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APPENDIX G - DoD CONTRACTS

HYDRAULIC POWER TRANSMISSION REQUIREMENTS

(June 1999)

I. DESIGN

A. Hydraulic Fluid

Hydraulic fluid, for systems not accumulator-loaded or for accumulator-loaded systems with pressures equal to or less than 600 p.s.i., shall be petroleum base of a type or grade selected from Mil. Spec. MIL-H-17672. For deck winch systems, the fluid shall be as specified in the applicable equipment specification. For accumulator-loaded systems (except catapults, jet blast deflectors, integrated catapult control station, barricade erecting equipment, and arresting gear) with pressures that exceed 600 p.s.i. with an operating temperature range from 30 degrees F to 160 degrees F, the hydraulic fluid shall be fire-resistant phosphate ester base in accordance with Mil. Spec. MIL-H-19457 C Amendment 1. Hydraulic fluid for catapults, jet-blast deflectors, integrated catapult control stations, LSO station, barricade erecting equipment and weapons elevators shall be a water base fluid in accordance with Mil. Spec. MIL-H-22072 C. Hydraulic fluid for the arresting gear shall be an ethylene glycol base fluid in accordance with MIL-H-5559. For accumulator-loaded systems with pressures higher than 600 p.s.i., and operating temperatures below 30 degrees F, the selection of a suitable fluid shall be referred to the Shipbuilder. Each system shall be designed to use the selected fluid with consideration given to the effects of viscosity changes within the range of operating temperatures.

Hydraulic components shall be designed and installed so that systems using fire-resistant hydraulic fluids will not be contaminated by petroleum base fluids.

B. Pressure and Piping Design

Hydraulic systems shall be designed for an operating pressure not in excess of 3,000 psi and total pressure under hydraulic shock not exceeding 4,500 psi unless otherwise specified in the purchase order or in applicable equipment specifications.

Design pressure for return piping between a component and its cut-out valve or between a component and a restrictor in the line shall be equal to the system design pressure; or, in the case of overhauling loads, the sum of the overhauling pressure and the system design pressure.

The design pressure for piping, valves, and fittings in return lines not subject to supply pressure and overhauling pressure shall be based on fluid supply tank pressure plus expected pressure drop between operating equipment, cut-out valve, or restrictor and the fluid supply tank.

All components, piping, and fittings of hydraulic systems shall be designed to withstand hydraulic shock. Total pressure under hydraulic shock shall not exceed one and one-half times the system operating pressure unless otherwise specified herein or in applicable equipment specifications.

For purposes of design, the increase in pressure due to hydraulic shock in the catapult hydraulic systems shall be calculated in accordance with Mil-Std. MIL-STD-777. For other hydraulic systems it shall be calculated using the following formula:

Ps = C(V-15)

Where:

Ps = pressure increase due to hydraulic shock, psi

V = maximum velocity of fluid flow in pipe, feet per second

C = 60 for petroleum base fluids

C = 70 for water base hydraulic fluids

C = 90 for phosphate ester fluids

The increase in pressure due to hydraulic shock, Ps, shall be added to the operating pressure and when this total pressure is in excess of the system design pressure, the total pressure shall be used to determine the proper wall thickness of piping.

C. Fluid Velocity

Except for the catapult hydraulic systems, high pressure piping shall be of a sufficient diameter to limit velocity of hydraulic fluid to 20 feet per second. For the catapult hydraulic system, see Mil. Std. MIL-STD-777.

The fluid velocity in pump suction lines having no positive head shall be limited to about four feet per second (see section II.A.).

D. Arrangements

The use of piping and pipe connections shall be minimized by manifolding valves with related functions.

Threaded fastenings shall be as required by Appendix B. The use of set screws shall be avoided.

Where necessary, hydraulic auxiliaries shall be provided with drip pans fitted with means for draining the pan.

Where necessary, moving parts of systems shall be fitted with covers or guards to prevent damage to equipment and injury to personnel.

Hydraulic systems shall have the necessary pressure gages and means for bleeding, venting, replenishing, and draining.

Vents and replenishing connections to system components shall be located as high as practicable to avoid air pockets.

If a stop valve is installed in the replenishing and vent line, protection shall be provided against the inadvertent application of destructive pressure when the stop valve is closed.

Means shall be provided for access to, and cleaning of, fluid supply tanks and for drawing off water which may be present in the tanks. A connection shall be fitted to permit venting air-loaded supply tanks while filling.

Systems, except for steering gear, shall be arranged so that the pump normally starts without load.

Aircraft elevator main hydraulic pump controls shall be designed to start the pumps at reduced load as approved by the Purchaser.

E. Materials

Use of cast iron in hydraulic systems other than that permitted in MIL-P-17869 shall be submitted to the Shipbuilder for approval.

Cadmium plating or zinc plating shall not be applied to any part of hydraulic equipment which may be in contact with hydraulic fluid.

Cadmium plating or zinc plating shall not be used on surfaces of internal parts which are in moving wearing contact during operation. For further restrictions on cadmium plating, see Appendix B.

System components shall be painted only where necessary for preservation. Paint in accordance with Mil. Spec. MIL-P-23236, class 1, 2 or 4. Mil. Spec. MIL-C-22750 shall be used on hydraulic components for systems which use phosphate ester fluid.

For surfaces which come in contact with water based hydraulic fluid, the use of aluminum is not allowed.

II. COMPONENTS

A. Hydraulic Pumps and Motors

Hydraulic pumps and motors shall be of piston or vane type, and shall comply with Mil. Spec. MIL-P-17869.

To preclude cavitation in hydraulic pumps, systems shall be designed to provide an adequate supply of fluid to the pump. Closed loop systems shall provide for replenishing the pump by means of an accumulator and shuttle valve if the inlet line will be subject to rapid pressure pulsations or if large quantities of replenishing fluid are required for short periods of time.

B. Rams and Hydraulic Cylinders

These devices shall be designed to be as simple as possible consistent with the function for which they are intended. Moving members of rams and cylinders shall be sufficiently wear resistant to insure long service life and shall be of such design, application, and material that corrosion of the exposed surfaces will not occur. Pistons and rods that slide in and out of cylinders shall be fitted with a wiper. Leakage, drain and air bleeder connections shall be included as necessary. Where necessary, cylinder design shall include internal buffers or dash pots as an aid in decelerating parts attached to the piston rod or ram. Seals shall become more effective with an increase in pressure. Piston rings, or equivalent shall not be used as a primary seal. Wherever possible, the arrangement of the rod and cylinder should be such that the rod is withdrawn into the cylinder when the equipment is secured, to protect the sliding surface of the rod.

C. Accumulators

Accumulators shall be used where necessary to reduce peak power requirements and to control hydraulic pump operation. Accumulators, except aircraft elevator hydraulic system accumulators, shall be of a piston, bag, or diaphragm type designed to withstand five times the operating pressure of the hydraulic system. Accumulators may be charged with air, except for bag-type accumulators subjected to pressure higher than 600 psi, in which case the Shipbuilder approval shall be obtained. Provisions shall be made to prevent extrusion of the bag or diaphragm through the fluid pressure connection.

Accumulators shall be designed in accordance with Section VIII of ASME Boiler and Pressure Vessel Code, except that welded fabrication and inspection shall be in accordance with Appendix K-DoD.

D. Tanks

Pressure tanks and fluid reservoirs shall be of copper, copper base alloy, corrosion resistant steel, or steel construction. The inside of steel pressure tanks and steel fluid reservoirs in water based hydraulic systems shall be coated using a 3 coat epoxy system in accordance with MIL-P-24441.

Unless otherwise specified, the inside of medium steel tanks and medium steel reservoirs that contain phosphate ester fluid shall not be coated. All

surfaces to be coated shall be mechanically cleaned, dry, and free from oil, grease, paint, dirt, and other contaminants, and shall be abrasive blasted to bare metal.

All weld spatter and welding flux shall be removed before the coating process. When it is necessary to stress-relieve welded tanks, this heat treatment shall be accomplished prior to cleaning.

All steering gear tanks and reservoirs shall be left uncoated.

Reservoirs and service tanks shall be capable of withstanding, without leakage, an internal pressure of 8 psi. When separate reservoirs are provided to serve as stowage tanks, their capacity shall not exceed 125 percent of the total amount of fluid required to fill the active system. Reservoirs and tanks shall be designed and constructed to prevent the entrance of any foreign matter. Filling and breathing pipes on reservoirs shall be arranged to prevent fluid spillage under roll and pitch conditions specified in Appendix B. Breathing pipes shall be terminated near exhaust ventilation terminals if practicable. Reservoirs shall be provided with reliable means for determining the fluid level, arrangements for cleaning and draining, and with baffle plates to minimize aeration and cavitation. Return lines, other than drain lines, shall terminate below the fluid level and shall be separated from the pump suction lines to prevent fluid flowing from the return lines directly back to the pump.

E. Filters

Filters shall be readily accessible, and all filter elements shall be removable for service and inspection without disconnecting the attached pipe or dismounting the filter housing. Frequency of servicing shall be indicated on a label plates attached to the filter. Filters employing earths or clays shall not be used. Filter elements shall comply with MIL-F-24402, MIL-F-8815, or MIL-F-5504, and shall be capable of removing all particles 15 microns or greater in size. New filter assemblies shall be equipped with differential pressure gages.

Breather pipe caps shall have removable air filter screens.

Filler pipes for tanks and liquid reservoirs shall include a removable filter screen of 180 mesh or finer.

Closed loop type systems -- A full flow filter shall be installed in the discharge line and a strainer in the suction line of each replenishing pump. Filter cases shall have built-in by-pass valves set to open when the pressure drop across the filter element reaches the value recommended by the filter element manufacturer. These by-pass valves shall be capable of handling the entire replenishing pump capacity.

Other than closed loop systems -- A filter shall be installed in the discharge line and a strainer in the suction line of each pump. Filters shall be full flow where the volume of flow allows a reasonable size filter, but where an excessively large filter would be required, the Shipbuilder will consider use of a partial flow type. Provision shall be made to allow full flow by-pass of the filters when the pressure drop across the filter elements reaches the value recommended by the filter element manufacturer.

F. Valves

Directional and volume control, check, pilot and servo valves for hydraulic system shall be designed for minimum resistance to flow when in the operating position. Valves may be pilot operated to maintain operating devices such as solenoid, cams, and levers at a minimum size. Provision shall be made for locking adjustable valves at service adjustment to prevent tampering. No valve shall operate improperly because of back pressure or surges. Valve operation shall be such as to prevent detrimental surges in the hydraulic system. All valves shall be permanently marked to indicate proper connection in the system, and directional arrows shall be used as appropriate. The force to manually operate control valves shall not exceed 15 pounds applied to the rim of the operating wheel or the end of the operating lever. All valves in a system shall be adequately supported. Valves shall be mounted using cap screws or bolts extending through or into the valve body. Lug mounting of valves will not be permitted.

By-pass or unloading valves shall be designed to operate with a minimum pressure drop across the valve. Throttling shall be minimized.

Pressure control valves (including relief, check, unloading, back pressure, and sequence valves) shall be damped to eliminate hydraulic squeal and chatter, at all rates of flow up to the maximum design rate. Relief valves shall be accurate within nine percent of setting and shall reseat at not less than 85 percent of setting. Relief valves shall be adjustable. Relief valves shall be set to begin opening at 110 percent of design pressure unless otherwise specified.

Where practicable, pump discharge relief valves in open loop systems shall discharge directly to the supply tank or reservoir.

High pressure valves on the air side of accumulators shall be of a type capable of preventing a shock wave from being produced when rapidly opened. Cams for operating cylinder deceleration valves shall be designed to provide positive motion of the valve in both directions.

In general, passages through cutout valves shall be equivalent in area to the connected piping.

G. Coolers

Supplemental cooling, if provided, shall be designed to maintain the hydraulic fluid temperature below the limits specified herein. Air to oil type heat exchangers may be used when specifically approved herein or in applicable equipment specifications.

Heat exchangers shall conform to MIL-C-15730.

The following requirements apply to all heat exchanger installations:

Provision shall be made for automatically stopping the heat exchange process when the hydraulic fluid temperature drops below the manufacturer's recommendations for most efficient operation of the pump, motor, and other devices in the system. Arrangements shall be provided for preventing excessive pressure drops in the event that the exchanger becomes clogged. Valves and piping arrangements shall permit isolating heat exchangers and by-passing hydraulic fluid. The design shall include easy access for servicing and repair.

H. Gages

A pressure gage shall be provided in each system and located for good visibility and for safety of personnel.

All pressure indicators shall be of the safety case design to prevent their becoming a personnel hazard should leakage or rupture of the pressure element occur. Pressure indicators shall be in accordance with MIL-G-18997, Size 3-1/2 inch through 8-1/2 inch.

The maximum scale reading on pressure indicator dials shall be 1-2/3 times the normal system operating pressure. When the scale range thus determined does not coincide with a scale range tabulated in the applicable gage specification, the next higher range listed in the specification shall be selected.

Dampers shall be used in any system where pressure pulsations prevent accurate gage readings, and on air and hydraulic pneumatic systems above 250 psi.

Pressure pulsation dampers shall be in accordance with Mil. Spec. MIL-D-2940. For gas service, dampers shall be located between the gage valve and the root connection to prevent the occurrence of compression ignition in the gage. Compression ignition may result from sudden impact or shock pressures initiated by the opening of the gage valve. For liquid service, the damper may be located, as convenient, in the gage line.

Gage connections shall be in accordance with Mil. Spec. MIL-F-21467, Figure 4, for 1/4-inch tubing size.

I. Rotary Actuators

Rotary actuators shall comply with Mil. Spec. MIL-A-24533.

III. TESTING REQUIREMENTS

Unless otherwise specified, all rams, cylinders, accumulators, valves, fittings, and tanks used in hydraulic systems shall be tested hydrostatically before installation to 150 percent the system design pressure except in the case of components where overhauling loads are aided by system pressure, in which case test pressure shall be 150 percent the summation of the overhauling pressure and the system design pressure. All parts shall withstand these pressures without leakage. This test is to be conducted before the final cleaning.

Hydraulic fluid tanks which are not subject to pressure shall be proven tight by filling them with fluid under a pressure sufficient to demonstrate fluid tightness.

The test fluid shall be completely removed from the tanks upon completion of the test if it is other than the operating fluid.

Prior to shipboard tests, the fluid filters in the hydraulic system shall be cleaned and the filter elements renewed.

Rams, cylinders, accumulators, valves, piping, fittings, and tanks shall be tested after installation, for tightness and strength, to 150 percent the operating pressure, except in the case where overhauling loads are aided by system pressure, in which case the test pressure shall be 150 percent the summation of the overhauling pressure and the system operating pressure.

Test pressures shall be developed by means other than the system pumps if the system pumps cannot safely develop the required pressure. When hydrostatically testing axial piston pumps, or installed closed loop systems containing this type of pump, both pump ports shall not be pressurized simultaneously.

Unless otherwise specified, hydraulic systems shall be designed and installed so that the temperature of the fluid anywhere in the system shall not rise more than 70 degrees F. above the ambient temperature when the systems are subjected to the operational test specified herein or in applicable equipment specifications. The operational test shall be conducted when the ambient temperature is between 40 degrees F. and 90 degrees F. The fluid temperature in closed loop systems shall be measured in the pump case drain line as well as in the main pipes. This requirement shall be met preferably without the use of fluid coolers.

IV. GASKETS AND PACKING

Gaskets for use in systems containing petroleum base fluids shall be in accordance with Mil. Spec. MIL-R-83248 type I. Gaskets for use in systems containing phosphate ester fluid shall be in accordance with Mil. Spec. MIL-G-22050 or Mil. Spec. MIL-R-83248 type I. Gaskets for use in systems containing water base fluids shall be in accordance with Mil. Spec. MIL-G-22050 or Mil. Spec. MIL-R-83248 type I. Preformed packing, petroleum hydraulic fluid resistant, shall be in accordance with Mil. Spec. MIL-P-25732.

Where phosphate ester type hydraulic fluids and lubricants are used, the vendor shall verify the compatibility of materials used for seals, diaphragms, etc., with the fluid used.

Packing material for use in systems containing phosphate ester fluid may be tetrafluoroethylene (TFE) braided yarn in addition to that required by MIL-STD-777. TFE braided yarn shall be Synthepack Style 8922 PTFE lattice braid yarn manufactured by Garlock Mechanical Packing Division of Colt Industries or equal.

V. DRAWINGS

American Standards Association Standard ASA Y32.10 shall be used for hydraulic symbols on hydraulic system diagrams.