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MILITARY SPECIFICATION

HYDRAULIC EQUIPMENT, ORDNANCE SHIPBOARD

(GENERAL SPECIFICATION FOR)

1. SCOPE

1.1 Scope.- This specification is intended to cover the general requirements applicable to all hydraulic equipments for shipboard use under the technical control of the Bureau of Ordnance . Requirements and information which apply to individual equipments designed for specific purposes will be furnished in the form of detail procurement specifications or will be included directly in the procurement documents which are issued with invitations to bid. The requirements contained in this specification shall apply to shipboard ordnance hydraulic equipments when directly referred to in the detail procurement specification of procurement documents

1.2 Classification.- The types (classification) of equipment shall in each case be as required by the detail procurement specification.

2. APPLICABLE DOCUMENTS

2.1 The following specifications, standards, drawings, and publications, of the issue in effect on date of invitation for bids, shall form a part of this specification to the extent specified herein:

SPECIFICATIONS

FEDERAL

FF-B-171 - Bearings, Ball, Annular, (General Purpose).
FF-B-185 - Bearings, Roller, Cylindrical; and Bearings, Roller, Self-Aligning.

NN-B-621 - Boxes, Wood, Nailed and Lock-Corner.
NN-P-515 - Plywood, Container Grade.
QQ-P-416 Plating, Cadmium (Electrodeposited).
QQ-Z-325 Zinc Plating (Electrodeposited).
LLL-B-631 - Boxes; Fiber, Corrugated (For Domestic Shipment) .
LLL-B-636 - Boxes; Fiber, Solid (For Domestic Shipment).
PPP-B-601 - Boxes, Wood, Cleated-Plywood.
PPP-B-676 - Boxes; Set-Up, Paperboard.

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JAN-P-106 - Packaging and Packing for Overseas Shipment - Boxes; Wood Nailed.
JAN-P-108 - Packaging and Packing for Overseas Shipment - Boxes, Fiberboard (V-Board and W-Board), Exterior and Interior.
JAN-P-120 - Packaging and Packing for Overseas Shipment - Cartons, Folding, Paperboard.
JAN-B-121 - Barrier - Materials, Greaseproof'.
JAN-P-125 - Packaging and Packing for Overseas Shipment - Barrier-Materials, Waterproof, Flexible.
JAN-P-127 - Packaging and Packing for Overseas Shipment - Tape, Adhesive, Pressure-Sensitive, Water-Resistant.
JAN-P-133 - Packaging and Packing for Overseas Shipment - Boxes, Set-up, Paperboard
MIL-A-140 - Adhesive, Water-Resistant, Waterproof Barrier-Material.
MIL-S-901 - Shockproof Equipment. Class HI (High-Impact), Shipboard Applications, Test for.
MIL-E-2036 - Enclosures for Electric and Electronic Equipment (Naval Shipboard Use).
MIL-S-5049 - Scrapers; Hydraulic Piston Rod.
MIL-A-5498 - Accumulators, Aircraft Hydraulic Pressure.
MIL-F-5504 - Filters, Hydraulic, Aircraft.
MIL-H-5511 - Hose; Aircraft, Hydraulic, Pneumatic, Fuel and Oil Resistant.
MIL-P-5514 - Packings; Installation and Gland Design of Aircraft Hydraulic and Pneumatic (General Specification for).
MIL-P-5516 - Packings and Gaskets; Hydraulic, Aircraft.
MIL-O-5606 - Oil; Hydraulic, Aircraft, Petroleum Base.
MIL-P-6889 - Primer; Zinc-Chromate, For Aircraft Use.
MIL-Z-17871 - Zinc-Coating (Hot-Dip Galvanizing).
MIL-C-15111 - Cylinders, Compressed Gas (Seamless, Non-Shatterable, for Storing Compressed Air).
MIL-C-16173 - Corrosion Preventive, Solvent Cutback, Cold Application.

MIL-T-17113 - Tests; Shock, Vibration, and Inclination (for Electronic Equipment) General Specification for.
MIL-C-17711 - Coating, Chromate, for Zinc Alloy Castings and Hot-dipped Galvanized Surfaces.
MIL-C-17795 - Cleaning and Protecting Integral Piping for Oil Hydraulic Power Transmission Equipment.
MIL-P-20085 - Packing, Sheet, Plant - or Animal - fiber.

NAVY DEPARTMENT

MIL-C-18487 - Compound, Gun-slushing
51 F 21 - Fluid, Power-Transmission.
51 F 23 Fluid, Hydraulic,

BUREAU OF ORDNANCE

NAVORD OS 6341 - Miscellaneous General Design Requirements

STANDARDS

MILITARY

MIL-STD-129 - Marking for Shipment and Storage.

BUREAU OF ORDNANCE

NAVORD OSTD 2 - Method of Marking Ordnance Material.
NAVORD OSTD 52 - Painting of Ordnance Material.
NAVORD OSTD 60 - Six and Ten Splined Holes and Shafts.
NAVORD OSTD 63 - Piping, Tubing, and Fittings for Hydraulic Equipment.
NAVORD OSTD 78 - Preparation of Ordnance Classification of Defects (NAVORD OCD's)
NAVORD OSTD 599 - Drafting Practice.

AMERICAN STANDARDS ASSOCIATION

ASA B-5.15 - Involute Splines.

PUBLICATIONS

ORDNANCE PAMPHLETS

OP 1 -- Preparation of Ordnance Publications.
OP 400 - General Instructions for the Design, Manufacture, and Inspection of Naval Ordnance Equipment.

ORDNANCE DATA

NAVORD OD 3000 - Lubrication of Ordnance Equipment, Including Power Transmission (Hydraulic) Fluids, Recoil and Related Flu.ids, Cleaning and preserving Materials, Miscellaneous Materials, and their uses.
NAVORD OD 8999 - Provisioning Requirements for Initial Spares .

NATIONAL BUREAU OF STANDARDS

Handbook H28 - Screw Thread Standards for Federal Services.

(Copies of Specifications, Standards, Drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3* REQUIREMENTS

3.1 Materials.-. All materials used in hydraulic equipments shall be of high quality suitable for the purpose, and shall be specified In accordance with the policy outlined In sections on materials, specifications, and standards in Standard NAVORD OSTD 599 and Pamphlet OP 400.

3.1.1 Metals.-

3.1.1.1 Corrosion Protection.- Metals which are not of a corrosion-resisting type, unless in constant contact with hydraulic fluid, shall be suitably protected against corrosion, Those components which are continually submerged in hydraulic fluid during normal operation, but which are exposed to local atmosphere during shipment and preinstallation storage, snail be protected by the application of suitable coating or preservatives.

3.1.1.2 Zinc and cadmium coating.- Cadmium-plating shall not be applied on 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 subject to rubbing or abrasion. Zinc hot-dipped coating, when used, shall be in accordance with Specification MIL-Z-17871, with a supplementary chromate treatment In accordance with Specification MIL-C-17711. Zinc plating shall be in accordance with Specification QQ-Z-325, Type II. When used, cadmium plating shall be in accordance with Specification QQ-P-416, Type II.

3.1.1.3 Bearing and thread material.- Bearing and thread materials shall be selected with a view toward minimizing the possibility of seizure, scratching, or galling.

3.1.1.4 Dissimilar metals.- The use of dissimilar metals in intimate contact, especially brass, copper, or steel in contact with aluminum shall be avoided whenever possible. Where contacts are unavoidable, the metals shall be protected or insulated against corrosion.

3.1.1.5 Cast iron.- The use of cast iron is not authorized without written approval of the Bureau of Ordnance for each specific part. Consideration will be given to the use of certain cast Iron for valve blocks, if of proper design.

3.1.1.6 Non-destructive inspection.- All magnetizable, critical parts which are designed with a low factor of safety shall be designated as subject to magnetic inspection,where considered necessary. Such inspection shall be designated on the drawings of the parts. Cracks or other injurious defects shall be cause for rejection. Where necessary, other non-destructive inspection methods shall be designated on the drawings of the parts.

3.1.2 Packing and gaskets.- Plant, or animal fiber sheet gaskets if used shall be in accordance with Specification MIL-P-20085. When appropriate, packings and gaskets shall be manufactured in accordance with Specification MIL-P-5516.

3.1.3 Fluids,- Fluids conforming to Specification 51 F 21 or Specification 51 F 23 will normally be used in the hydraulic System. Fluid Conforming to Specification 51 F 21 shall be used. unless otherwise specified or allowed.

3.1.3.1 Filtering.- All hydraulic fluid shall be filtered through a 10-micron filter before installation in hydraulic systems.

3.1.4 Storage life.- Synthetic rubber packings, gaskets and other component parts used shall not be over 2 years old when the component is submitted for acceptance under contract. For components which incorporate other organic materials that may deteriorate with age, the contractors shall state the storage life expectancy and submit substantiating data to support their recommendations .

3.2 General requirements .- Hydraulic systems shall be as simple, reliable, and foolproof as possible with respect to design, manufacture, inspection, Installation, operation, and maintenance commensurate with other criteria.

3.2.1 Safety of operation.- Interlocks shall be provided to prevent improper or unintended operation of the hydraulic system. When practicable, all elements shall be designed so that any - failures or combinations of failures which may occur shall result In a safe condition of the hydraulic system.

3.2.2 Endurance.- The hydraulic system shall be capable of satisfactory operation during and after the endurance tests in 4.2.4.9

3.2.3 Strength requirements.- Hydraulic equipment which is subject to working pressure shall be capable of withstanding a hydrostatic pressure equal to two times the maximum required *re*-lief valve setting, or to 1,000 pounds per square inch above the maximum required relief valve setting, whichever is the smaller value, without external leakage or permanent deformation. Tanks , which normally operate at approximately atmospheric pressure, shall be capable of withstanding an internal pressure of 5 pounds per square inch in excess of *the* maximum operating pressure in the tank without leakage or permanent deformation. Hydraulic equipment shall be of adequate strength to withstand all surge pressures which may occur in the equipment. Tanks Subject to surge pressure, particularly normally full tanks, should be cylindrical in shape when practicable, or otherwise designed to insure against fatigue failure induced by repeated surges.

3.2.4 Weight.- The weight of the hydraulic equipment shall be the minimum consistent with the requirements of performance, and with other pertinent criteria.

3.2.5 Form, outline, and dimensions.- The hydraulic equipment shall conform generally (or exactly, if so required by the detail specification) In form and outline to the Ordnance Drawings or Sketches listed in the detail specifications, and shall conform strictly to such dimensions and tolerances as appear on those drawings, in order to ensure proper assembly and functioning in combination with other parts of-the assemblies for which the equipments are intended, and in order to avoid mechanical interferences therewith. The hydraulic equipment must in all cases be capable of erection, inspection and servicing within the spaces available, as shown on the applicable drawings or sketches, and all parts shall be capable of passage through

the access openings to those spaces. Information on these access openings will be stated in the applicable drawings or detail specifications.

3.2.6 Protective coatings.- The protective coatings of all parts shall be that required by conditions of use and for good appearance. Unless otherwise specified, hydraulic equipment, as furnished by the contractor, need be painted for protective purposes only. Such painting shall be In accordance with the applicable provisions of Standard NAVORD OSTD 52, and is required only for exposed, unplated, non-working surfaces of steel, bronze, or aluminum parts.

3.2.7 Fluid Velocity.- Sizes of piping-and passages shall be such that he velocity of fluid in pressure lines does not exceed 20 feet per second except when other considerations justify higher velocities. Suction lines shall be sufficiently large, taking bends and other restrictions into consideration, to ensure sufficient pressure at pump Intake ports at the minimum ambient temperature.

3.2.8 Back pressure.- The hydraulic system shall be designed so that proper functioning of any unit shall not be affected by the back pressure in the system.

3.2.9 Operating conditions. All hydraulic equipment shall operate satisfactorily under the following conditions:

3.2.9.1 Operating positions.- As prescribed in the detail specifications .

3.2.9.2 Environmental conditions.- The hydraulic system shall be capable of operation and storage under the environmental conditions In Specification NAVORD OS 6341, Condition 11, unless otherwise specified.

3.2.9.3 Shock and vibration.- The shock of gunfire and shipboard vibrations shall not cause any hydraulic equipment to malfunction. All equipment shall be sturdy enough to withstand the forces or vibrations engendered by a near bomb hit or underwater explosion,

3.2.9.3.1 Shock.- Ability of the equipment to withstand shocks due to near bomb hits or underwater exposions shall be determined by test in accordance with Specification MIL-S-901, with the following exception: Acceptability of the equipment will be contingent upon the equipment withstanding the tests and performing its principal function subsequent to the shock

tests . Minor damage or distortion will be permitted providing such damage or distortion can not in any way Impair the ability of the equipment to perform Its principal function Functioning will not be required throughout or during the application of the shock .

3.2.9.3.2 Vibration.- Unless otherwise provided for in the detail specification, the ability of the equipment to withstand vibration conditions on shipboard shall be determined by vibration tests In accordance with Specification MIL-T-17113.

3.2.10 Clearances and interchangeability. - Working clearances shall be suitable for operating temperatures between the minimum, ambient temperature and 20 degrees Fahrenheit above the maximum operating temperature as set by the manufacturer in response to Paragraph 3.4.1.6 of this specification. So far as is practicable, all parts shall be originally Interchangeable between units of the same style and size. This does not preclude the replacement of items such as gearing or control valves and sleeves in matched sets when considered necessary. All parts subject to replacement in the ordinary exigencies of service shall be made to such a degree of accuracy,as to insure interchangeability without further machinine,

3.2.11 Bearings.- Friction losses shall be minimized by the use, wherever practicable, of ball bearings comforting to Specification FF-B-171, or roller bearings conforming to Specification FF-B.185. Needle-type roller bearings and taper-type roller bearings may be used in applications where these bearings are more suitable than either sleeve bearings or roller bearings conforming to Specification FF-B-185. The speeds and loads applied to each bearing must be within the limits specified by the bearing manufacturer.

3.2.12 Valve Springs.- The use of valve springs as a sole means of operating valves is not considered desirable. Whenever practicable the breakage of a valve spring or its failure to function shall not interfere with the satisfactory operation of the equipment in or with which it is used. The valves which operate in units normally subject to shock, fox' example in units attached to gun housings shall not be shifted unintentionally due to the shock associated with recoil and counter-recoil. Pressure surges due to shock, operation of cylinders, or any other operation, shall not cause any valves to be shifted unintentionally. All valves normally subject to shock, and held by spring loaded detents must be placed with the valve axis at right angles to the direction of predominant shock to prevent unintentional shifting. The designed stresses in spring elements shall be held at a sufficiently low level to ensure reliability.

If practicable, spring operated valves should be provided with a differential area under pressure, or a small pressure-operated plunger, which produces a force in the same direction as the spring force an the valves. (This is not necessarily required In the case of simple spring loaded relief valves.) Wherever practicable, cams which operate valves shall be positive motion cams . If practicable, all slotted cams or discs, which operate in conjunction with spring loaded valves and detents) shall be.. designed to produce a single oscillation of a small magnitude a short distance before the detent is in line with each slot. This oscillation will assist in freeing the valve if it tends to stick during normal operations, or if the equipment is left idle for long periods of time.

3.2.13 Lubrication.- Adequate provision snail be made for lubrication of all bearings and rubbing surfaces. Bushings pierced by holes for lubrications shall be positively fastened to prevent movement where such movement would cut off lubrication. If lubrication by other than the hydraulic fluid itself is provided, standard lubricants only, as described in Publication NAVORD OD 3000 shall be used unless specifically approved by the Bureau of Ordnance.

3.2.14 Threaded fastenings.-

3.2.14.2 Form .- All screw threads used to secure one part to another shall be In accordance with Handbook H28 and its supplement.

5.2.14.2 Fit.- Unless otherwise specified all threads shall be Class 2 fit or better. Studs, however, shall have threads of Class 4 fit on “studded” ends, as opposed to "nut" ends. Other reliable methods of securing studs may be used if approved by the Bureau of Ordnance.

3.2.14.3 Locking devices.- Through bolts *with* lock nuts shall be used where practicable. The use of locking devices, such as wired heads, lockwashers or special types of lock nuts for all threaded parts, Is required. Lockwashers shall not be used Inside of hydraulic units. The working loose, in service, of threaded parts due to lack of locking devices will be considered due to a defect In design. The use of set screws or locking screws shall be avoided wherever practicable.

3.2.15 Shaft connections.- Shaft connections, including the connections between shafts and gears, which are required to transmit power or considerable torque, or which are used where angular accuracy or the elimination of lost motion is important, or where rotating parts are subject to frequent reversals in

direction, shall be splined In accordance with Standard NAVORD OSTD 60, Where all mating parts are furnished by the contractor, an Involute spline in accordance with the American Standards Association ASA B-5.15 standard may be used.

3.2.16 Inspection holes for gearing.- All housings containing gears shall be provided with adequately covered openings in sufficient number to allow visual inspection of the teeth on as many gears as practicable. Such openings shall expose to view at least 2 gear teeth at a time. The openings, although preferable, need not be at the meshing points of the gearing, if such is impracticable.

3.2.17 Noise and vibration.- Noise and vibration, particularly that due to turbulence, to rapid change of speed or direction, to cavitation of the hydraulic fluid, or to working contacts of moving parts, shall be reduced to the minimum by proper design, consistent with other pertinent criteria. Consideration will be given to the proposals of bidders and contractors to reduce the transmission of noise and vibration by the use of mountings or couplings specially designed for that purpose.

3.2.18 Prelection of' moving parts. - Except as otherwise specified or shown by the drawings or sketches listed in the applicable detail specification, or as specifically allowed 'by the Bureau of ordnance: all moving parts shall be enclosed in watertight housings . Equipment to be installed in exposed locations on board ship shall be capable of' withstanding the submersible (15-foot submergence) test of Specification MIL-E-2036. Equipment to be installed below decks or within completely shielded enclosures shall be capable of withstanding the watertight (3-foot submergence) test of Specification MIL-E-2036. The above requirements will not normally apply to the air breather vents on the expansion tank, unless otherwise specified in the detail specification. However, means should be provided to prevent entrance of spray or water-through these vents under normal conditions encountered on board ship.

3.2.19 Leakage.- Leakage of fluid from the hydraulic system is objectionable and shall be minimized, at all points where necessary, by the provision of collecting chambers and drain lines to the supply tank. Special consideration shall be given to the design of all parts through or past which fluid may escape from the hydraulic system. Shaft packings or seals and pipe fittings and connections shall be designed to Insure the minimum leakage of fluid: drip pans shall be provided where practicable for collecting unavoidable fluid leakage. Excessive fluid leakage shall be considered to constitute an unsat-

isfactory condition, and shall be corrected by the contractor. When practicable, bolt spacing access and inspection covers shall not be greater than the depth of the cover above the gasket plus 2 inches. Bolt spacing shall not be greater than 6 inches.

3.2.19.1 Packing installation.- Packings for pipe flanges shall be in accordance with Standard NAVORD OSTD 63. When applicable, the Installation and gland design for packings should be in accordance with Specification MIL-P-5514.

3.2.20 Thermal expansion.- All closed circuits shall contain provisions to insure against excessive pressure resulting from thermal volumetric changes.

3.2.21 Air vents. Air vents shall be provided at all points in hydraulic systems where air will tend to accumulate and may result in unsatisfactory operation. All air vents shall be accessible after final installation of the equipment on board ship. Disconnection of pipe lines or loosening of flanges does not constitute approved air venting means.

3.2.22 Pressure gage connections.- Pressure gage connections shall be provided in sufficient number to permit an operating check of the equipment. The connections shall be so located in each equipment that pressure gages can be temporarily attached even when the equipment Is installed on board ship. Pressure gage connections shall consist of holes tapped for and closed by lfl-inch International Pipe Standard steel pipe plugs when the Installation of such tapered thread plugs will not produce harmful distortion. To prevent distortion of hydraulic units, it will be permissible to use an intermediate adapter having straight threads and a flange with a suitable seal on one side and a l/4-inch pipe tap on the other side for forming the gage connection.

3.2.23 Filling and draining.- Hydraulic systems shall be arranged so as to be filled through a single properly capped, vented, and screened filling opening. This filling opening shall be so constructed that, when closed, it will not permit leakage of fluid In any required operating position. The filler cap shall be easily installed or removed by hand or by use of ordinary non-powered hand tools. To prevent loss of the cap when removed, it shall be attached to the hydraulic unit (normally the tank) with a chain or by other suitable means. The use, while filling a system, of the air vents provided on other parts of the hydraulic system, is permissible

provided that the necessity for such use is clearly stated on a filling instruction plate Means shall be provided for draining the hydraulic fluid from all parts of the hydraulic system. All internal pockets in which hydraulic fluid, water, sludge or other contaminants may collect shall be provided with drains which will permit removal of all fluids, when the equipment is in Its normal installed position. The instructions for the equipment should state the minimum frequency recommended for such draining procedures. Each system shall be provided with a main drain, from which substantially all the liquid In the system may be withdrawn with facility and without waste of liquid unless otherwise specified or allowed. When required by the detail specification, provision shall be made for connection to all tanks and all large components of hydraulic systems to a centralized filling and draining system. Suitable shut-off valves and pipe connections will be required for this purpose

3.2.23.1 Draining of compressed gas containers.- Compressed gas containers such as accumulator air chambers or air flasks connected to the accumulator, into which hydraulic fluid may leak or which may accumulate condensed water vapor, should be provided with adequate means for draining or “blow down" of these fluids, This is essential in order to reduce the possibility of “Diesel action" with the hydraulic fluid when recharging the container with compressed air. Unless otherwise approved by Bureau of Ordnance it should be possible to drain these fluids without removing the compressed gas container from its installed position. The draining provisions should include a slow-opening valve and a drain plug in series. When necessary, a drain pipe may be provided to avoid spilling of the drained fluid on the adjacent equipment.

3.2.24 Cleaning of parts and system.- All parts of hydraulic system units shall be thoroughly cleaned prior to assembly or installation of that unit. Each new hydraulic system shall be operated, each unit being operated at least 10 times, for a length of time (at least 15 minutes), sufficient to insure filtration of all circulating fluid. Filling equipment which is uses for this cleaning process shall be provided with filters with the same, or finer, degree of filtration uses In the hydraulic system. Dead-end lines in the system shall be properly connected to clean completely such lines during actuation of the system. If the filter element In the hydraulic system is used during this operation, It shall be replaced.

3.2.25 Marking of parts and assemblies.- Parts and assemblies shall be marked in accordance with Standard NAVORD OSTD 2.

3.2.26 Emergency provisions.- All hydraulically operated parts which are essential to safety, or which are required to function in order to permit continuation of operations until a safe condition is obtained, shall have provisions for emergency manual operation.

3.2.27 Dangerous Operations.- All parts of the hydraulic system which are manually operated and which, when improperly operated, may endanger the safety of personnel or equipment shall be suitably marked by attached warning plates stating the necessary precautions to be taken to prevent injury. These parts shall also be suitably protected or designed to prevent inadvertent operation.

3.2.28 special tools.- Hydraulic systems shall be so designed that special tools will not be required for assembly and disassembly of units, unless it can be shown that the use of special tools is unavoidable. In such cases, the contractor shall submit drawings of the tools with substantiating evidence justifying the special tools before the hydraulic unit may be approved for service use.

3.2.29 Gages.- Gages which are necessary to ensure proper fits between the hydraulic equipment and the mating equipment furnished by the Government shall be provided in accordance with the requirements of Publication OP 400.

3.2.30 Standard parts.- See Publication OP 400.

3.2.31 Resonant frequency.- When hydraulic power transmission equipment is used as part of an automatic control system, the resonant frequency should be sufficiently high to ensure satisfactory operation.

3.3 Component design general requirements.-

3.3.1 Hydraulic pumps.- Except when otherwise specifically approved for each application, all pumps furnished for hydraulic systems shall be of a positive displacement type. Pump capacities shall be as required to obtain the maximum combination of speed (discharge) and torque (pressure) required by the applicable detail specification, when operated in combination with all other specified equipment. The pumps shall be of rugged and substantial construction; they shall be designed in accordance with the best modern practice, and shall be suited

In all respects LO perform the functions intended in an efficient manner. Pumps shall be designed so that they will not emit excessive noise, particularly if due to turbulence or cavitation of the oil, to rapid change of speed or direction of the moving parts of the pump, or to the working contacts of the moving parts with each other or with the fixed parts of the pumps. Unless otherwise approved, hydraulic pumps shall be self lubricating with no provisions other than the circulating hydraulic fluid. The pump shall not vibrate excessively under any conditions of operation at all speeds up to and including the rated speed. Over-pressure protection shall be provided on the discharge side of' all pumps. The direction of rotation of each pump shall be clearly indicated on the pump where it can be readily seen.

3.3.1.1 Power pumps.. Power pumps may be of the following types:

(a) Parallel Piston Pumps
(b) Radial Piston Pumps
(c) Vane Pumps
(d) Gear Pumps

The pumps shall have no deleterious pulsation or variation In delivery at constant pressure when operating at rated speed.

3.3.1.1.1 Pressure.- Unless otherwise specified, all power pumps shall be capable of continuous satisfactory operation at a pressure of at least 1,000 pounds per square inch, When required by the detail specification, piston type pumps shall be designed to be capable of operation at a pressure of at least 2,500 Pounds per square inch.

3.3.1.1.2 Efficiency.- Pump efficiency (overall) at the specified pressure, normal operating speed and approximately maximum delivery rate shall be not less than 60 percent, computed as follows:

efficiency, % = 0.0583 p Q/H.P. input In which
p = pressure psi)
Q = delivery (gallons per minute)

An efficiency of 75 percent in lieu of 80 percept may be acceptable for gear pumps, particularly if a reduction in noise is obtained. When a hydraulic pump and a hydraulic motor are used together as a transmission, the overall efficiency will be stated in the detail specification.

3.3.1.1.3 Neutral interlock.- Electrical interlock switches shall be furnished with hydraulic pumps of the variable discharge type for the purpose of preventing the electric motors from starting under load, and uncontrolled operation of the associated drive equipments. Normally the neutral interlock switch shall be operated by the variable discharge stroking mechanism in such a way that the switch is closed only when the stroking mechanism is in, or very near, the neutral position. Devices other than electrical switches may be provided to accomplish the Intent of this requirement.

3.3.1.1.4 Stroking mechanism.- The stroking mechanism, for controlling the rate and direction of flow of the hydraulic fluid between the variable discharge type hydraulic pump and the hydraulic motor or cylinder, and thereby the speed and direction of motion of the driven equipment, shall be in accordance with the requirement of the detail specification.

3.3.1.2 Auxiliary pumps.- Auxiliary pumps may be used for supercharging or replenishing systems, for control or servo circuits, and as sump pumps and oscillator pumps. Auxiliary pumps may normally operate at full capacity during the entire time that the electric power motor is running at constant speed (that is, continuously in one direction). When the volume of fluid delivered is not required for control or supercharging purposes, the fluid shall be by-passed through a relief valve or its flow shall be reduced or limited by other. hydraulic means . The rate of delivery and the working pressure of auxiliary pumps shall be determined by the designer of the hydraulic power equipment. The power inputs to auxiliary pumps shall be added to those of corresponding power pumps in all computations of overall efficiency and no-load input unless otherwise specified. sump pumps, when required, shall operate when the hydraulic system is cut in to return the hydraulic fluid to the tank. Sump lines must be in the lowest portion of the hydraulic units so that the hydraulic fluid cannot enter any associated cable or other electrical compartment.

3.3.1.3 Lubrication pumps.- Lubrication pumps may be of two types:

(a) Uni-Directional Pumps which deliver lubricant in one direction only regardless of the direction of rotation of the driven end.
(b) Reversible Pumps which reverse the direction of delivery of the lubricant with the reversal of direction of rotation of the driven end.

Gear-type and vane-type auxiliary pumps may be used for lubrication pumps when they are driven continuously in one direction at a uniform speed of rotation suitable to this type. Working clearances for lubrication pumps shall be suitable for the operating temperatures specified. The pumps shall be self-priming and shall function satisfactorily when operating at the designed speed(s). The type of lubricant, the volume delivered, the working pressure, and the suction lift of the pump will be stated in the detail specification.

3.3.2 Hydraulic motors.- Hydraulic motors may be of the following types:

(a) Parallel Piston Motors
(b) Radial Piston Motors
(c) Gear Motors

Under constant pressure and with constant resistance, motors shall be designed to have substantially constant speed in all positions of rotation. Unless otherwise specified, motors shall e capable of continuous satisfactory operation at a pressure drop of at least 1,000 pounds per square inch. When required by the detail specification, piston type motors shall be designed to be capable of operation at a pressure drop of at least 2,500 pounds per square inch. The motor capacities and efficiencies shall be those necessary to obtain the combination. of torque and speed required by the detail specification, when operated in combination with all other specified equipment.

3.3.3 Hydraulic cylinders.- Hydraulic cylinders shall be of the simplest practicable design for the work intended, consistent with other pertinent criteria. Cylinders, pistons, and piston rods shall be sufficiently hard and corrosion resistant to ensure adequate service life. The surface finish of the cylinder bore or the piston rod sliding past packings or seals (particularly O-rings) shall be 15 micro inches RMS or less. When required, hydraulic cylinders shall be provided with internal buffers to decelerate the moving systems attached to the piston rods. Provision shall be made to clean externally sliding parts, such as piston rods, by means of scrapers similar to those in Specification MIL-S-5049, when these exposed surfaces are subject to the accumulation of foreign particles. If the piston rod remains extended for long periods of time, a felt wiper shall be provided for the purpose of lubricating the piston rod. Means shall be provided for maintaining a supply of hydraulic fluid on the felt, -without requiring disassembly of the cylinder.

Air vents, for removing trapped air, shall be provided at the highest point in the hydraulic cylinder in its final installed position, when required by the design of the hydraulic system. Where practicable, a drain connection to the" tank shall be provided at the piston rod end of the cylinder to remove hydraulic fluid leakage past the piston rod main seal.

3.3.4 Oil filters.- Oil filters shall be provided in all hydraulic systems. They shall filter all of the circulating fluid in auxiliary pump and lubrication pump circuits, preferably on the discharge side of these pumps. When required by the detail specification, filter units shall be installed in multiple, so that one unit can be removed for cleaning while the other remains operable. A selector valve shall be provided on each multiple (duplex) filter housing to permit selection of flow of fluid through either or both filter elements. In the event that multiple filters are not required, suitable valves shall be installed to allow for opening and cleaning the filters without draining the system.
Suitable relief valves shall be provided to by-pass the hydraulic fluid in event of excessive restriction to flow through the filter elements. All types of' filter elements shall be removable for service and inspection without disconnecting fittings or disturbing the mountings. The degree of filtration (spacing of the filter element) shall require approval by the Bureau of Ordnance. Oil filters shall be inert to the hydraulic fluids.

3.3.4.1 Micronic type filters.- When required by the detail specification, micronic type filters shall be provided in hydraulic systems to remove from the hydraulic fluid particles of foreign matter larger than 10 microns (0.00039-inch). In circuits having a small rate of flow, micronic type filters may be used as full-flow units (that is, filtering all fluid discharged by the pump) without requiring excessively large filters, In applications using full-flow micronic filters, means should be provided to indicate either visually or electrically (when the physical location of the filter unit is remote) excessive restriction to flow through the filter elements. For circuits In which the rate of flow is large, micronic type filters may be used in a by-pass arrangement so that only a portion of the flow in the circuit will be filtered. Micronic type filters used in a by-pass arrangement need not be installed in multiple. Micronic type filters shall be in accordance with applliable portions of Specification MIL-F-5504.

3.3.5 Relief valves.- Relief valves shall be provided to protect all equipment from the effects of excessive pressure. Relief valves shall be arranged so that their settings may be adjusted In service, but so that the settings are not subject to accidental change. In order to avoid unauthorized changes in pressure settings, which may cause damage to the equipment, adjustments which require changes in thickness of a spacer or shim will be acceptable. All plungers, balls,pistons, etc., in relief valves shall be accurately guided to prevent cocking and jamming of the relief valve off its seat.
Unless otherwise specified in the detail specification, the following relationship in pressure values shall be provided in the design of relief valves.

Cracking pressure-91 percent (minimum)
Full-flow pressure-100 percent
Reseat pressure-82 percent (minimum)

Hydraulic fluid vented by relief valves shall be returned to the hydraulic system.

3.3.6 Pump unloading devices.- All hydraulic systems shall be provided with means whereby the input to the hydraulic pump, including associated auxiliaries required for its operation, under "No-load" conditions (that is, when the pump is driven at normal operating speed without causing useful work to be performed by a hydraulic motor or cylinder), where the temperature of the hydraulic fluid is approximately 120 degrees Fahrenheit, shall not exceed the value allowed by the detail specification. For variable discharge pumps, the stroking mechanism may be returned to neutral (thereby reducing the pump discharge to zero) for "No-load" conditions . For other hydraulic systems with constant discharge pumps, "No-load" conditions may be obtained by various methods such as:

(a) By-passing the pump discharge to tank through the directional control valve when this valve Is in the neutral position.
(b) Unloading the pump through an automatic regulator in systems with accumulators.

(1) For accumulators designed so that an external mechanical indication of the amount of liquid in the accumulator is provided (for example, in a piston and cylinder type, the position of the piston rod indicates the amount of fluid in the cylinder), the mechanical indication may be used to

operate a directional control valve to connect the pump discharge to either the 'tank or the accumulator, depending upon the amount of hydraulic fluid in the accumulator.

(2) For accumulators of the diaphragm or bag types, an automatic pressure regulator may be used to cut-in or cut-out the pump delivery, depending upon the pressure in the accumulators .

3.3.6.1 pressure regulators (unloading valves).- Pressure regulators are units which relieve pumps from working pressure loads during the time that the hydraulic system is between cut-out and cut-in range by providing free flow of the hydraulic fluid at low pressure through the pump delivery lines back to the tank without relieving pressure from the working parts of the hydraulic system. The design and construction of pressure regulators shall be such that they will not be affected by back pressure or pressure surges which might tend to cause them to operate or by-pass fluid in other than the intended manner or to become inoperative. Opening and closing of the pressure regulator shall be damped to the extent that harmful shock loads are eliminated The internal leakage of the regulator shall be as small as practicable and shall not be sufficient to affect the operation of any unit of the hydraulic system.

3.3.7 Directional control valves.- When specifically required by the detail specification, directional control valves shall be provided to govern the direction of flow of" hydraulic fluid between the hydraulic pump and the hydraulic motor or cylinder. Installation and design of directional control valves shall be such that they will not be affected by back pressure, or pressure surges, which might tend to cause them to open or move from their setting, or cause them to by-pass hydraulic fluid in other than the intended manner. The design of directional control valves shall be such as to offer a minimum restriction to the flow of hydraulic fluid. All ports on separately mounted directional control valves shall be clearly marked to indicate the proper connection to be made. Directional control valves, in general, will be operated by any one or any combination of the following methods:

(a) Manually.
(b) Mechanically or hydraulically (cams, springs, hydraulic pressure, etc.).
(c) Electrically (solenoid, motor).

For manually operated directional control valves, the force required to shift the valve operating lever shall not exceed 15

pounds, unless otherwise specified in the detail specification. An instruction plate shall be mounted on each manually operated directional control valve, near the operating lever. This plate shall identify the unit and Indicate the direction of motion for actuation.

3.3.8 Check valves.- The design of check valves shall be such as to offer the smallest practicable restriction to flow of the hydraulic fluid. 'All plungers, balls, pistons, etc., shall be accurately guided to prevent misalignment or chattering on their seats . The direction of flow shall be clearly and permanently indicated by arrows on the valve housing for individually housed units .

3.3.9 Accumulators.- Hydraulic pressure accumulators shall be non-shatterable in accordance with Specification MIL-C-15111. The compressed gas shall be separated from the hydraulic fluid by either of two methods:

(a) Diaphragm or bag type separator.
(b) Piston type separator.

Standard gas charging and pressure gage connections shall be provided on all accumulators, 'by means of which the pressure in the gas chamber may be read, and additonal compressed gas may be admitted when necessary. For small accumulators where permanent attachment of a pressure gage connection may not be practicable, the pressure gage connection may be included as part of a separate gas pre-charge gaging device or as part of the gas filling connection.
In determining the capacity of accumulators, consideration shall be given to the following factors:

(a) Efficient duty cycle for the hydraulic system.
(b) Ability to complete a cycle in the event of electric power-failure, in order-to obtain a safe condition for all associated equipment.
(c) Effects of temperature variations (ambient air temperature, hydraulic fluid temperature, and the compressed gas temperature.)

A manually-operated valve shall be installed between the accumulator and the hydraulic system to permit the accumulator pressure to be shut off from the hydraulic system. For piston type accumulators, this valve will normally be closed by the operator, when the accumulator is fully charged with hydraulic fluid, before the hydraulic pump drive motor is-de-energized. This will help reduce

leakage of the compressed gas from the accumulator gas chamber. A manually operated valve shall be provided in the hydraulic system to permit release of the fluid pressure to the tank. This is required to permit checking of the gas pressure in the accumulator. Each accumulator shall be provided with a permanently legible attached warning:

"RELEASE FLUID PRESSURE BEFORE DISCONNECTING PRESSURE LINE. RELEASE GAS AND FLUID PRESSURE BEFORE DISASSEMBLING, STORING, OR SHIPPING ACCUMULATOR."

A warning plate shall be attached to the compressed gas filling attachment (or to any gas filling valve which is provided as part of the accumulator) cautioning the operator to admit compressed gas very slowly. Gas filling valves shall be of a slow-opening type. These precautions are required to prevent auto-ignition (diesel action) of the hydraulic fluid when compressed air is added to the accumulator.

3.3.9.1 Diaphragm and bag type accumulators.- Compressed nitrogen only shall be used in daphragm and bag type accumulators in order to prevent possible auto-ignition of the hydraulic fluid in the event of puncture or failure of the separator. Compressed air may be used in case of emergency when compressed nitrogen is not available, but should be replaced by nitrogen at the earliest opportunity. Diaphragm and bag type accumulators shall be designed to prevent extrusion of the diaphragm and bag through the fluid port. The separators shall be designed to have a minimum of stretch during operation. The separators shall be capable of 1,000,000 cycles of operation, of which 100,000 cycles shall be between zero pounds per square inch and maximum pressure. The remaining 900,000 cycles shall occur between the rated cut-in and cut-out pressures, controlled by an unloading valve. The separators of diaphragm and bag type accumulators shall be capable of meeting the physical property tests of Specification MIL-A-5498, except that hydraulic fluid conforming to Specification 51 F 21 may be substituted for fluid conforming to Specification MIL-O-5606, and the minimum temperature for the bending test may be minus 20 degrees Fahrenheit instead of minus 65 degrees Fahrenheit. However, the separator shall not be damaged by storage at minus 80 degrees Fahrenheit. Unless otherwise approved, cleaning and coating of internal surfaces of diaphragm and bag type accumulators shall be in accordance with Specification MIL-C-15111, except as follows:

(a) Use only zinc chromate primer In accordance with Specification MIL-P-6889.

(b) Coat threads in neck with corrosion preventive in accordance with Specification MIL-C-16173.

3.3.9.2 Piston type accumulators.- Either compressed air or compressed nitrogen (preferably the latter, if available in sufficient quantity may be used in piston type accumulators. Although a limited amount of hydraulic fluid on the cylinder walls is normally exposed to the compressed gas as the piston reciprocates In the cylinder, such fluid, in addition to the fluid which may leak past the piston packing, may eventually collect in the air filling passages. To prevent auto-ignition, rolls of copper screens, which absorb heat from the incoming air shock wave, should be placed In the air passages. Provisions shall be made for draining hydraulic fluid and water from the compressed gas chamber. Drainage provisions should be Installed so that draining may be accomplished without removing the accumulator from its installed position. When required by the design and installation provision shall be made for venting air from the hydraulic fluid chamber of the accumulator.

To prevent corrosion inside of piston type accumulators due to the action of the high pressure air, moisture which may be introduced with the air, and the hydraulic fluid, the following precautions shall be taken:

The interior surfaces of the compressed gas chamber shall be tinned. After these surfaces have been thoroughly cleaned and pickled, they shall be subjected to the action of zinc chloride-ammonium chloride (70-30) flux, followed by flooding with molten solder (50 tin, 50 lead) while the temperature of the forging is between 425 degrees Fahrenheit and 440 degrees Farenheit. The tinned surfaces shall be allowed to cool without any rubbing or wiping which might reduce the thickness of the coating. Any other tinning process proposed will require approval by the Bureau of Ordnance.

The Interior surface of the hydraulic fluid chamber shall consist of a corrosion resistant liner such as bronze or monel metal. The piston surface shall be of a type to resist galling (seizing) with the material of the internal surface of the cylinder.

3.3.10 Tanks.- Containers of hydraulic fluid in a hydraulic system (including “supply”, “expansion”, “surge”, or"auxiliary" tanks or “lubrication” oil reservoirs) are subject to the following requirements:

3.3.10.l Number and capacity.- Unless otherwise specified, or allowed, no tank shall service more than one system; but a system may require more than one tank, due to the conditions of installation (as when space In a given location is restricted) or to the type of equipment proposed (as when necessary to prevent the formation of air pockets in any part of the system,to

allow space for expansion and "make-up" fluid when main reservoirs are normally completely fllled *or to Insure* the Immersion of a unit mounted higher than the main reservoir when such unit requires immersion). The total capacity of a system to contain hydraulic fluid shall be sufficient to meet all test requirements (unless specifically excepted) of the detail specification. If a given system is expected by a bidder to require a greater fluid capacity than is provided by the drawings or sketches referenced in the detail specification, the additional capacity considered necessary shall be stated in the bid.

3.3.10.2 Lubrication oil reservoirs.- Separate lubrication oil reservoirs shall be provided when specifically required by the detail specification.

3.3.10.3 Material and construction.- Tanks may be ox" nonferrous materials or of' galvanized steel construction. If the tank is to be fabricated, the process shall be subject to the approval of the Bureau of Ordnance.
Suitable paint coatings on tanks may be used for corrosion protection, subject to the approval of the Bureau of Ordnance.

3.3.10.4 Filling and draining.- See paragraph 3.2.23 of this specification.
Each tank shall be fitted with a means for indicating the level of the fluid within, at least to the extent of showing whether or not the fluid is being maintained at the proper level. visual liquid level indicators are considered desirable, provided that they are demonstrably visible and reliable under all *normal* operating conditions, and that they are sc constructed that their injury cannot result *in* serious loss of fluid from the system.
If filling connections on tanks are located close to the overhead structure, the proposed method of filling will require approval by the Bureau of' Ordnance. Each tank shall be fitted with a drain plug which will permit complete draining of all the fluid in the tank.
An instruction plate shall be attached to the tank near the filling connection, and so located as to be easily readable. This plate shall contain simple and complete instructions for filling and shall include at least the following information.

(a) Total fluid capacity of the system.
(b) Tank capacity (to normal level in tank)
(c) Specification of hydraulic fluid(s).
(d) Position of operating cylinders during filling (when this will Influence the proper filling of the tank).

(e) Any other special instructions considered necessary, including condition of accumulators when filling to Indicated level.

3.3.10.5 Access.- When any operating mechanisms such as pumps, valve-. , are mounted within a tank in such a way as not to be readily removable therefrom, the tank shall have properly covered hand holes to provide adequate access for the inspection and adjustment of the mechanism mounted within.

Unless otherwise required by the detail specification, it shall be possible to adjust any relief valves mounted within tanks without requiring removal of the hydraulic fluid from the tank. This may be accomplished either by mounting the relief valve adjustment element above the highest level of the fluid (and by providing a suitable access opening for this adjustment), or by providing an adjusting means on the outside surface of the tank. Ample and accessible provisions shall be made for complete cleaning of the tank.

3.3.10.6 Settling basin and oil screen.- If filters are not provided in the hydraulic system, a settling basin with a removable oil screen shall be provided in the bottom of the expansion tank to permit metal particles, sludge, etc., to be separated from the fluid. The screen shall be located so that the hydraulic fluid flowing Into the tank passes through it at a relatively low velocity. Provision shall be made for removing the screen for cleaning without loss of' the fluid in the tank.

A baffle or set of baffles shall be provided in tanks where necessary to prevent surging of fluid or to prevent foaming or vortexing of fluid as it enters the tank from the return line. The baffles should be designed to prevent direct internal flow from the returning inlet to the outlet to the other components of the system.

3.3.10.7 Venting of tanks.- Tanks containing combustible fluids shall be provided with adequate venting for relief of excessive internal pressure In the tanks which may occur as a result of being subjected to external fire. For tanks having a test pressure of 5 pounds per square inch above atmosphere pressure, the following venting areas are required:

Tank Capacity	Required Total Venting Area	Nominal IPS Vent Which Provides Required Area
Gallons	Square Inches	Inches
10 to 20	0.53	3/4
20 to 50	0.86	1
50 to 100	1.50	1-1/4
100 to 200	2.04	1-1/2
200 to 500	3.35	2
500 to 1000	4.79	2-1/2
1000 to 2000	7.39	3

In the application of the requirement for the above venting areas, judgement may be exercised in certain cases. Where a tank is so located that its external surface will not be exposed directly to the flame of a fire, smaller vents may be adequate. In some extreme Instances, deviations from the above venting requirements may be required because of space, accessibility, or other considerations. Requests for such deviations should be submitted to the Bureau of Ordnance for approval.

3.3.11 Pressure gages.- When required by the detail specification, pressure gages shall be furnished with the hydraulic equipment to indicate the system main pressure, fluid and gas pressure In the accumulator, auxiliary pump pressures, etc. Pressure gages shall be of the safety type. Pressure gage dampeners shall be used where necessary.

3.3.12 Piping and fittings.- The contractor furnishing the hydraulic equipment shall also furnish all integral piping and those pipe fittings (flanges) which are directly attached to the equipment furnished by the contractor. Piping and fittings shall be in accordance with Standard NAVORD OSTD 63. Wherever practicable the piping shall be arranged with the minimum number of joints necessary to insure that each separately mounted hydraulic component can be removed without disturbing any other component . The use of straight pipe lines installed between two rigid connections shall be avoided wherever possible. Where such straight lines are necessary, provisions shall be made in the mounting of the units or in the rigid connections to insure that no excessive strains will be applied to the tubing and fittings . All piping, fittings, fluid passages, cored holes, or drilled holes must be free of burrs, or foreign matter which might cause damage to any hydraulic unit or contamination of the hydraulic fluid. Sharp edges shall be removed whenever they adversely affect the flow of hydraulic fluid.

3.3.12.1 Pipe supports.- Except as otherwise approved, all hydraulic piping shall be adequately supported to prevent excessive vibration and resultant fatigue failure. Provisions shall be made for change in pipe length resulting from contraction and expansion. Supports shall be placed as close to bends as possible to minimize overhang of the pipe.

3.3.12.2 Swivel joints.- In parts of-hydraulic systems where relative motion exists between two points, suitable swivel joints may be used If applicable. The swivel joint shall be designed so that temperature extremes or heavy radial loads will not force the joint out of alignment or tighten the packing to the point where the joint will not turn freely. The packing for the swivel joint shall be designed to provide a seal when initially assembled; and internal pressure in the swivel joint shall increase the sealing action. The packing shall also prevent leakage of air into the swivel joint where the internal pressure Is below atmospheric pressure.

3.3.12.3 Internal cleanliness.- All piping which has been heated for bending, welding or brazing, shall be cleaned by pickling, wire-brushing, washing and proper drying in accordance with Specification MIL-C-17795. This cleaning is to be done by the party performing the bending, welding, or brazing. However, all piping shall be examined and, if necessary, recleaned immediately prior to installation.

3.3.13 Flexible hose.- Flexible hose, when used in hydraulic systems, shall be in accordance with Specification MIL-H-5511.

3.3.14 Workmanship The workmanship shall be such as to meet all the requirements of the specifications and drawings.

3.4 Data requirements.-

3.4.1 Information with bids shall include the following:

3.4.1.1 Outline drawings showing the overall and principal dimensions of the entire equipment. Wherever proper operation of the contractor - furnished equipment is to be contingent upon the use of any particular design or arrangement of any Government - furnished unit, such design or arrangement is to be clearly indicated.

3.4.1.2 Guaranteed maximum total weight, without hydraulic fluid . The approximate quantity of hydraulic fluid required for the system shall be stated.

3.4.1.3 Description, schematic diagrams, specifications, and drawings in sufficient detail to explain clearly and completely the operation and adjustment of the proposed equipment in conjunction with the Government - furnished equipment.

3.4.1.4 Curves of estimated minimum performance, as may be required by the detail specification.

3.4.1.5 Pressures required to meet the specified operating conditions .

3.4.1.6 A statement of the maximum temperature of the hydraulic fluid at which the hydraulic equipment will operate satisfactorily.

3.4.1.7 A statement of the ability of the proposed hydraulic equipment to operate satisfactorily under the conditions and loads stated in the detail specification when using a hydraulic fluid which meets the requirements of Specification 51 F 21, or in the case of lubricating pumps, the appropriate lubricant specified in the detail specification.

3.4.1.8 A statement of the capacity of the tank which will meet the requirements of the detail specification without causing the temperature of the hydraulic fluid to rise above the value stated in response to paragraph 3.4.1.6 when the ambient temperature is 110 degrees Fahrenheit.

3.4.1.9 A statement of the rated continuous and overload pressures of the hydraulic pump, and the maximum delivery of the hydraulic pump at these pressures.

3.4.1.10 A detailed description of any means proposed to reduce the transmission of noise and vibration.

3.4.1.11 A statement setting forth in detail any exceptions which are being taken to the detail specification, together with a complete description of any proposed substitutions.

3.4.1.12 A list of additional components which are considered necessary for the proper operation of the proposed equipment In accordance with the detail specification, but which are not definitely covered therein.

3.4.1.13 A list of the parts of the proposed equipment which are of types that have previously demonstrated their suitability for service use by being subjected to performance tests by the Bureau of Ordnance.

3.4.2 Drawings for design approval.- Drawings for design approval, in accordance with Publication OP 400, are required unless otherwise specified. All drawings for design approval shall be submitted at one time in order that Intelligent action may be taken on each drawing. The contractor may make partial submission of such drawings only with the specific approval, In advance, of the Bureau of Ordnance.

3,4.2.1 Schematic diagrams.- Drawings for design approval shall include schematic Diagrams showing the action of all component parts of the equipment In each of the various phases of operation, and indicating the pressure and directions of flow of fluids and the relative speeds and directions of rotation of all gears and shafts, together with a complete description of the operation of the equipment.

3.4.3 Instructions for installation.- Advance instructions for installation, in sufficient detail to explain clearly the installation and-adjustment of all parts, shall accompany each shipment of hydraulic equipment, or shall be forwarded at the same time, under separate cover, to the same destination as the shipment. These instructions need not be in the final form required in the ordnance pamphlet for the equipment, but shall be sufficiently complete for the purpose intended. Four copies of the instructions for installation shall accompany the drawings for record.

3.4.4 Drawings for record.- Drawings, in accordance with Publication OP OO and Stmdard NAVORD OSTD 599, are required unless otherwise specified.

3.4.5 Ordnance pamphlet.- An ordnance pamphlet, covering the hydraulic system, shall be furnished by the contractor in accordanice with Publication OP 1 if required by the detail specification or contract. The ordnance pamphlet shall contain a comprehensive section on all safety precautions, and a check off list on operating and maintenance practices required to ensure safety of the system.

3.4.6 Spare parts, tools, and accessories.- Lists of recommended spare parts, tools, and accessories shall be prepared in accordance with Publication NAVORD OD 8999.

3.4.7 Ordnance classification of defects.- If required by the detail specification contract, an ordnance classification of defects (OCD) shall be furnished by the contractor In accordance with Standard NAVORD OSTD 78.

4. QUALITY ASSURANCE PROVISIONS AND TEST PROCEDURES

4.1 General.- Inspection and tests will be broadly divided into manufacturer's shop tests and Bureau of Ordnance tests. (See Publication OP 400). Manufacturer's shop tests are further subdivided into "type" tests and "routine" tests. The "type" tests are a complete series of tests to-determine compliance of the design with the applicable'~pec~f~cation requirements, and are normally conducted on the first, or one of the first, units produced. The "routine" tests are a limited series of tests to determine whether the subsequent units produced are satisfactory. The detail specification will indicate which tests are "type" and which are "routine" .

4.2 Manufacturer's shop tests.- Manufacturer's shop tests as follows, unless otherwise specified,or as may be further specified in the detail specification, shall be conducted at the contractor's plant, In the presence of the Government Inspector or his representative. The contractor shall supply all materials, equipment, and personnel necessary for the performance of the tests, unless otherwise specified.

4.2.1 Test reports.- Detailed records of the tests, clearly Indicating quantities measured and units of measurement, shall be kept on suitable typed or printed test sheets furnished by the contractor, in the form of ordnance data publications (NAVORD OD) as specified in Publication OP 1. Copies of the test reports shall be furnished as follows at, or before, the time of delivery of the equipment. The Government inspection shall retain the original (master) copy of the report, unless otherwise specified.

4.2.1.1 Type test report distribution.- Distribution shall be as follows:

Bureau of Ordnance ..... 2 copies
Naval Gun Factory, Washington, D.C.....
..... 1 reproducible copy plus 1 copy
Supply Officer or Naval Inspector of Ordnance at each point of delivery, for equipment to be delivered at that point:
For the use of the installing agency ..... 1 copy
For each ship receiving equipment ..... 1 copy
For spare equipment ..... 1 copy

4.2.1.2 Routine test reports.- Routine test reports of each equipment are to be retained by the Government inspector, unless otherwise specified. One copy of each ordnance data (NAVORD OD) publication, in reproducible form, summarizing the routine tests of hydraulic equipment furnished under each contract shall be forwarded to the Bureau of Ordnance. The summary shall list for each routine test required by the detail specification only the highest and lowest values found in all of the routine test reports for each type of hydraulic equipment.

4,2,2 General examination.- Each hydraulic system and unit thereof shall be carefully examined to determine conformance with the detail specification with respect to the required drawings, materials, workmnanship, protective coatings, finish, and all other requirements not specifically called for under the *test* procedures .

4.2.3 Hydrostatic tests.- Unless otherwise specified, all hydraulic equipments subject to working pressure shall be subjected to a hydrostatic pressure equal to two times the maximum required relief valve setting or 1,000 pounds per square inch above the maximum required relief valve setting, whichever is the smaller value for that part of the system, for a period of at least 10 minutes. No part shall show any sign of unacceptable external leakage, failure, malfunction, or take any permanent set during this test It shall be permissible during the hydraulic test to utilize external or internal stops, locks, or other means to prevent motion of or damage to valves, pistons, *or* other parts.

4.2.3.1 Hydrostatic test of tanks.- Tanks, which normally operate at approximately atmospheric pressure, shall be subjected to an internal pressure of 5 pounds per square inch in excess of the maximum operating pressure for a period of at least 10 minutes . Pressure surges during operation shall be taken into consideration in determining the maximum operating pressure. The tanks shall show no sign of leakage during, or permanent deformation after, the test.

4.2.3.2 Submergence test.- Tests shall be conducted to determine compliance with the requirement of paragraph 3.2.18.

4.2.4 Performance tests.- Each hydraulic system shall be subjetted to performance tests, including the following tests, which Will , in general, be designated in the detail specification as "type" or "routine" tests. The hydraulic pump need not be driven during these tests by the electric motor intended for final installation, unless specifically required.

On all performance tests, the pertinent data shall be measured and recorded at the beginning, middle, and end of' the tests , and at suitable intervals throughout the test. The size and length of piping should be comparable to that intended for the shipboard installation.

4.2.4.1 Power and efficiency.- Power and efficiency tests shall be performed in accordance with the requirements of the detail specification. During the tests, the arrangement and adjustment of all equipment undergoing test shall be the same as for service Installation, unless otherwise specified or allowed. Cyclic controls causing intermittent motion may be removed during this test.

4.2.4.2 Temperature rise.- A duty cycle will be specified in the detail specification for the temperature rise test. The temperature rise at the hottest part of the hydraulic sytem shall not be greater than the value obtained by subtracting 110 degrees Fahrenheit (the maximum required ambient temperature for satisfactory operation) from the maximum allowable hydraulic fluid temperature furnished by the contractor in response to paragraph- 3.4.1 .6.

4.2.4.3 No-load power loss.- With the pump being driven at its normal operating speed,but with the pump unloading device functioning so that no useful work is being performed, a test shall be performed to demonstrate that the overall No-Load Power Loss does not exceed that allowed by the detail specifications, when the temperature of the hydraulic fluid is approximately 120 degrees Fahrenheit.

4.2.4.4 Noise and vibration.- Noise and vibration shall be noted during all ests . Excessive noise or vibration shall be cause for rejection of the equipment.

4.2.4.5 Slow speed test.- The following slow speed test will normally be required only for hydraulic equipment which is intended for operation of training and elevating gears. With the hydraulic pump being driven at normal operating speed and with the hydraulic motor output shaft delivering the torque specified In the detail specification, the maximum variations of the time of quarter turns of the output shaft, at an intended speed of one revolution per minute (in each direction), shall not exceed 20 percent of the average value. If no torque is specified, it shall be approximately equal to that developed by a hydraulic fluid pressure equal to 1/2 of the relief valve pressure setting l This test shall be conducted starting with the hydraulic fluid at about room temperature and then shall be repeated with the hydraulic fluid at the maximum temperature reached during the power arm efficiency test of paragraph 4.2.4.1

4.2.4.6 Lubrication tests.- Lubrication of variable-discharge hydraulic pumps shall be investigated by the performance of the following test, with a head of hydraulic fluid on the pump not exceeding the static head of the final Installation, except that if supercharging means will be used In service, the pumps shall be similarly operated during the tests:

(a) The Pump shall be rotated continuously at normal operating speed under "zero-stroke".

(b) The pump shall be rotated at normal operating speed under "zero-stroke" for a total elapsed time of 50 hours during which, at 10 minute intervals, the stroking mechanism shall be moved rapidly through a complete cycle (that is, from neutral to the extreme position in one direction, then to the extreme position in the reverse direction, and finally to neutral). During these tests there shall be no indications as evidenced by marked changes in power consumption, noise, or otherwise, that the pump is being excessively worn or poorly lubricated.

4.2.4.7 Leakage tests.- The following tests shall be conducted with hydraulic fluids conforming to Specification 51 F 21 at a temperature not less than 120 degrees Fahrenheit.

4.2.4.7.1 External leakage.- External leakage shall be measured during the Endurance tests of paragraphs 4.2.4.9.1 and 4.2.4.9.2. The leakage of hydraulic fluid shall not exceed 5 cubic centimeter per hour of operation for power transmission units or per 1,000 cycles for cyclic equipment.

4.2.4.7.2 Internal leakage.- Variable speed hydraulic power transmission equipment shall be tested for internal leakage by locking the hydraulic motor shaft (In its most leaky position) to prevent rotation. With the pump rotating at rated speed, measure the movement of the stroking mechanism from the neutral position necessary to develop hydraulic pressures of 60 percent and 100 percent of the maximum continuous rated working pressure stated in response to paragraph 3.4.1.9. Measurements shall be made on each side of the neutral position. Relief valves may be rendered inoperative if required for this test.

To determine the dynamic leakage characteristics of the hydraulic motor, the stroking mechanism shall be held at an angle which produces approximately 40 revolutions per minute of the hydraulic motor shaft under no load. Readings of hydraulic motor speed versus differential pressure drop across the motor shall be taken at 25, 200, 400, 600, 800 and 1,000 pounds per square inch, first in one direction and then in the other. Relief valves may be rendered inoperative for this test.

4.2.4.8 Low temperature test.- The hydraulic system shall be tested to demonstrate its ability to start and to operate continuously (but not necessarily at the required speed and efficiency) at the minimum ambient temperature prescribed In the detail specifications, without overloading or stalling the electric motor. The pump shall be driven by the electric motor Intended for final installation.

If the contractor has no facilities for low temperature tests, arrangements may be made for conducting this test at a Government laboratory. The information furnished with the bid should indicate whether or not the bidder desires to make special arrangements for this test.

4.2.4.9 Endurance test.- Each type of hydraulic system shall be subjected to endurance tests as described in the detail specification. In general, the endurance tests will Include the following requirements, with the hydraulic fluid temperature not less than 120 degrees Fahrenheit. The hydraulic system shall operate satisfactorily at the end of the tests, with no failure of parts and no excessive wear during the tests.

4.2.4.9.1 Variable speed power transmissions.- The stroking mechanism of the hydraulic pump shall be controlled by suitable means to oscillate with approximately simple harmonic motion about the neutral position of the stroking mechanism. The amplitude of this motion shall be 9/10 of the full speed displacement of the stroking mechanism. The period of oscillation, unless otherwise specified In the detail specification, shall be 2 seconds (on large units the period may be 4 seconds). The hydraulic motor shall be connected to a flywheel of such moment of inertial to produce pressures equal to the maximum rated pressure. This test shall continue for 500 hours.

4.2.4.9.2 Cyclic equipment.- Unless otherwise stated in the detail specification, cyclic equipment, such as hoists, gun loading mechanisms, etc., shall be operated at normal cyclic rate, simulating possible extreme conditions which may be encountered in service, for at least 50,000 cycles.

4.2.4.9.3 Accumulators.- Each type of accumulator using a diaphragm or bag separator, with the associated unloading, relief and check valves shall be operated for 1,000,000 cycles. During this test, the number of cycles in which the accumulator fluid pressure Is reduced to zero pounds per square inch shall be 100,000 cycles. The remaining 900,000 cycles In which normal cycling between normal cut-in and cut-out pressures occurs shall be controlled by the unloading valve.

4.2.4.10 Jam test. - Whenever required by the detail specification, It shall be demonstrated that no part of the equipment will be damaged if each operating unit of the hydraulic system Is stopped or held securely In any position of the stroke (or motion) of the unit, and the appropriate controls are positioned to move the units l

4.2.4.11 Malfunction tests.- A series of control operations shall be performed, including any possible Inadvertent or unintended operations, to determine any malfunctioning which could be encountered.

4.2.4.12 Emergency operation.- All emergency provisions in the hydraulic system shall be operated to determine their adequacy .

4.2.4.13 Shock and vibration.- Each type of hydraulic equipment shall be tested in accordance with Specification MIL-S-901. When applicable, the detail specification will prescribe the required vibration tests. Unless otherwise specified in the detail specification, the vibration tests shall be conducted In accordance with Specification MIL-T-17113. If the contractor has no facilities for conducting these tests, arrangements may be made for their completion at a Government *facility.

4.2.4.14 -Wear.- Each equipment submitted to type tests shall afterward be disassembled and Inspected for wear. Any wear considered excessive shall be reported to the Bureau of Ordnance; it may cause the worn unit or the entire equipment to be rejected. After completion of type tests and before delivery of the equipment, worn parts shall be replaced as required by the inspector, and the equipment shall be subjected to routine tests.

4.3 Service tests.- Service tests, as required by the detail specification, will be performed after delivery of the equipment . Any test required to be performed as a manufacturer's shop *test* may be repeated as a service test, and when so repeated, the service test results shall be considered conclusive. During service tests, all valves and other adjustable mechanism of the hydraulic system shall be at the same condition of adjustment with which the equipment passed the manufacturer's shop tests. The contractor shall have the privilege of witnessing the service tests through representatives whose appointment for such purpose shall be subject to approval of the Bureau of Ordnance.

Service tests may be sub-divided Into "type tests" which are to be performed upon representative equipments, and "routine tests" which are to be performed upon each equipment as delivered; but any "type test" may be performed as a "routine test" upon any equipment delivered.

When so specified, acceptance of an equipment will be contingent upon Its performance during service tests. When not otherwise specified, the replacement or repair of parts or units shown to be defective by service tests Is covered by the contractor's guarantee.

5. PREPARATION FOR DELIVERY

5.1 General.- Because of variations in size, shape and weight hydraulic units, the following methods of preservation, packaging and packing may not be practicable for all parts of hydraulic systems. The contractor shall submit for Bureau of Ordnance approval any proposals for alternative methods considered more applicable or desirable.

5.2 Preservation.- Unless otherwise specified or approved, hydraulic equipment shall be cleaned internally and completely filled with hydraulic fluid conforming to Specification 51 F 23, and then completely sealed with suitable closures. When shipment of a filled system is not practicable, thin film protection of Internal surfaces in accordance with Specification MIL-C-16173, Grade 2 is acceptable.

All pipe flanges shall be sealed for shipping purposes by plates extending over the entire flange area instead of by discs centered in the gasket area. Piston rods shall be placed In a retracted position and the remaining exposed surface shall be coated with rust-preventative compound conforming to Specification MIL-C-16173, Grade 2. The piston rods shall then be completely wrapped with moldable Grade C paper confirming to Specification JAN-B-121. Exterior bare metal surfaces shall be protected from corrosion by coating with Compound conforming to Specification MIL-C-16173, Grade 2, when the equipment will be boxed and stored indoors. For exterior bare metal surfaces on equipment which may be stored outdoors in an unboxed condition, these surfaces shall be coated with gun slushing compound conforming to Specification 14 C 8. Projecting parts, such as drive shafts, shall be covered with a suitable protective cover to prevent possible mechanical damage. Preservation of spare parts shall be in accordance with instructions furnished by the Ordnance Supply Office.

5.3 Packaging.- Each hydraulic unit, unless otherwise specified or approved, shall be wrapped in greaseproof paper Specification JAN-B-121 Grade A and sealed with tape, Specification JAN-P-127. For overseas packaging, the wrapped equipment shall be cushioned and packaged in a paperboard box conforming to Specification JAN-P-120 or JAN-P-133 or a fiberboard box con-

forming to Specification JAN-P-108. For domestic packaging, the following Specifications apply: LLL-B-631, LLL-B-636, and PPP-B-676. For heavy equipment wooden boxes in accordance with Specification PPP-B-601 or NN-B-621, may be required to provide adequate protection.

5.3.1 Weight limitations.- Unless the weight of a single item exceeds the weight limitations specified herein, the gross weight of an individual shipping container shall not exceed 200 pounds for domestic shipment and 150 pounds for overseas shipment. For fiberboard boxes the gross limitation shall not exceed the weight shown on the box maker's certificate. Where weight limitations shown on the box maker's certificate exceed those shown in the applicable box specification, the limitations of the specification shall apply.

5.4 Packing.- Unless otherwise specified, all items shall receive domestic packing. Each container shall be designed to enclose the contents in a snug, tight fitting manner.

5.4.1 Domestic packing.- Unless otherwise specified, Interior packages shall be packed in substantial containers so constructed as to insure acceptance by common or other carrier for safe transportation at the lowest rate to the point of delivery. When fiberboard exterior containers are used, such containers shall be fabricated from fiberboard having a Mullen test of 275 pounds or more. Containers shall be able to withstand storage, rehandling, and reshipment without the necessity of repacking.

5.4.2 Overseas packing.- Unless otherwise specified, for overseas packing the interior containers shall be packed in an exterior shipping container in accordance with Specification PPP-B-601 or JAN-P-106. All plywood, when used, shall conform to Specification NN-P-515, Type I or II, Class 2. Each exterior container shall be furnished with a sealed case liner fabricated from barrier material meeting the requirements of Specification JAN-P-125. All seams and closures of the case liner shall be sealed with adhesive in accordance with Specification MIL-A-140.

5.5 Marking.- Marking of unit, intermediate, and shipping containers shall be accomplished in accordance with Standard MIL-STD-129. Wherever the nature of the unit package is such that it does not lend Itself to stenciling or where the use of a label is Impracticable, a leather, metal, waterproofed cloth, or waterproofed shipping tag bearing the required markings shall be used.

6, NOTES

6.1 Intended use.- This specification may be used for any of the following purposes:

(a) As a guide in the preparation of detail specifications for the development, design, and test of hydraulic systems. Applicable portions of this general specification may be incorporated directly Into the detail specification.

(b) As a reference specification. The detail specifications may refer to applicable paragraphs of this general specification.

(c) As a procurement specification for specific (usually simple) components of hydraulic systems when the necessary detailed requirements needed to supplement the general requirements can be adequately covered by relatively brief statements in the contract.

6.2 Deviations.- The requirements of this specification are generally applicable to shipboard ordnance hydraulic systems and are based upon service experience to date. Deviations from these requirements, when included in a specific detail specification, will be considered by the Bureau of Ordnance upon the presentation of substantiating data by the bidder or contractor.

Patent notice: When Government drawings, specifications or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications , or other data is not to be regarded by implication or otherwise as In any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

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SPECIFICATION ANALYSIS SHEET

Form Approved
Budget Bureau No. 119-R004

INSTRUCTIONS

This sheet is to be filled out by personnel either Government or contractor, involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity *(as indicated on reverse hereof)*.

SPECIFICATION

ORGANIZATION *(of submitter)* | CITY AND STATE

CONTRACT NO. | QUANTITY OF ITEMS PROCURED | DOLLAR AMOUNT
$

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A. GIVE PARAGRAPH NUMBER AND WORDING.

B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES.

2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID

3. IS THE SPECIFICATION RESTRICTIVE?

☐ YES ☐ NO IF "YES", IN WHAT WAY?

4. REMARKS *(Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity)*

SUBMITTED BY *(Printed or typed name and activity)* | DATE

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