abrasive blasting is not permitted on any part of the hydraulic system. Unless a separate isolated room is provided in the shop for fabrication of hydraulic piping, abrasive blasting shall be prohibited in the same building that an open hydraulic component is housed. Abrasive blasting, chipping, or grinding will not be permitted in the vicinity of an installation site for an open hydraulic system.
- 4.4 Hydraulic pipe or tubing shall not be packed with sand during the bending process.
- 4.5 The pipe and tubing shall not be wire brushed after pickling.
- 4.6 Cloth or paper material shall not be used in drying operations, nor for capping open ends (see 5.7).

4.7 The interior and exterior of the ferrous pipe, tubing and fittings (except corrosion-resistant steel) shall be treated as specified in 5.5 to prevent rust.

4.8 Openings shall be capped and sealed air tight after the cleaning process with a material in accordance with MIL-C-5501 (see 5.7). The openings shall remain capped until immediately before connecting to the equipment for which the pipe is intended.

4.9 Pipe or tubing that has had heat applied at the site of installation to assist in forming shall be returned to the shop or other areas where facilities exist for recleaning, repickling, and retesting.

5. DETAIL REQUIREMENTS

5.1 Safety precautions. The contractor or shipyard representative shall insure that this cleaning is coordinated through the safety superintendent to provide adequate personnel protection from acid and chemical hazards. In general, all chemicals involved are harmful to the eyes and skin. Personal contact with chemicals should be avoided. Obtain medical attention immediately if acid or caustic get in the eyes. Face shields or goggles must be worn by personnel dumping chemicals into mixing tanks. Avoid breathing mists or vapors over mixing tanks. Rubber overshoes or boots, gloves, aprons, and hats, or other foul weather gear are required for personnel who are mixing caustic or acidic cleaning solutions.

5.2 Cleaning. The cleaning and treatment compounds described herein are environmental pollutants if discharged to the water and can be toxic to fresh water and marine organisms. Disposal procedures specified in 5.9 shall be followed. The following procedure shall be followed in preparation for pickling:

- (a) Wire-brush entire surface, including interior. Boiler tube brushes or commercial pipe-cleaning apparatus may be used.
- (b) Blast thoroughly with air to remove loose particles.
- (c) Remove grease, oil, and shop dirt by immersing the work in sufficient quantity of the following solution at 200° + 10°F for 15 minutes or longer, depending upon the degree of contamination:

Trisodium phosphate (see O-S-642) or sodium hydroxide (lye) (see O-S-598) . . . . .	.7 to 10 ounces.
Detergent, nonionic (polyethylene-glycol monoalkylaryl ether) (see MIL-D-16791) . . . . .	.1 fluid ounce.
Water . . . . .	.1 gallon.

- (d) Rinse thoroughly in warm water (at least 120°F).
- (e) If cleaned pipe, tubing, and fittings are not pickled immediately, dry with warm, dry, oil-free air which has been filtered through at least 15-micrometre absolute rated filters (hereafter referred to only as clean air) and protect from dust, dirt, oil and moisture.

5.3 Pickling and hydrostatic tests (prior to installation). Pickling and hydrostatic tests shall be in accordance with the procedures specified herein. Caution shall be exercised by the operator during the pickling process insofar as time of immersion in the acid bath is concerned. The assembly shall remain in the bath only long enough to permit adequate pickling (removal of scale), as determined visually. Due to the nature of the pickling process, this caution is necessary to insure and protect the mechanical properties of the pipe, tubing, or fitting. The position of the tubing in the pickling bath should be changed occasionally to make sure that if gas pockets form they shall not always be at the same location. When hydraulic fluid is used for hydrostatic testing, the assembly shall be degreased just prior to further brazing or welding.

5.3.1 Nonferrous pipe, tubing, and fittings (bronze, copper, copper-nickel, and nickel-copper, not aluminum).

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5.3.1.1 Nonferrous metals other than nickel-copper. The pickling procedure shall be as follows:

- (a) Pickle free from scale in a solution of the following composition at room temperature:

Sulfuric acid, 66 degrees Baumé, specific gravity (sp. gr.), 1.83, conforming to type I, class 1 of O-S-809	. . . . .	.7 to 14 fluid ounces.
Water	. . . . .	.1 gallon.

(Caution: The acid shall always be added carefully to the water.)

Note: If red stains appear, immerse the work briefly in a solution formulated as above but which contains in addition 2 to 4 ounces of sodium dichromate (per gallon) conforming to O-S-595. This solution shall be maintained at a temperature range of 70° to 120°F.

5.3.1.2 Nickel-copper. The pickling procedure shall be as follows:

- (a) Pickle for 20 to 40 minutes in a hot solution (180° ± 10°F) of the following composition:

Hydrochloric acid, 20 degrees Baumé, sp. gr. 1.16 (see O-H-765)	. . . . .	.1/2 gallon.
Cupric chloride	. . . . .	4 ounces.
Water	. . . . .	1 gallon.

- (b) Rinse in hot water.

- (c) Immerse for 5 to 10 minutes in a bath composed as follows (temperature 70° to 100°F).

Sulfuric acid, 66 degrees, Baumé, sp. gr. 1.83 conforming to type I, class 1 of O-S-809	. . . . .	13 fluid ounces.
Sodium dichromate (see O-S-595)	. . . . .	17-1/2 ounces.
Water	. . . . .	1 gallon.

5.3.1.3 Treatment following pickling. The treatment following pickling shall be as follows:

- (a) Immediately after pickling, rinse in a clean, warm water bath.
 (b) Neutralize traces of acid from the pickling operation by rinsing the work in an alkaline bath containing 4 ounces (per gallon of water) of soda ash conforming to O-S-571.
 (c) Rinse thoroughly in fresh, warm water.
 (d) If hydrostatic test will not be performed with water (see 5.3.1.4), dry with clean air.

5.3.1.4 Hydrostatic test prior to installation. The piping assembly shall be subjected to the specified test pressure with tap water, fluid in accordance with MIL-C-81302, or with a hydraulic fluid equal to, or compatible with, that normally used in the system. If leaks occur, they shall be repaired and the assembly repickled and retested. Following a satisfactory test, the solution shall be drained and all openings capped. If water or MIL-C-81302 fluid is used, the assembly shall be blown dry by clean air before openings are capped. The piping assembly shall then be installed up to the components (see section 4 and 5.3).

5.3.2 Ferrous pipe, tubing, and fittings (other than corrosion-resistant steel). The pickling procedure shall be as follows (see 5.3):

- (a) Pickle free from rust and scale in a hot solution (150° ± 10°F) of the following composition:

Sulfuric acid, 66 degrees Baumé, sp. gr. 1.83 conforming to type I, class 1 of O-S-809	. . . . .	.7 to 14 fluid ounces.
Inhibitor (see O-I-501)	. . . . .	Quantity recommended by manufacturer.
Water	. . . . .	.1 gallon.

5.3.2.1 Treatment following pickling. The treatment following pickling shall be as follows:

- (a) Rinse immediately after pickling in a clean, warm water bath.
- (b) Immerse for several minutes in an alkaline bath containing 4 ounces (per gallon of water), of soda ash conforming to O-S-571.
- (c) Rinse by immersing in a clean, warm water bath.
- (d) Immerse in a solution composed of 1 ounce sodium chromate (per gallon of water) conforming to O-S-588 for at least 2 minutes at room temperature.
- (e) If the hydrostatic test is to be performed with hydraulic fluid (see 5.3.2.2), rinse the work with clean water, then dry with clean air.

5.3.2.2 Hydrostatic test prior to installation. The piping assembly shall be subjected to the specified test pressure using a sodium chromate solution (1 ounce sodium chromate per gallon of water) or with a hydraulic fluid equal to, or compatible with, that normally used in the system. If leaks occur, they shall be repaired and the assembly repickled, treated, and retested as specified herein. Following a satisfactory test, the fluid shall be drained and all openings capped. If a water solution has been used, the assembly shall be blown dry with clean air before openings are capped. The piping assembly shall then be installed up to the components (see section 4 and 5.3).

5.3.3 Corrosion-resistant steel pipe, tubing, and fittings. The pickling operation shall be as follows (see 5.3):

- (a) Immerse work for 10 to 15 minutes in a hot solution ($130^{\circ} \pm 10^{\circ}\text{F}$) of the following composition:

Nitric acid (see O-N-350) 13 to 20 fluid ounces.
 Hydrofluoric acid (60 percent) (see
 O-H-795) 1 to 2 fluid ounces.
 Water 1 gallon.

- (b) Rinse in a clean, warm water bath.
- (c) If hydrostatic test will not be performed with water (see 5.3.1.4), dry the piping assembly with clean air.

5.3.3.1 Hydrostatic test prior to installation. The piping assembly shall be subjected to the test specified in 5.3.1.4.

5.4 Flush of installed system for removal of brazing fluxes. The entire piping system, after installation up to, but not including, the components shall be flushed to remove brazing fluxes. Flushing blocks and other jumpers shall be used to connect piping around components not being flushed. Before filling the system with water, a low pressure air test (up to 100 pounds per square inch (p.s.i.)) shall be applied to the piping to check for leaks. Any one of the three following procedures shall be conducted. (The hot flush and hot circulation methods are preferred.) Flush water containing flux residues may be discharged to a sanitary sewer system or overboard if connection to a sewer is not feasible.

- (a) Hot flush with nonrecirculating fresh water for 1 hour while ensuring that the temperature at any part of the system does not go below 110°F .
- (b) As an alternative to the hot flush procedure, a hot recirculating procedure with fresh water may be conducted for a period of 1 hour for systems where such an arrangement is feasible. The system temperature shall be monitored so that no part of the system falls below 110°F . Following the recirculating, the system should be flushed with fresh water for 15 minutes at a minimum temperature of 60°F .
- (c) Cold soak the system for 12 hours using fresh water at a minimum of 60°F . At the completion of the 12-hour soak, systems shall be flushed with nonrecirculating fresh water at a minimum of 60°F for 4 hours.

Under all of the above flux removal procedures, the system shall be full of water so that joints are completely submerged at all times. The minimum flow rate in gallons per minute (gal/min) required for removal of residual brazing flux in piping systems shall be 1.5 times the internal pipe diameter (i.d.) in inches. Upon completion of the flux removal procedure, completely drain the system and dry with air.

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5.5 Hydrostatic test after installation. The entire piping system, after installation up to the components, shall be subjected to the specified test pressure with tap water, fluid in accordance with MIL-C-81302, or with a hydraulic fluid equal to, or compatible with, the fluid normally used in the system. If water has been used, the system shall be drained completely after the test and blown dry with clean air. Components and piping assemblies which passed a hydrostatic test prior to installation need not be retested. However, those connections by which the tested units and assemblies are piped to the system shall require a hydrostatic test.

5.5.1 Hydraulic systems and components which are subject to corrosion shall be preserved in accordance with MIL-P-116. Prior to assembly, all oil films and preservatives shall be removed from those sections which shall be subjected to welding or brazing operations. Assembled systems which have been protected by a preservative fluid in accordance with MIL-H-6083 or MIL-C-23112 shall be thoroughly drained and blown down before adding the system fluid. (See 5.9 for disposal instructions for these fluids.) If the assembled system has not been thoroughly cleaned prior to adding protective fluids, a complete flush (see 5.6) shall be required before putting the system into operation.

5.5.1.1 Assembled systems. Hydraulic systems which are to be left inactive for 6 months or less shall be protected by filling with the system fluid. Those systems which are to be left inactive for an extended period (6 months or more) shall be filled with a suitable preservative fluid. For systems containing petroleum base fluids, the preservative fluid shall conform to MIL-H-6083. For systems containing phosphate ester base hydraulic fluids such as MIL-H-19457 fluids, the preservative fluids shall conform to MIL-C-23112. Adequate vents and tanks shall be provided to compensate for the expanding and contracting fluid and minor system leaks. When the system is preserved with other than the normal system fluid, tags with the following information shall be conspicuously attached:

"This system has been filled with preservative fluid to (specification) on (date). This fluid must be completely blown down and drained before adding system fluid."

5.5.1.2 Components. If system components are not to be installed immediately, preservation shall be in accordance with the requirements specified in 5.5.1.2.1 through 5.5.1.2.3.

5.5.1.2.1 Short term (internal surfaces). For petroleum oil system components, short term preservation of internal surfaces shall be accomplished with fluids conforming to MIL-H-6083. For phosphate-ester system components, internal surfaces shall be preserved with fluids conforming to MIL-C-23112. Preservation with coatings in accordance with MIL-H-6083 or MIL-C-23112 fluids are satisfactory for one year, after which recoating is required. Since these fluids, in small quantities, are compatible with the system operating fluids, draining of residual fluid prior to installation will provide adequate removal of the preservatives. (See 5.9 for disposal instructions for these fluids.) (See 5.6.2 for definition of acceptable liquid contamination.) Complete removal and degreasing is required when brazing or welding is necessary to reassemble the system. A tag with the following information shall be attached to the assembly:

"The interior of this item has been (filled, coated) with corrosion preventative fluid to (specification) on (date). Coatings require replacement one year from date. Prior to assembly, complete removal and degreasing is required if brazing or welding is necessary to assemble components."

5.5.1.2.2 Long term (internal surfaces). For petroleum oil system components, which are expected to be in storage for considerably longer than one year, internal surfaces shall be treated with preservative in accordance with MIL-P-116, type P-2 (MIL-C-16173, grade 2). A tag with the following information shall be attached to the assembly:

"The interior of this item is coated with corrosion preventive compound, grade 2 of MIL-C-16173. This compound must be removed just prior to installation."

Phosphate ester system components in long term storage will require annual treatments with fluid conforming to MIL-C-23112. The assembly shall be tagged as specified in 5.5.1.2.1.

5.5.1.2.3 External surfaces. For external surfaces of petroleum oil and phosphate ester fluid system components requiring preservation, coatings in accordance with MIL-P-116, type P-1 (MIL-C-16173, grade 1) or type P-19 (MIL-C-16173, grade 4) shall be applied where the preservative would not have to be removed for system operation, or where preservative removal by scraping or solvent action would not damage the part or equipment. Where removal of the preservative will be required, such as when the preservative would otherwise be in contact with the system fluid, a coating conforming to MIL-P-116, type P-2 or type P-19 shall be applied. A tag with the following information shall be attached to the assembly:

"The exterior of this item has been coated with corrosion prevention compound to (specification), (coating type or grade). Removal of this compound (is, is not) necessary prior to installation."

5.5.1.3 Preservative removal. The coatings in accordance with MIL-P-116, type P-2 and P-19 and fluid films in accordance with MIL-H-6083 and MIL-C-23112 can be removed by cleaning solvent trichlorotrifluoroethane conforming to MIL-C-81302, type II. Surfaces cleaned with solvent will be left unprotected and shall be immediately wetted with the system fluid unless welding or brazing will be required to reassemble the system. For preserved petroleum system components which will not require degreasing, cleaning oil conforming to MIL-C-15348 will also adequately remove type P-2 preservative. Immediately after using oil conforming to MIL-C-15348, the component shall be wetted, and the system filled shortly thereafter, with the system operating fluid. When solvents conforming to MIL-C-81302 are used to remove protective coatings, complete removal of the solvent is required to avoid subsequent contamination of the system operating fluid. Furthermore, the use of these solvents requires that adequate ventilation be provided to avoid excess inhalation of fumes by personnel. (See 5.9 for disposal instructions for these fluids.) (See 5.6.2 for safety precautions.)

5.6 System flushing. Installed piping shall be flushed before being put into operation. Flushing fluids shall be limited to either type II cleaning compound in accordance with MIL-C-81302, or the system operating oil, unless otherwise specified or approved by the contracting officer or ship supervisor. Flow rates shall be sufficient to maintain the Reynolds number specified in 5.6.1. Flushing shall be performed on the entire system, but may be accomplished piecemeal on those circuits which can be independently cleaned and isolated. Complex systems may be divided into parts in order to assure the required flow rate in every part of the system during flushing. Hydraulic pumps, motors, complex valves and devices that restrict flow or could be damaged by contaminants dislodged during flushing shall be removed from the circuit; and temporary pipe, flushing blocks, tube, or hose substituted in their place. A temporary filter, conforming to MIL-F-24402, or equal, shall be installed in the circuit being flushed and clean filter elements installed as necessary to keep the pressure drop across the filter within the specified limits. Filter bypass valves shall not be used. The flushing fluid shall be filtered through a filter conforming to MIL-F-24402 as the system is filled. Flushing shall be performed in the same direction as the normal fluid flow during system operation. When the normal system flow may be in either direction, such as in actuator lines, flushing these lines in both directions is required. Circuits having a rise in the direction of flow shall require reversing the direction of the flush to insure that the system is clean in both directions. When flushing is done in both directions, flushing in the direction of normal flow should be done last. Components such as reservoirs, accumulators, and cylinders shall be flush rinsed with a high velocity jet stream or wiped as required to attain the specified cleanliness. Pistons must be removed from cylinders and accumulators for cleaning. Where wiping is necessary, lintfree toweling (NSN 7920-00-044-9281, or equal) shall be used. Components cleaned in the shop prior to

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installation and properly preserved, sealed, and stored may be connected to the piping, after the pipe is flushed, without further cleaning (see 5.5.1.2). Samples for component contamination tests shall be taken from the final cleaning fluid. Reservoirs and tanks coated internally with paint or plastic shall be checked for compatibility with the cleaning fluid prior to use. Reasonable technical competence must be exercised in planning the flushing of a system. (MIL-HDBK-407 is most valuable for background information.) Unless otherwise specified by the contracting officer or the ship supervisor, flushing shall continue until the fluid entering the temporary filter meets the class 10 requirements of NAS 1638 for particulate contamination. Prior to termination of flushing the system piping, the water content of the flushing fluid shall be determined when the flushing fluid is oil. The water content shall not exceed 0.05 percent for any single sample. The average of the samples taken prior to terminating the flush shall not exceed 0.03 percent for any system or circuit thereof. When flushing with MIL-C-81302 solvent, any water from the system will be floating on the top of the solvent in the static condition. After flushing and reassembly, the system shall be filled with clean water-free fluid which meets the applicable fluid specification and has been final filtered through a filter in accordance with MIL-F-24402.

5.6.1 Procedure for solvent flush. Unless otherwise specified by the contracting officer or ship supervisor, flushing with fluid conforming to type II of MIL-C-81302 shall be required for all Naval surface ship hydraulic systems. The flow rate shall be such that the Reynolds number (Re) is not less than 100,000 in any pipe of the circuit being flushed. Pumps used for flushing service shall be suitable for the solvent used and capable of the flow rates shown in table I. The solvent should not be allowed to reach boiling temperature (117.6°F) during flushing to preclude pump damage and flow interference. Operation of the system hydraulic pumps, motors and other components filled with flushing solvent is prohibited. The entire flushing procedure (including dry-out) shall not exceed a five-day period for any system, or circuit of a system, which uses seals of ethylene propylene, butyl, silicone rubber, or unknown sealing materials. Several seals of these materials in each system should be visually examined, after dry-out, for abnormal swelling. Completion time may be extended if the system uses seals of nitrile, fluorocarbon rubber, or other materials known to have long-term compatibility with the solvent. After draining the solvent upon completion of the flush, the system shall be dried with filtered dry warm air, 140° ± 10°F. To insure that all the solvent has evaporated, the entire pipe system shall reach a minimum temperature of 120°F. All low parts of the piping and possible liquid traps shall be checked (on the bottom side) with a contact pyrometer to insure that the minimum temperature has been reached before warm air flow is discontinued.

Table I - Minimum flow rate for flushing with
fluid (Re=100,000)^{1/}

Pipe size - inside dia- meter	Trichloro- trifluoro- ethane (MIL-C-81302)	Pipe size - inside dia- meter	Trichloro- trifluoro- ethane (MIL-C-81302)
(Inches)	(Gal/min)	(Inches)	(Gal/min)
To 0.5	7	2.5 to 3.0	40
0.5 to 0.75	10	3.0 to 3.5	46
0.75 to 1.0	13	3.5 to 4.0	52
1.0 to 1.25	16	4.0 to 5.0	66
1.25 to 1.50	20	5.0 to 6.0	79
1.5 to 2.0	26	6.0 to 7.0	92
2.0 to 2.5	33	7.0 to 8.0	105

^{1/} Flow rate calculated for fluid densities and viscosities at 80°F.

5.6.1.1 Special handling of fluids. Trichlorotrifluoroethane is considered a safe cleaning agent and is exempt from special controls of the Clean Air Act of 1970 as its vapor is not photochemically reactive. However, due to its unique properties, the following precautions must be taken:

- (a) The solvent has a low boiling point (117.6°F), a high evaporation rate and a high vapor density (6-1/2 times heavier than air). When used in spaces where spillage could occur or the fluid is exposed to the atmosphere, forced ventilation of the space is required with the exhaust duct placed at the lowest level possible in the space being ventilated. The American Conference of Governmental Industrial Hygienists (ACGIH) and the Occupational Safety and Health Act (OSHA) in table G-1, paragraph 1910.93, Rules and Regulations have set a Threshold Limit Value (TLV) (a concentration of solvent vapor in air to which nearly all workers may be repeatedly exposed day after day without adverse effect) for trichlorotrifluoroethane of 1000 parts per million (p/m). Prolonged breathing of higher concentrations of the solvent shall be avoided as narcosis, anoxia, anesthesia or intoxication can be experienced by persons so exposed. Persons having known disqualifying factors such as pre-existing liver disease, alcoholism, renal and heart diseases, obesity and diabetes shall not be assigned to work with the solvent. All persons required to work in confined spaces where liquid solvent or vapor is present shall be instructed as to the nature of the hazards involved in accordance with paragraph 1926.21 of OSHA Rules and Regulations.
- (b) Trichlorotrifluoroethane is a nonflammable cleaning agent. However, the fluid or vapor shall not be exposed to high temperatures or flame. The solvent begins to decompose in trace quantities at 600°F and increases with temperature rise. The products of decomposition are toxic and corrosive; one of the products is phosgene (carbonyl chloride) gas which has a TLV of 0.1 p/m. Welding in spaces where solvent vapor is present is prohibited.
- (c) Synthetic rubber gloves shall be worn when handling the solvent as it dissolves natural oils and dry chapped hands may result.
- (d) In confined spaces the contamination level of the air shall be monitored by use of a total Hydrocarbon Analyzer or an equivalent instrument. Hydrocarbon Analyzers for this purpose are National stock numbers (NSN) 6630-00-442-6409, 6630-00-442-6410 and 6630-00-462-9133. When drying out the cleaned piping system with warm air the air-solvent vapor effluent shall be exhausted outside for safe dispersal and the area posted "Hazardous Vapors - Keep Clear".
- (e) MIL-HDBK-406 provides a comprehensive listing of the solvent characteristics (compatibility, miscibility, solubility, etc.) relating to other materials.
- (f) After use, the solvent shall be collected and recovered by distillation, and stored in labeled clean containers or bulk storage for further use. Where stills are not available, the solvent shall be stored for redistillation elsewhere. Dumping of any trichlorotrifluoroethane into any body of water is prohibited.

5.6.2 Procedure for oil flush. Flushing with the system operating fluid, or an otherwise approved (by the contracting officer or ship supervisor) oil, shall be performed at flow rates which will provide a Reynolds number of at least 4000 in every pipe of the circuit being flushed. For those systems in which the operating fluid is in accordance with MIL-L-17331, alternative flushing oils which conform to MIL-L-17672 are allowed in order to more easily achieve the required turbulent flow. Upon completion of flushing with oils other than the system operating fluid, the system shall be completely drained and blown free of flushing fluid, and the system refilled with operating fluid. Depending upon the complexity of the system and the amount of flushing oil left behind, a second or third drain-and-fill sequence may be required to provide minimal acceptable liquid (not solid) contamination. Acceptable liquid contamination shall be that amount which could be tolerated in a fluid without causing failure of the fluid in any of the tests required by the applicable fluid specification.

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- # 5.6.3 Flushing fluid samples. Unless otherwise specified by the contracting officer or ship supervisor, samples shall be taken from the bottom side of the pipe within five feet of the inlet of the flushing filter during full flow. The size of each sample drawn shall not exceed one liter and shall include the fluid and contaminants trapped by the valve and adapter during the preceding 5-minute flushing period. (Open the valve to purge the valve entrance of contaminants, close the valve and wait 5 minutes and draw the sample.) The entrance to the sampling port shall be flush with the inner circumference of the pipe, and the valve connector (adapter) shall not extend into the pipe beyond the inner surface of the pipe. For taking samples from the system during flushing, diaphragm (packless) valves are recommended. Where the hydraulic system is equipped with sampling valves, samples may be taken from those valves, in lieu of the location specified above.
- # 5.6.3.1 Sample analyses. The test method for determination of particulate contamination shall be in accordance with SAE ARP 598, or an automatic particle counter capable of being calibrated in accordance with ANSI B93.28. Directions in the manual for the respective instrument shall be followed. Water content shall be determined by ASTM D1744 method, or with commercially available automatic water-analyzing equipment capable of accurately determining water content down to 0.01 percent, such as the Beckman KF4 Aquameter.
- # 5.7 Capping and sealing open ends. Open ends shall be capped or sealed to preserve cleanliness of assemblies for stowage, transit, or installation operations. All caps shall have the same grade of cleanliness as the pipe or assembly to be sealed. The use of water-proof tape conforming to PPP-T-60, electrical plastic tape, or other compatible tape is allowed to hold caps in place. However, the use of any tape as a cap is prohibited. Caps shall be made in accordance with MIL-C-5501 with the following exceptions:
- (a) Materials. Materials used in the manufacture of protective caps shall be of high quality, compatible with the fluid used in the capped system. Materials conforming to commercial specifications may be used provided they pass the tests specified below and the torque test specified in MIL-C-5501. The use of commercial specifications will not constitute waiver of inspection. Materials shall not chip or shred during normal usage. Plastics and elastomers may be used provided they pass the tests required herein.
 - (b) The requirements for durability, repeated assembly test, protection after installation, and drop and sealing tests specified in MIL-C-5501 shall not apply. In lieu thereof the tests specified in (c) and (d) herein shall apply.
 - (c) Sealing (first article inspection). A fitting, assembled and tested as described in (d), shall then be immersed in the fluid to be sealed at a temperature of $160^{\circ} \pm 2^{\circ}\text{F}$ and held for 5 minutes. No leakage shall result.
 - (d) Sealing (quality conformance inspection). Samples selected shall have the sealing surface wet with the fluid to be sealed, assembled to a fitting connected to an air supply of 2 pounds per square inch minimum air pressure, and immersed in water or other suitable fluid for a period of at least 30 seconds and not more than one minute. No leakage shall occur. Applied torque shall be as specified in MIL-C-5501. Test shall be conducted at room temperature. Cloth shall not be used. Wood inserts (plugs) shall not be used; however, wooden blocks bolted over the flanged ends may be used. The open ends shall remain capped until immediately before connecting to the equipment for which pipe is intended. Unthreaded pipe ends shall be capped with unthreaded caps.
- # 5.7.1 In systems using petroleum base hydraulic fluid, plastic or rubber material may be used for caps, with the exception of butyl rubber. The pipe end shall be completely covered with sheet plastic or rubber (except butyl) and secured to the pipe outside diameter with electrical plastic tape or some other compatible tape. These materials may be used for threaded and unthreaded closures.

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5.7.2 In systems using phosphate ester type fire-resistant hydraulic fluid, butyl rubber and compatible plastics may be used for caps. The pipe end shall be completely covered with compatible sheet plastic or butyl rubber, and secured to the pipe outside diameter with a compatible tape.

5.8 Ferrous systems (except corrosion-resistant steel). When specified by the command or agency concerned, ferrous piping, tubing, and fittings shall be phosphate coated, prior to installation, in accordance with the specified type and class of MIL-P-16232.

5.9 Disposal of waste materials used in cleaning. The following materials and solutions containing these materials shall not be discharged overboard. They shall be retained in containers and held for shore disposal:

- (a) Sodium chromate.
- (b) Sodium dichromate.
- (c) Lubricating oil.
- (d) Cleaning oil.
- (e) Corrosion preventive, solvent cutback, cold application.
- (f) Trichlorotrifluoroethane.

Other materials may be discharged overboard after neutralization to a pH of 6.8-8.5. If this is not possible, they shall be retained in containers for shore disposal. For more detailed instructions and information, see NAVSHIPS 0901-003-0001, Chapter 9003.

6. NOTES

6.1 THE MARGINS OF THIS STANDARD ARE MARKED "#" TO INDICATE WHERE CHANGES (ADDITIONS, MODIFICATIONS, CORRECTIONS, DELETIONS) FROM THE PREVIOUS ISSUE HAVE BEEN MADE. 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 AND RELATIONSHIP TO THE LAST PREVIOUS ISSUE.

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