US COAST GUARD
VISCOUS OIL PUMPING SYSTEM
(VOPS) OPERATION GUIDE

Prepared by

Commandant G-SEC-2C
Ocean Engineering Division
Office of Civil Engineering
US Coast Guard
2100 Second St. S.W.
Washington D.C. 20593
(202) 267-1094

Edition 1
01 October 2001

Acknowledgements:

This manual is a working guide for use in the instruction, operation and maintenance of the Coast Guard Viscous Oil Pumping System (VOPS). It is a system summary produced from system research and development sponsored by the U.S. Coast Guard from September 1999 to October 2000.

The principal personnel responsible for the direction of the VOPS development effort were:

Lieutenant Robert Loesch
U.S. Coast Guard Headquarters
Ocean Engineering Division
Washington, D.C.

Commander Michael Drieu
Eight Coast Guard District (mer)
New Orleans, LA

Mr. Craig Moffat
GPC/PCCI – U.S. Navy
SUPSALV
Williamsburg, VA

NOTE: FOR VOPS TECHNICAL SUPPORT, CONTACT:

HYDE MARINE, INC.
28045 RANNEY PARKWAY
CLEVELAND, OH 44145-1144
TEL: 440-871-8000 MOBILE: 440-725-3813
FAX: 440-871-810

OUTLINE

1.0 OVERVIEW

1.1 Objectives of the VOPS manual
1.2 Background of the VOPS
1.3 When to use the VOPS

Figure 1-1 *Concept of the USCG VOPS*
Figure 1-2 *Concept of the Annular Water Injection Flange*
Figure 1-3 *VOPS Kit Major Components*
Figure 1-4 *Annular Water Injection Flange and Water Side Hose and Piping Sub-Assembly*

2.0 SYSTEM CONFIGURATION AND SITE SET UP

2.1 The Annular Water Injection Flange (AWIF)
2.2 Mounting the AWI flange onto the DOP250 pump
2.3 Access to Oil Tank
2.3.1 Hydrasearch Fitting Adaptor
2.4 Securing Line
2.5 Monitoring Pipe Section
2.6 Rupture Disc Pressure Relief Device
2.7 AWI Water Pump
2.8 Hydraulic Power Requirements
2.9 Hydraulic Power Unit (HPU)
2.10 Hydraulic Flow Control Stand
2.11 National Strike Force Strike Team VOPS Ready Load

Figure 2-1 *The Annular Water Injection Flange (AWIF) with Monitoring Pipe Section Attached*
Figure 2-2 *Off-Loading Cut-Away of Pumping from Double Bottom of Cargo Vessel*
Figure 2-3 *Recommended VOPS Shipboard Arrangements*
Figure 2-4 *The Monitoring Pipe Section*
Figure 2-5 *The Annular Water Injection (AWI) Pump*
Figure 2-6 *The Coast Guard High Volume Pumping Unit (HVPU)*
Figure 2-7 *VOPS Hydraulic Flow Control Stand*
Figure 2-8 *General Schematic for VOPS Layout*
Figure 2-9 *Hydraulic Power Supply Component Subassembly*
Figure 2-10 *Containerization of the VOPS*
Figure 2-11 *Prime Mover Load*
Figure 2-12 *Support Hose*
Figure 2-13 *Desmi DOP 250 Product Pump*

3.0 OPERATION

3.1 General Emergency Offloading Procedures
3.2 VOPS Set Up (Hydraulic Power)
3.3 DOP250 Product Flow Rate
3.4 AWI Rotan Pump Flow Rate
3.5 Supplemental Guidance

Figure 3-1 Steam Coil on CCN150-5C

4.0 APPENDICIES

Appendix A USCG VOPS System Inventory and Vender List

Appendix B Manufacturer's Operation and Maintenance Manual USCG VOPS Water Injection Pump

Appendix C Desmi Rotan Pump and Gresen Motor Manufacturer's Operation and Maintenance Manuals

Appendix D Pump Chart Information

Figure D-1 Pump Availability Matrix
Figure D-2 Oil Viscosity Properties (in Centistokes and Saybolt Universal Units)
Figure D-3 DOP250 Hydraulic Input to Product Output
Figure D-4 DOP160 Hydraulic Input to Product Output
Figure D-5 Distance pumping curve with DOP250 using VOPS AWIF
Figure D-6 Centrifugal Pump Performance Summary
Figure D-7 Diesel Pressure Drop Through 6-Inch Hose
Figure D-8 Friction Losses at Various Viscosities with Water Injection at 6%
Figure D-9 Centrifugal Pump Capacity Pumping Fresh Water
Figure D-10 USN CCN-150 POL Pump Diesel Fuel Pumping Range Via 6 Inch Hose
Figure D-11 DOP 250 Pump Curve for 24,000 cSt. Viscosity
Figure D-12 KMA333 Pump Curve for 17,000 cSt. Viscosity
Figure D-13 USCG CCN150-5C with US Navy Wrap-around Steam Coil at 1,200 cSt.
Figure D-14 USCG CCN150-5C Pump Curve for 16,000 cSt. Viscosity

SECTION 1.0 OVERVIEW

1.0 OVERVIEW

1.1 Objectives of the VOPS Operation Guide:

This manual is to be used as the Viscous Oil Pumping System (VOPS) Operation Guide. It contains specific information on the system overview, configuration, set-up, and operation. Additionally, it contains the Annular Water Injection Pump Operating Guide, system component manufacturers' operation and maintenance guides, and a compilation of pump curves. It is the summarized compilation of viscous oil pumping research and development sponsored by the U.S. Coast Guard.

The goals of this manual are to:

1. Provide National Strike Force Strike Team members with knowledge of the VOPS including when to use, how to use, system capabilities and limitations
2. Provide National Strike Force Strike Team members with maintenance information on the equipment components of the overall system
3. Provide a basis for the development of VOPS job aids
4. Provide a basis for development of the VOPS Personal Qualification System (PQS)

1.2 Concept and Background of the VOPS:

1.2.1 Concept of the VOPS: By the nature of their high viscosities, heavy fuel oils and emulsions when pumped produce high pressures within conventional lightering hoses. This is due to high internal friction between the viscous product and the interior of the hose. Water, on the other hand has virtually no viscosity, produces much less friction when flowing, and thus can be pumped substantially easier through hose. The concept of the USCG VOPS is to introduce water into the discharge side of a positive-displacement lightering pump at a pressure greater than that of the discharged viscous product. This water mixes minimally with the discharged oil and forms a ring around the viscous product. The product, with the lubricating sleeve of water, is allowed to flow through the discharge hose at a much lower pressure and as a result at a higher flow rate. This has been referred to as "lubricated flow" and "core-annular flow". This technology, however, is referred to as "Annular Water Injection, (AWI)".

The key component of the system is an annular water injection flange (AWIF) mounted on the discharge end of a Desmi DOP-250 positive displacement screw pump. The annulus delivers a small amount of water (approximately 5 % of the oil flow) at high pressure into the oil stream. The water "ring" that is created reduces the friction between the highly viscous oil and the pipe, or hose wall. This friction reduction significantly reduces the large pressure losses incurred during viscous oil lightering operations. The concept of the USCG VOPS is shown in Figure 1-1. The operation of the AWIF is shown in Figure 1-2. Detailed diagrams of each are shown in Figures 1-3 and 1-4.

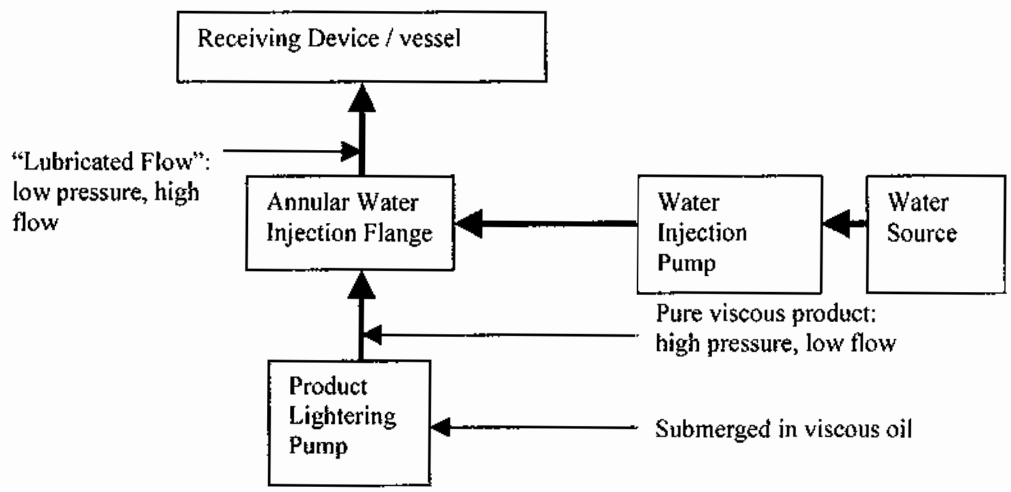
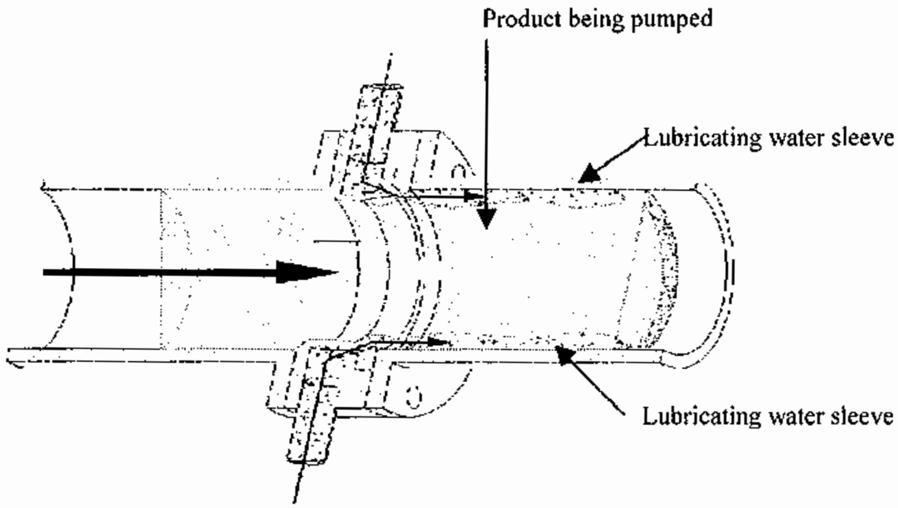


Figure 1-1. Concept of the USCG VOPS.



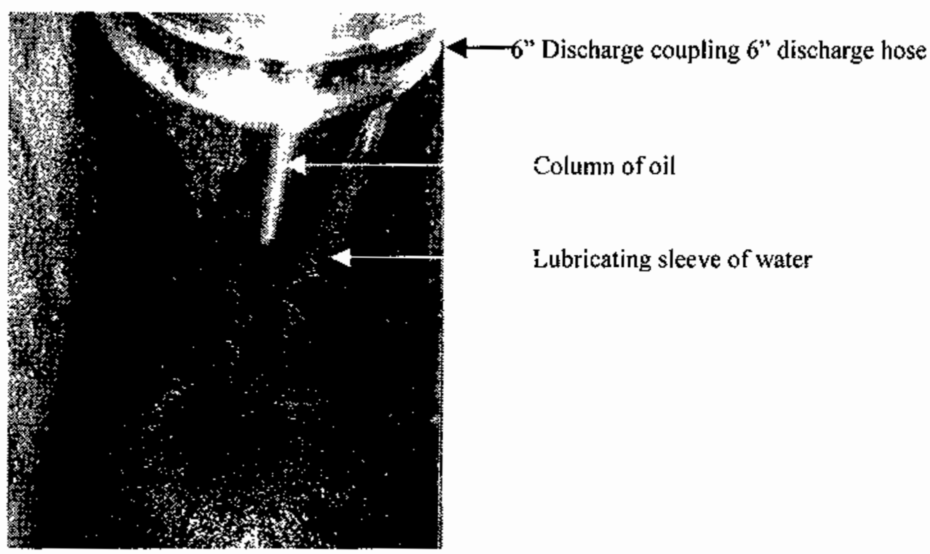


Figure 1-2. Concept of Annular Water Injection Flange (AWIF)

The upper diagram in Figure 1-2 depicts the internal theory behind annular water injection technology. The large black arrow shows the pumped fuel path up through the pipe. The small arrow traces the entrance of the small amount of water into the injector flange. The photo below shows the water ring surrounding the pumped product as it is being discharged into the holding tank.

1.2.2 Previous Work: Driven by the desire to improve the capability to lighter grounded vessels, such as the freight vessel NEW CARISSA, the U. S. Coast Guard (USCG), in partnership with the U.S. Navy Supervisor of Salvage (SUPSALV) and industry, designed, developed and tested a prototype viscous oil pumping/off-loading system.

Two variations of the annulus were tested. The original annulus used was manufactured to DIN standards and donated for testing by FRAMO of Norway. A redesigned version was fabricated by Global-PCCI, JV under contract to USN SUPSALV and USCG HQ. The new design was fabricated so that it would meet U.S. ANSI standards, and improve the flow characteristics of the water path. The other changes in the new design were in flange size, orifice dimensions, the addition of a water diversion ring, and a change in the material from steel to structural grade aluminum.

The FRAMO annulus was tested in Seattle, Washington (September, 1999), and both annuli were tested at the Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT) Facility in Leonardo, NJ (November 1999), with excellent results. A third test was conducted at the OHMSETT facility in March of 2000 using centrifugal pumps and steam injection with viscous oil. The emphasis of this batch of testing was to compare centrifugal pumps in light to medium viscous oil. The VOPS system with the AWIF was only used in one round of testing.

Test results from the September and November 1999 workshops proved that a small amount of water, circumferentially injected into an oil transfer system, is capable of dropping discharge head pressure by ratios of greater than 10:1. The highlight of the testing was the verification that the prototype water injection system (formerly called the VOPS) could transfer oil in the 17,000 cSt viscosity range through US NAVY 6 inch floating hose system over a distance of greater than one quarter of a mile. The pumping was done at a flow rate of 450 gallons per minute and a head pressure of less than 90 psig. Without the use of annular water injection techniques, one would have had to over come a head pressure of approximately 870 psig with the same oil and transfer system.

By reducing the discharge pressure in a piping system, the off-loading, or oil transfer team is able to push heavier (more viscous) oils, and or push light oils longer distances without increasing the quantity or size of the discharge pumps while increasing the safety of the pumping operation.

Next, a series of tests was carried out in Alaska in October 2000 with the AWI system using a weathered crude oil, and the same oil emulsified to 40% and 60% water by volume, resulting in a viscosity range of 1,000 to 50,000 cSt at 1 s^{-1}. Tests were done both with and without the use of AWI to compare the effect. Tests were also done using alternative AWI fluids: a 50/50 glycol/water solution, diesel, and diesel with emulsion breaker. For all tests with AWI, the injection rate was nominally 5% of the emulsion flow rate.

Use of the AWI system with water as the injection fluid dropped the line pressure significantly, from a maximum of 108 psi at a pumping rate of 600 bbl/h, to 12 psi at the same flow rate. Use of alternative AWI fluids also proved promising.

From these workshops and tests, we have been able to improve the viscous oil pumping capability of the U. S. Navy, U. S. Coast Guard and industry at minimal costs and without significantly increasing existing inventories. The addition of annular water injection allows the operator to increases both the pumped volume of very viscous products as well as the distance they can be pumped. Full pumping rates of 100 m^3/hr and higher were achieved with oil in the 17,000 cSt range out to 400 meters (1300 feet) of hose, using a very small amount of injected water (varying between 4% and 6% of the oil volume). Prior to this development heavy oil pumping was restricted to very short pumping distances. Future developments in this system in the form of pump technology and system procedures will further the enhancement of the US NAVY and USCG Pollution abatement and Salvage response systems.

By December 2000, the Coast Guard VOPS had been delivered to all three National Strike Force Strike Teams. The salient components of the VOPS as provided to the National Strike Force Strike Teams consist of the following:

1. (1) Annular Water Injection Flange (AWIF)
2. (1) Desmi Rotan Water Injection Pump
3. (1) Flow Control Stand
4. (1) Pressure Monitoring Pipe Section
5. 1300 feet of Titan 242 lay flat discharge hose with Hydrasearch fittings

It must be noted that the VOPS as provided is in itself not a complete lightering system. It is instead a system, which enhances the operation of existing lightering pump systems.

1.3 When To Use the VOPS

The VOPS to include the AWIF is an enhancement to the conventional lightering load. The VOPS should be deployed and operated whenever a heavy, viscous product requires lightering. This applies to heavy viscous oils such as Bunker C, number 6 fuel oil, water / oil emulsions, high pour point crude oils and oils at low temperatures. Number 6 fuel oil has a viscosity range of from 1,500 to 25,000 centistokes at 60 degrees F. The decision to use the VOPS may make the difference between the transfer of product and no transfer of product.

The oil or emulsion product is often thermally unstable and subject to rapid cooling and thus large increases in viscosity. Heavy fuel oils within tanker and freighter vessels is often heated to maintain transfer pumpability. If such a vessel requires lightering, its heating system will often be inoperable and the product will often cool rapidly, emulsify with seawater and become impossible for conventional lightering equipment and approaches to be successful.

The VOPS should especially be deployed and operated in instances where product transfer distance is great. Due to the highly viscous capabilities of heavy oils, transfer system pressures can easily exceed the pressure rating of the hose and fittings without the aid of the annular water injection.

The VOPS can be used to enhance the operation of a centrifugal or positive displacement pump. It has been tested successfully with the CCN150-5C, DOP250 and DOP160 pumps common to the National Strike Force. However, a centrifugal pump is not recommended for any lightering use other than for water or very light oils of up to 10,000 centistokes of viscosity (see Section 3.5).

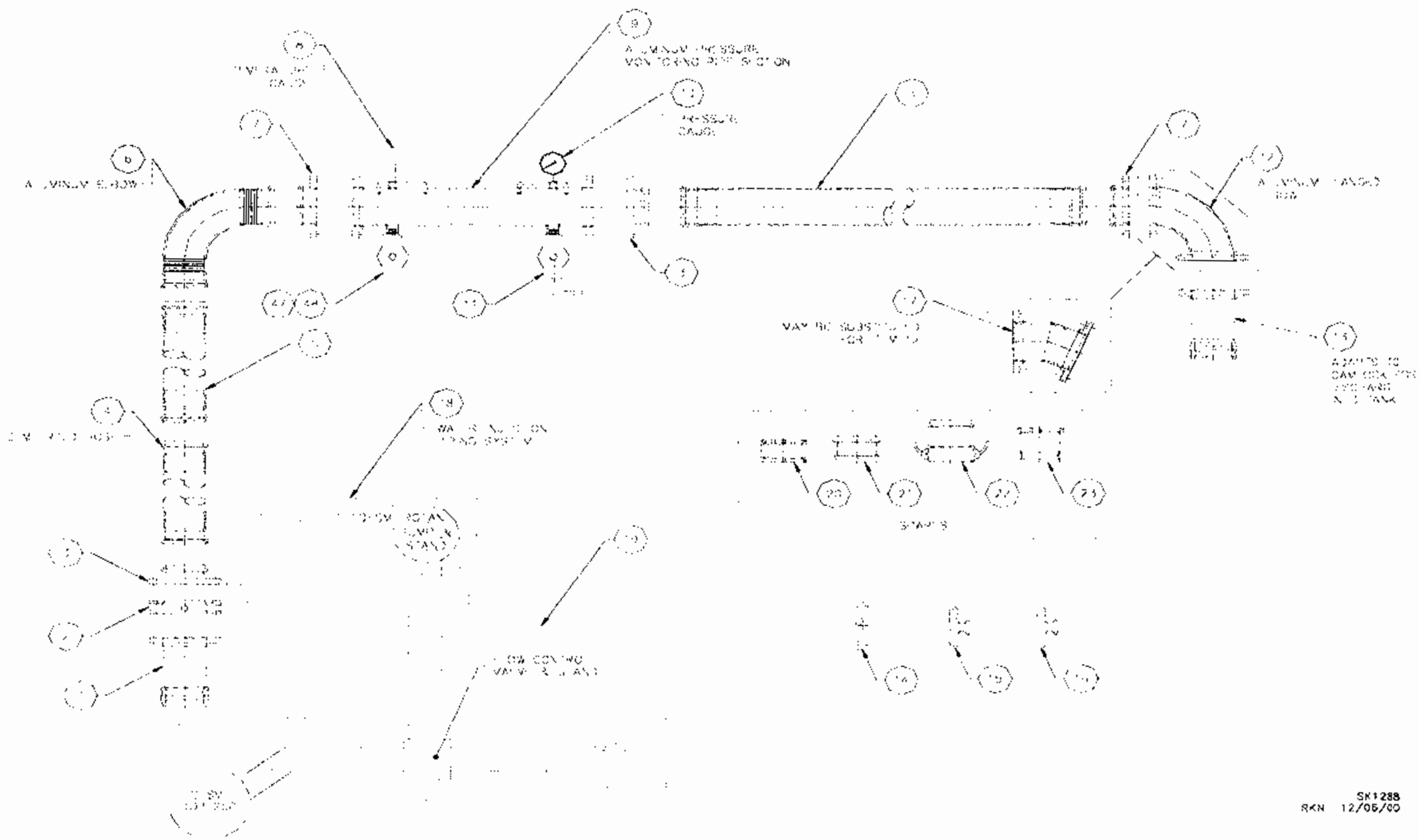


Figure 1-3. VOPS KIT MAJOR COMPONENTS (Refer to VOPS Inventory for part identification)

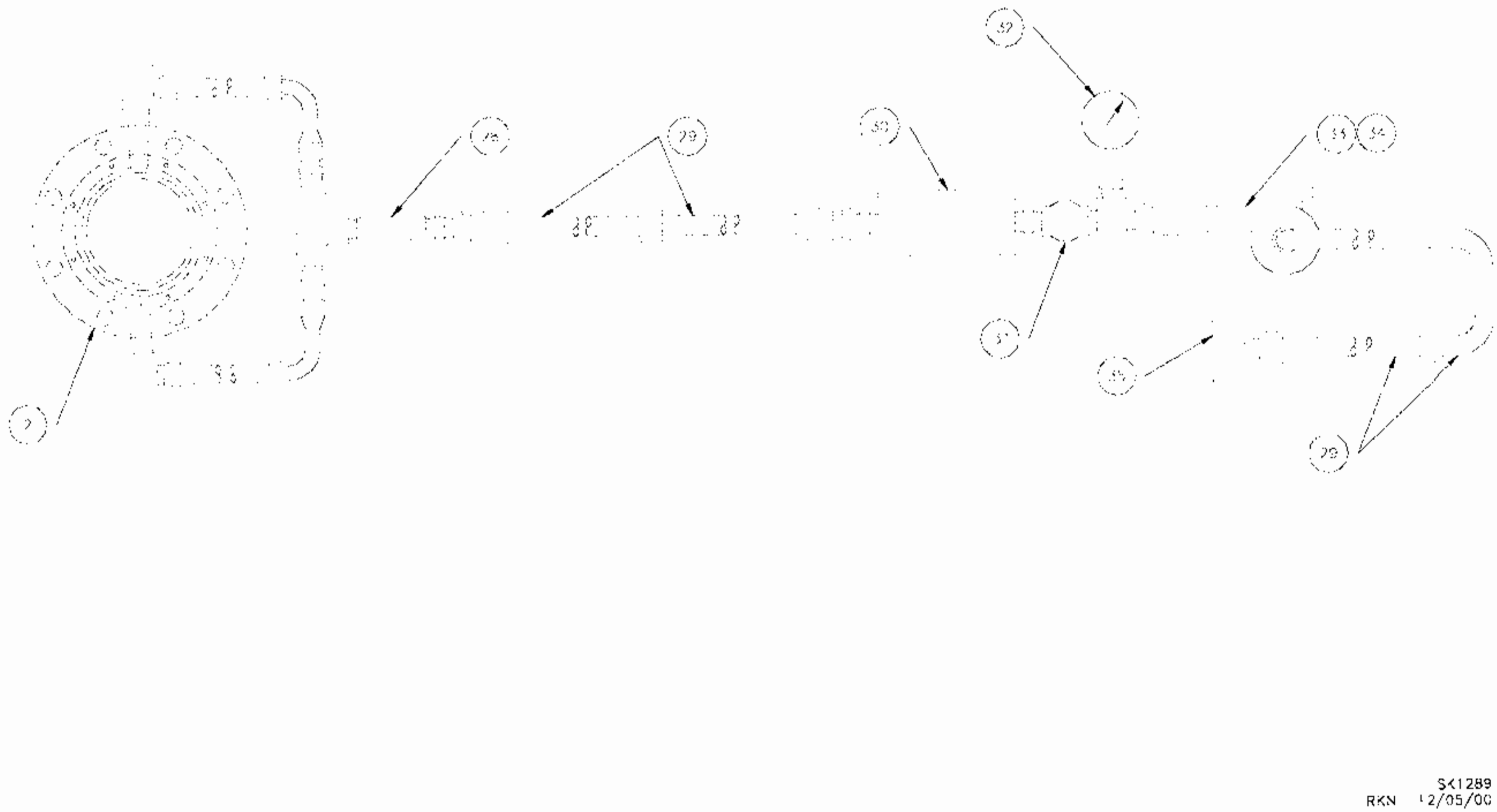


Figure 1-4. **ANNULAR WATER INJECTION FLANGE AND "WATER SIDE" HOSE AND PIPING SUBASSEMBLY**
(Refer to VOPS Inventory for part identification)

SECTION 2

2.0 SYSTEM CONFIGURATION AND SITE SET UP

Reference Figure 2-3. Recommended Shipboard VOPS Arrangement

2.1 The Annular Water Injection (AWI) Flange

The VOPS system is designed to be incorporated into, and enhance an existing off-loading pumping system. It is designed to be used when the oil characteristics to be pumped create higher frictional hose resistance than either the pump or the hose system can handle in the form of discharge pressure.

The system is based around the concept of injecting a small amount of water via uniquely designed annular injector into the internal circumference of a pipe or hose pumping oil. The water forms an internal coating or tube of water between the oil and the pipe wall. The tube or water "sleeve" replaces the oil to hose wall friction factor with an oil to water friction factor. The effect of this is a drastic reduction in head pressure from friction losses. The present AWI device is set up with an adaptor, which will thread onto the discharge nipple of the DOP250 pump.

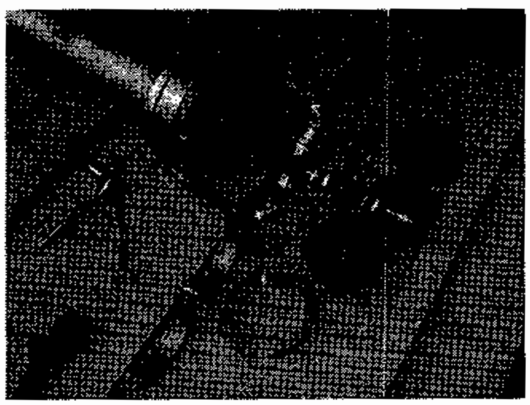


Figure 2-1. The Annular Water Injection Flange (AWIF) with Monitoring Pipe Section Attached.

2.2 Mounting the AWI Flange

This Annular Water Injector is built into a large flange that meets ANSI 150# bolting dimensions which allows it to be bolted into any matching ANSI 150# flange or adaptor. The VOPS kit includes an adaptor that has a 150# flange on one side and a female 150 mm NPSM thread on the other side that will thread down onto the existing male threaded end of a DOP250 pump (after removing the DOP250 threaded camlock from the discharge). These cam locks have either 3 or 4 (5 mm) Allen head locking screws in them that have to be removed and put back into the VOPS Flange adaptor. Also included in the VOPS kit is an allotment of 1.5" diameter discharge hose with camlock ends. This hose is the supply hose for the VOPS Flange. This hose needs to be attached to the VOPS inlet flange and secured so that it won't come off by using the dogged camlock.

2.3 Access to Oil Product

An ullage hatch, man-way or other opening that is large enough to allow the DOP250 into the tank must be located and opened. Minimum opening size for passage is 24 inches. All salvage practice precautions including but not limited to flammable vapor environments and grounding must be followed. A tripod with grip hoist or winch must be set up over the hatch with cable and hook ready to accept the DOP250. Normal bonding and grounding procedures must be practiced at all times per normal petroleum lightering procedures. The DOP250 with AWI attached should be lifted onto the grip hoist hook and lowered into the hatch opening. All hydraulic lines should be attached and secured at this time. The first section of discharge hose should be attached to the AWI flange using a hydrasearch to ANSI flange adaptor.

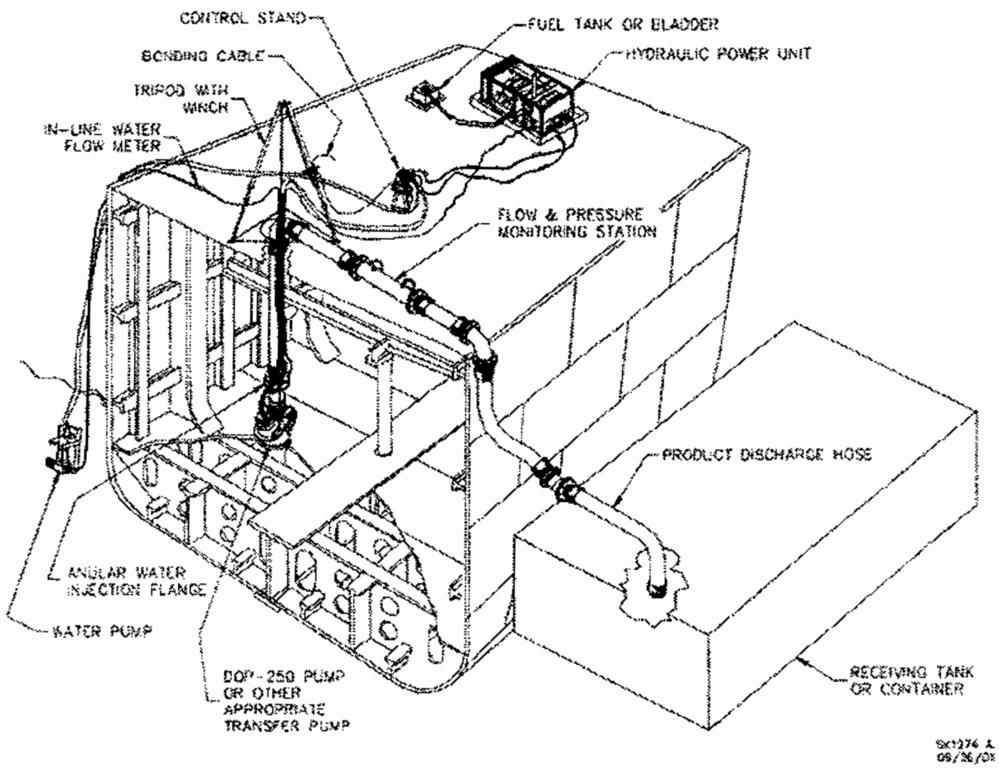


Figure 2-2. Off-loading Cut-away of Pumping from Double Bottom of Cargo Vessel

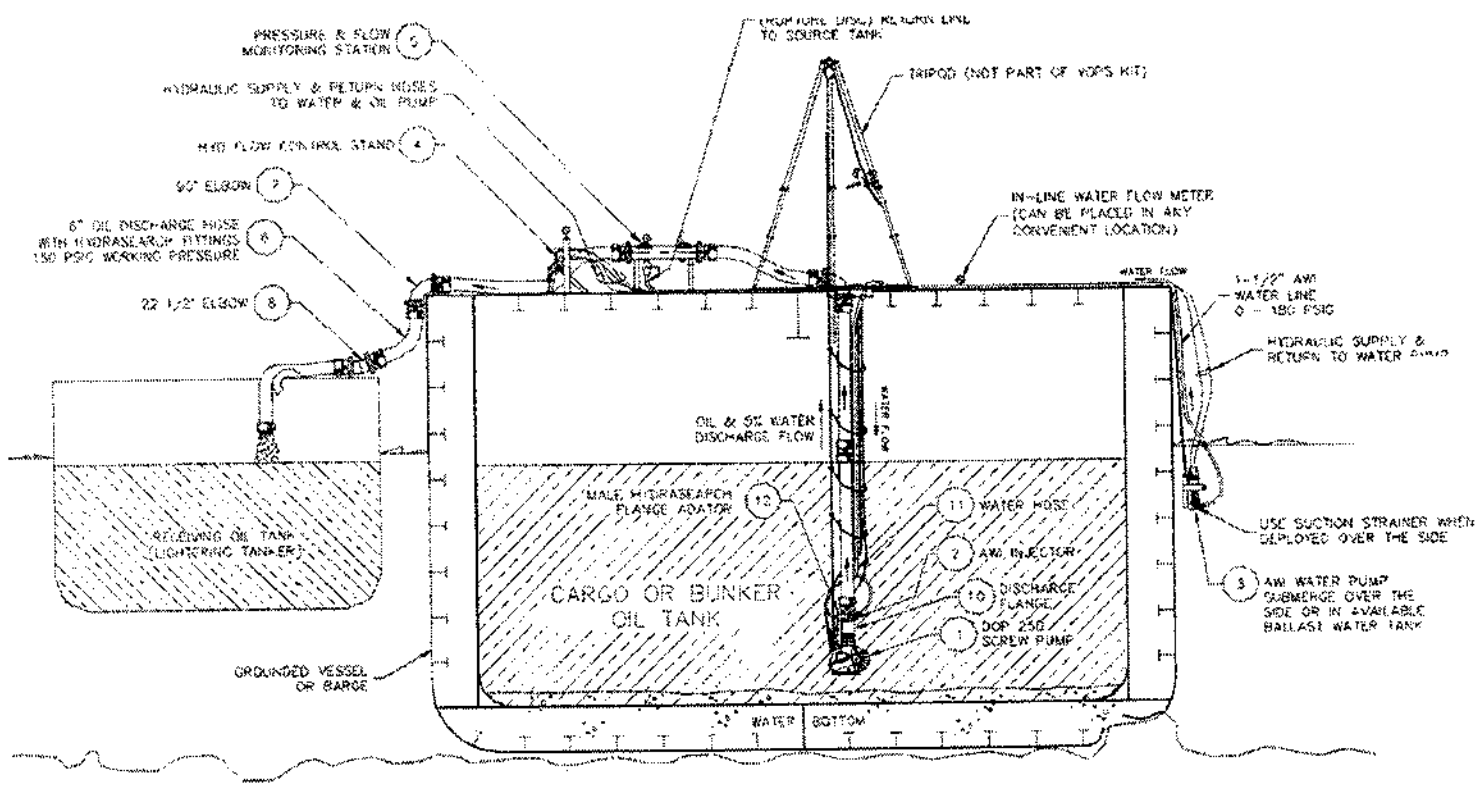


Figure 2-3. Recommended VOPS Shipboard Arrangement . Diagram meant for instructional purposes only. Follow all applicable salvage precautions.

2.3.1 Discharge Hose: The Hydrasearch Fitting adaptor is another aluminum flange that is bolted to the AWIF and allows the discharge hose connection to be attached at the flange. Almost all of the discharge hose connections in the VOPS kit are arranged in 50-foot sections. Each section terminates with one male, and one female hydrasearch fitting. The male end should always be on the discharging side of a system. (The male and female ends are most easily joined when sprayed with WD-40 or some other lubricant such as light oil). The use of a rubber mallet may be helpful in attaching new or heavily oiled hydrasearch fittings. The hydrasearch fittings are a close tolerance extruded aluminum fitting. The female end has an integral "O" ring inside. The male section is inserted into the female fitting until the mating collars are touching all the way around. Then a third piece (a hinged clamp) is placed around these collars. Once in place, the clamp can be rotated around the collars to any position. It is secured by flipping a hinged securing bolt down into a receiving slot where it is tightened using a medium size flat blade screwdriver. The female inlet and male outlet convention for fitting attachments is utilized both on the product hose mentioned above as well as the hydraulic hose used for fluid power. The first hose section used is usually the stiff or rigid 6 six foot long hose that came with the VOPS kit.

2.4 Securing line.

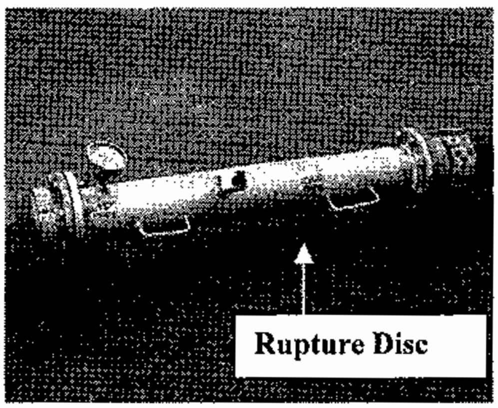
As the pump, AWI flange and hose is lowered in through the hatch opening, the operators must attach additional hose lengths as required. The resulting hose bundle needs to be strapped to the lowering cable at frequent intervals to keep them from becoming tangled and falling off into the tank. This can be done using marlin line and timber hitches or any suitable light line available.

2.5 Monitoring Pipe Section

The pump is lowered into the product oil tank either to the bottom or to a level above any water that may be in the tank if it has been holed or opened to the sea. The discharge hose and hydraulic hose bundles should be run over a "saddle" at the tank opening in order to eliminate kinks in the hose. The operator will need to install the 3-foot section of monitoring pipe (#3) into the discharge line at the first fitting that is available in the hose as it leaves the tank opening. An alternate location would be to attach it at the discharge elbow that makes the 90-degree transition from the vertical run in the tank to the horizontal deck run. The hydraulic flow control station should be located next to this station, as well, so that the pump operator can monitor system pressure, product flow rate, hydraulic pressures and hydraulic flow rate at the same location. The monitoring pipe has ports for the pressure gauge and temperature gauge located in the hard sided black instrument shipping case found with the system. These gauges need to be installed by the operator into the "monitoring pipe" section with at wrench by threading them into the female bosses in the pipe. These are all National Pipe Taper Threads (NPT).

2.6 Rupture Disc Pressure Relief Device

The rupture disc pressure relief device is simply a thin metal disc wedged into a small flange and plumed by the operator to the source oil tank. The disc will rupture or (blow open) at a given specified pressure range. The relief pressure or rupture pressure for this system is 210 psig at 70 degrees F. The disc pressure range is from about 189 psig to 231 psig. The reason for the large range of pressure relief is due to the difference in operating pressure range. The disc will break at the lower end of the range in temperatures that approach 100 degrees F, and will relieve at the higher end of the range in cold temperatures. So somewhere within that pressure range the disc will "pop" and divert part of the oil being pumped back to the source tank, which relieves some of the pressure in the system. The objective of this disc is to "POP" loudly and relieve oil pressure in the case that there is a complete blockage in the discharge line. This allows the line to relieve pressure without damaging the main hose or the DOP250 allowing the operator time to shut the system down and trouble shoot.



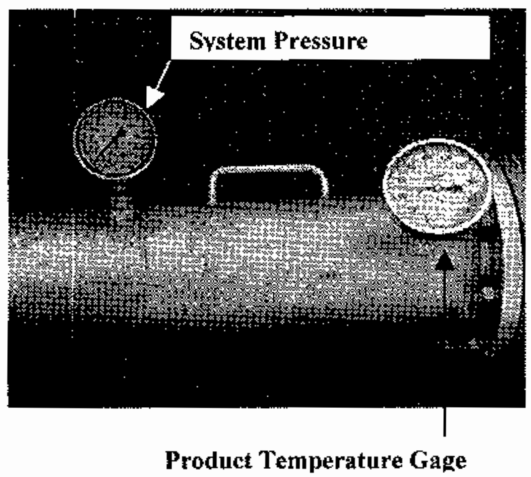


Figure 2-4. The Monitoring Pipe Section.

2.6.1 Eliminating Kinks in Discharge Hose: The VOPS system comes with 1300 feet of hose (in 50 foot sections) in its basic allotment. Lay out this hose so that it is free from obstructions, does not cross over sharp objects and is not subject to tight radius turns where the hose can kink. The kit contains several elbows. Three of theses elbows are made up with the male/female Hydrasearch fitting ends on them. These should be used in locations where radical turns are required in the hose runs. These locations would be at the transition from tank to main deck, the point where the hose leaves the ship and is directed down to a lightering barge or shore facility. Maintaining smooth runs is important to ensure that the operator is not unnecessarily adding excessive pressure losses to the pumping system.

2.7 Annular Water Injection (AWI) Water Pump

There is a small portable gear pump in the VOPS kit that has a sole purpose of providing the water for the AWI injector. This pump is also a DESMI product.

2.8 Hydraulic Power Requirements

Reference Figure 2-8 Hydraulic Power Supply Component and Sub-Assembly

The hydraulic power requirements of the system are as follows:

2.8.1 DESMI DOP250 Product Oil Pump Hydraulic power requirements
Hydraulic Flow = 0 to 42 gpm
Hydraulic Pressure = 3000 psi continuous and 3500 psi intermittent at the pump. Note: there can be significant pressure losses between the prime mover and pump.

2.8.2 DESMI DOP250 Product out-put rating
0 to 440 gallons per minute @ up to 150 psig discharge head.

2.8.3 DESMI ROTAN Water Pump Hydraulic input requirements
Hyd Flow = 0 to 9 gpm
Pressure = 3000 psi maximum

2.8.4 DESMI ROTAN Water Pump Out Put Rating
Water Flow Rate = 0 to 28 gpm
Water Discharge Pressure = 0 to 190 psig

NOTE: The DESMI Rotan Hydraulic flow rate input should not be allowed to go higher than 9 gpm. The pressure limit of 3000 psig is protected by a pressure relief valve incorporated into AWI pump circuit of the VOPS hydraulic flow control stand (4).

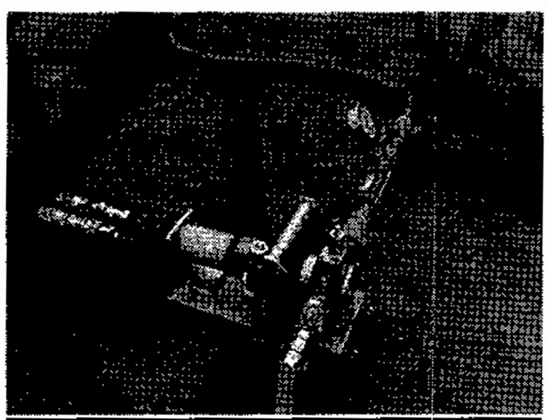


Figure 2-5. The Annular Water Injection (AWI) Pump.

2.9 Hydraulic Power Unit (HPU)

The VOPS system is designed to run from a portable hydraulic power unit such as the USCG HVPU (High Volume Pumping Unit US Navy Model 82647 "Mod 8" HPU. The USCG HVPU and The USN HPU are the same unit. The USCG HVPU is the preferred power unit for use with the VOPS. The smaller Coast Guard HPU (High Pressure Unit) may be used, however its limited hydraulic supply capacity may limit VOPS operation. Any hydraulic power unit that can supply a total of 52 gpm or more at a discharge pressure of 3000 psig or greater is capable of running the system to its full capability. This represents a power requirement of approximately 107 Horsepower as a minimum realistic size. This assumes an 85 % HPU efficiency.

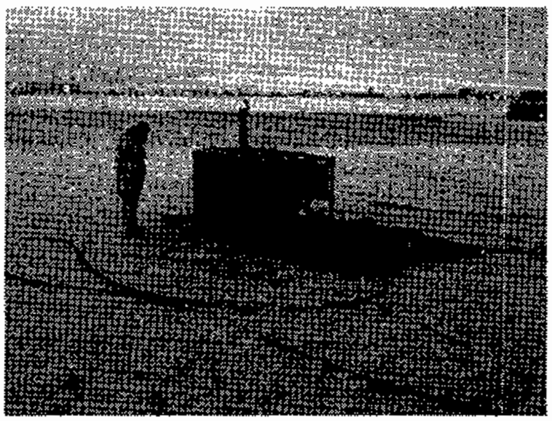


Figure 2-6. The Coast Guard High Volume Pumping Unit (HVPU)

2.10 Hydraulic Flow Control Stand

Referencing Figure 2-6 of this section, the HPU must run supply and return lines to the flow control stand. The case drain line is run directly to the DOP250 pump but should be bundled and run near the control stand for convenience. The DESMI Rotan pump does not have a case drain connection. The control stand has one each supply and return quick disconnect connection. These are Areoquip 5600-16 series Quick Disconnects (or QD's). All of the QD's in the system are of this type and size for simplification. Female ends are located in fluid receiving ports and male ends are located in fluid discharge ports. Thus the hydraulic control stand has an upper receiving port with a female Areo Quip QD and a lower outlet port with a male QD for the return line back to the HPU. The same gender and positioning trend is followed for the other four ports on the control stand.

The control stand is designed with a Gresen model V40 open center spool type control valve. This design allows the operator to adjust the HPU flow rate to any flow rate higher than the expected system total usage of 52 gpm. For example, to operate the

VOPS the operator would normally set the flow rate control knob on the Highstar HVPU to 60 gpm. This flow would run to the Gresen valve though the open center and back to the HVPU with only a very small pressure drop when no flow is needed by the system.

There are two flow control handles on the control stand. See Figure 2-7. These are blocked with removable pinned "stops" so that they can only turn in one direction for normal use. When hydraulic flow is required by one of the pumps (either the DOP250 or the Rotan water pump) the control handle is simply turned up **slowly** until the appropriate flow rate is reached.

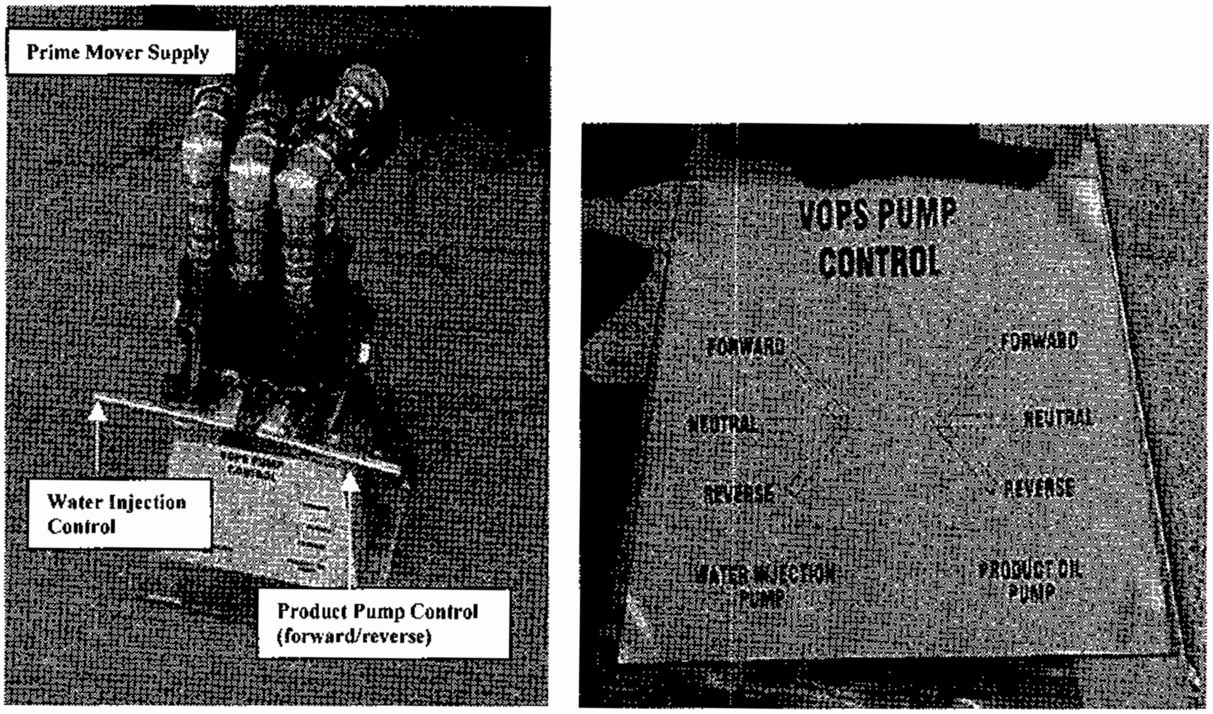


Figure 2-7. VOPS Hydraulic Flow Control Stand (prototype shown). This controls the flow of hydraulic power fluid to the water injection pump and the product pump. As seen, there is one circuit for main product pump and one auxiliary circuit for annular water injection. The reverse setting can be used to dislodge blockage from the lightering pump. To operate in reverse, remove the lever stops and rotate levers. **Do not use the reverse setting if using a centrifugal lightering pump.**

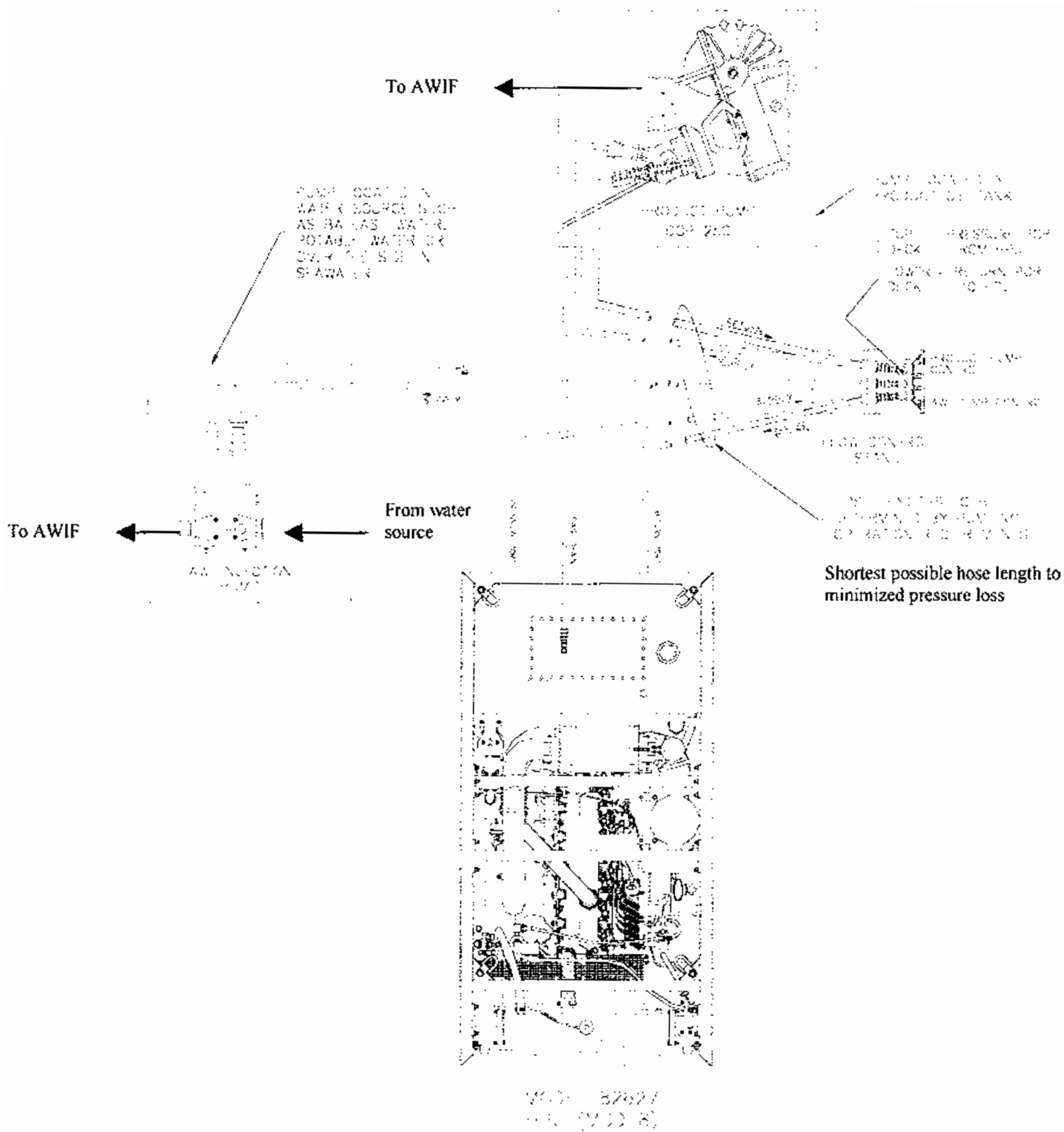


Figure 2-8. General Schematic for VOPS Layout. The above diagram shows the general schematic for laying out and connecting hydraulic hose in a VOPS pumping system. The four primary components in the system are the Hydraulic Power Unit (HPU), the Flow Control Stand, the offloading pump (DOP250 shown), and the water injection pump. **Note: AWIF is not shown.** When setting the system up on a vessel it is best to put the HPU as far away from the pumping operation as is practical to cut down on noise and sources of ignition for flammable vapors. Once the system is connected hydraulic fluid up to full output from the HPU can be applied to the control station.

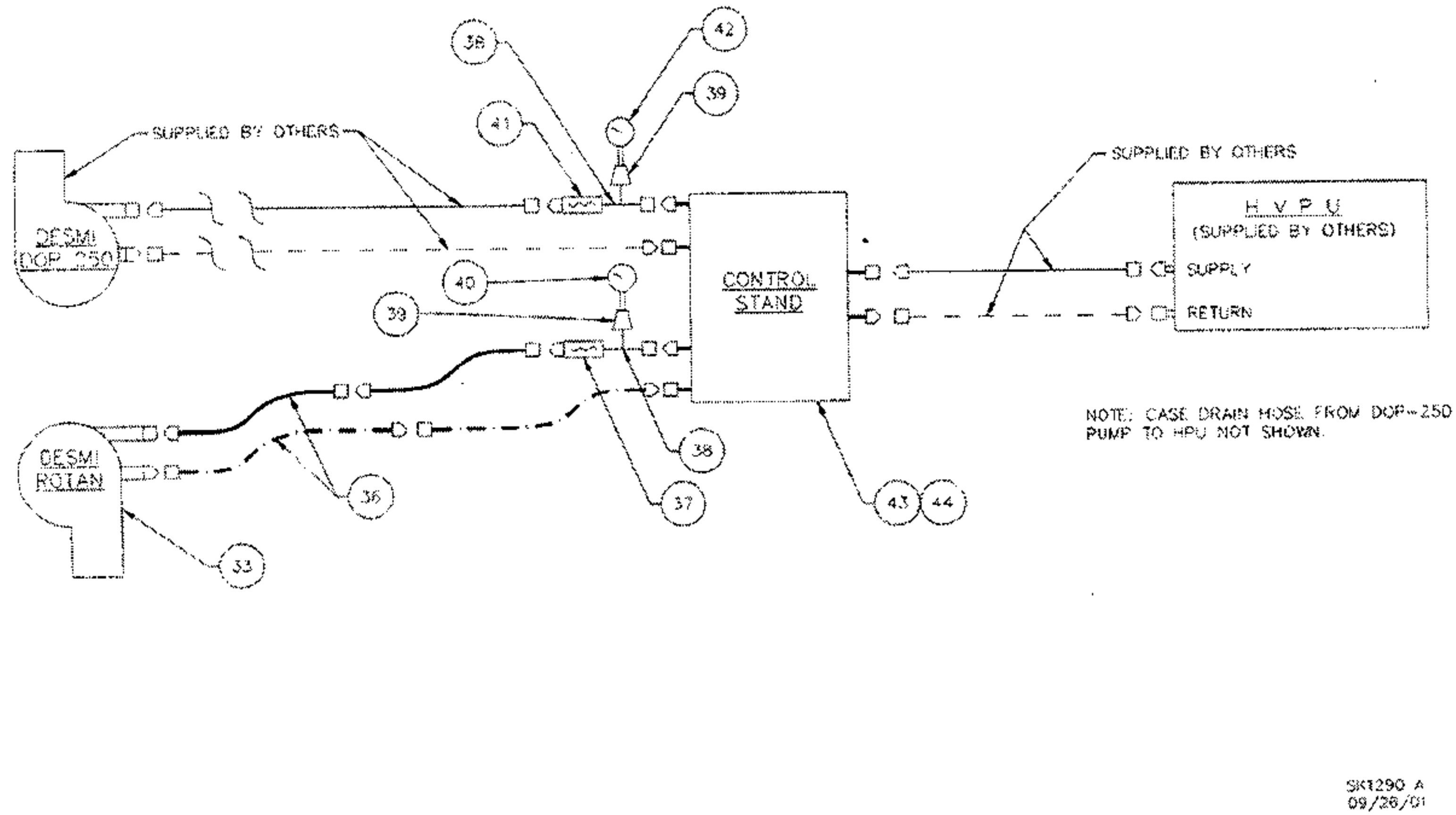


Figure 2-9. HYDRAULIC POWER SUPPLY COMPONENT SUBASSEMBLY
(Refer to VOPS Inventory for part identification)

2.11 NATIONAL STRIKE FORCE STRIKE TEAM VOPS READY LOAD

The VOPS should be integrated into the strike team standard pump load and be packed in a ready mode. The components consist of the following:

a. Control Stand, Monitoring Pipe, Accessories, and Tools: Consisting of Ropak side-drop boxes secured to aircraft-deployable pallets. The boxes contain discharge and hydraulic hose, control stand, monitoring pipe, VOPS fittings, tools etc.

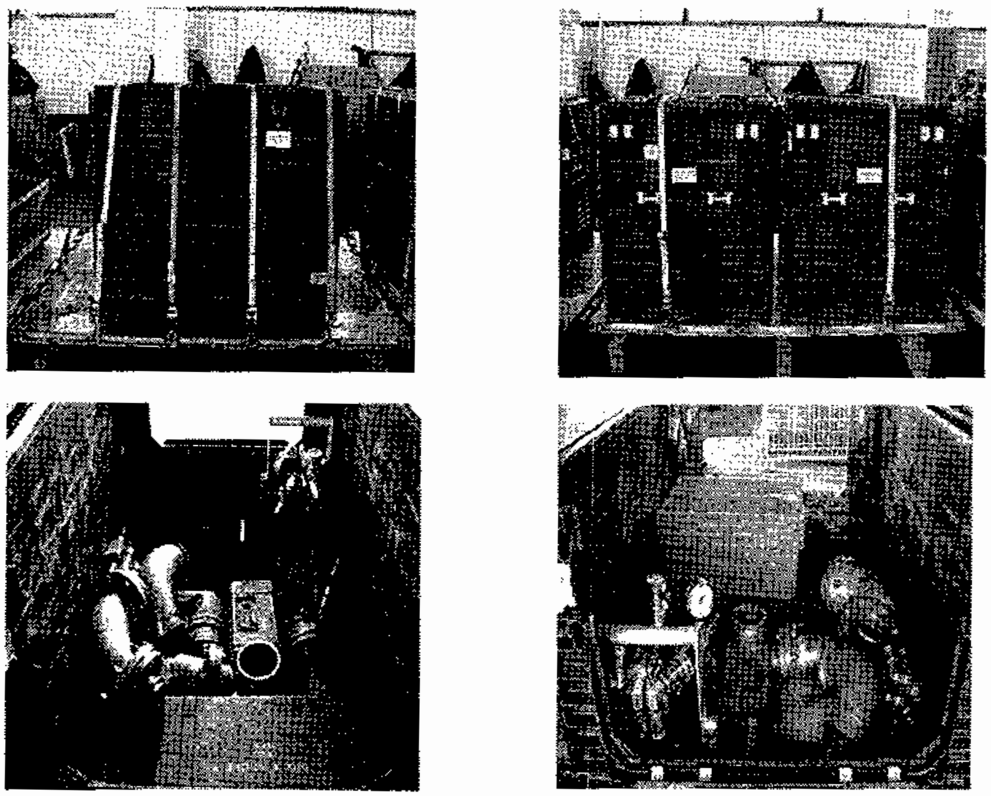


Figure 2-10. Containerization of the VOPS

b. Prime Mover Load. Consisting of a Coast Guard HPU or HVPU secured to an aircraft-deployable pallet.

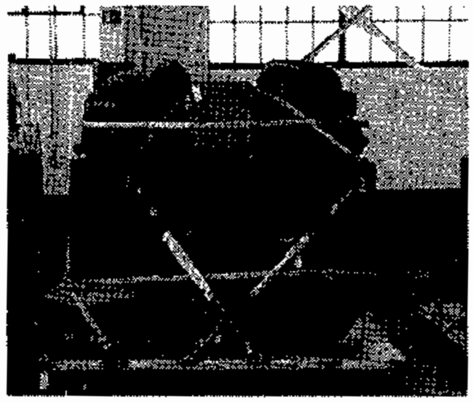


Figure 2-11. Prime Mover Load

c. Hose. 1300 feet of Titan 242 6-inch lay-flat with Hydrasearch fittings capable of a working pressure of 150 psi.

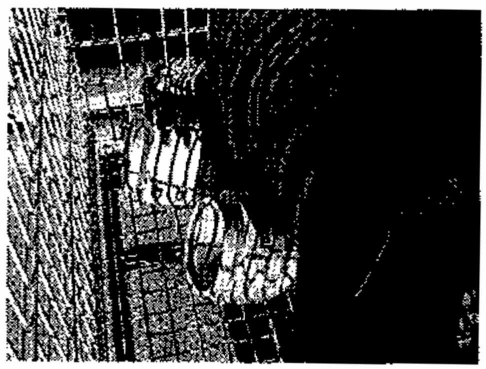


Figure 2-12. Support Hose

d. Product Pump. The VOPS will operate with many types of pumps such as the DOP250, DOP160 and CCN150-5C. However, the pump of choice is the DOP250. This pump is part of the Strike Team Large Pump Load.

Figure 2-13. Desmi DOP 250 Product Pump

SECTION 3

3.0 OPERATION

3.1 General Emergency Offloading Procedures

Conduct all operations in accordance with standard salvage practice. Chapter 6 of the U.S. Coast Guard National Strike Force Standard Operating Procedures provides salvage and lightering guidance. This is located at Contact the U.S. Coast Guard Marine Safety Center at (202)-366-6480, or 1-800-323-7233, or salvage@msc.uscg.mil prior to using Chapter 6 of the Operating Procedures. First, data must be gathered on oil type, oil temperature, viscosity, tank arrangement and access and any changing conditions. Information must also be gathered on vessel resources such as oil heating systems.

Set up the system as described in Section 2 System Component Description And Site Set Up. The tanks to be off-loaded must be identified after consulting with the Marine Safety Center. Master, Salvage Engineer or Naval Architect to determine the proper off-loading plan. The second step is to ensure that the recipient of the pumped product is ready to receive the volume of oil and water required to be off loaded. A pumping plan must include the procedures for communications, signals and terminologies used. Proper communications equipment (radios) is absolute essential unless the receiving party is with in close visual and hearing distance.

All precautions pertaining to flammable and or combustible cargos must be adhered to. This would include the proper bonding and electrical grounding of all off-loading and pumping equipment. Also the proper precautions pertaining to breathing of petroleum vapors must be strictly followed. This is especially pertinent when crude oil is being pumped. Sour crude oils, which are very prevalent in oil fields around Mexico and the Middle East, can give off Hydrogen Sulfide gas (H_2S). H_2S is not only extremely flammable but also is very toxic in even small concentrations. H_2S can also become pyrophoric. When left in a rusty tank without oxygen, H2S combines with iron oxide to form iron sulfide. When oxygen is re-introduced into the space it reverses the process creating enough heat, which can ignite a flammable vapor. This is why it is very important to gas free a tank using the tankers inert gas system.

If pumping from a grounded or stranded vessel to a shore facility via long hose runs, e.g., more than 300 feet, radio communications will be absolutely essential. Personnel safety for pumping operators, shipboard personnel and civilians must be the primary concern at all times.

3.2 VOPS Set-Up (Hydraulic Power)

Locate the HVPU out of the hazardous zone, but as close to the lightering and water injection pumps as possible to minimize hydraulic pressure loss. The HVPU must have supply and return lines run to the flow control stand. The flow control stand allows the separation of fluid power to the different pumps, it provides flow rate control to each individual pump, and it also provides pressure limit protection for the DESMI ROTAN pump. The case drain line is run directly to the DOP250 pump but should be bundled and run near the control stand for convenience. The DESMI Rotan pump does not have a case drain connection. The control stand has one each supply and return quick disconnect connection.

The control stand is designed with a Gresen model V40 open center spool type control valve. This design allows the operator to adjust the HPU flow rate to any flow rate

higher than the expected system total usage of 52 gpm. For example, to operate the VOPS the operator would normally set the flow rate control knob on the Highstar HVPU to 60 gpm. This flow would run to the Gresen valve though the open center and back to the HVPU with only a very small pressure drop when no flow is needed by the system.

There are two flow control handles on the control stand. These are blocked with removable pinned "stops" so that they can only turn in one direction for normal use. When hydraulic flow is required by one of the pumps (either the DOP250 or the Rotan water pump) the control handle is simply turned up **slowly** until the appropriate flow rate is reached. If the lightering pump becomes clogged with debris, remove the stops and reverse the flow lever. Never reverse flow if using a centrifugal pump.

3.3 DOP250 Product Flow Rate

The DOP250 is a positive displacement pump. Its output flow rate is basically proportional to the hydraulic input to the driving motor at a ratio of 10.4:1 product oil out put to hydraulic oil input. In order to gage the amount of product oil we are pumping, we can use a chart that shows us this relationship on a linear graph. See Figure 3-4. "DESMI DOP 250 HYDRAULIC OIL INPUT vs. PRODUCT OIL OUTPUT". This flow rate will vary somewhat with pressure in the product hose. It will be most accurate in the pressure ranges of 60 to 125 psig. The product oil pump flow rate is infinitely adjustable by varying the control valve on the control stand. ***This control must always be adjusted slowly so as not to over pressurize the hydraulics or the discharge hose.***

3.4 AWI Rotan Pump Flow Rate

3.4.1 General Procedure: The key to the success of the VOPS system is the ability to pump a small amount of water into the product hose at the pump. To do this, the operator must have an adequate supply of water. Any relatively clean water supply will work. It can be fresh water, salt water, river water, water and ethylene glycol or even diesel fuel. But water or water base fluids will work the best. Diesel fuel is not nearly as effective as an injected medium used to reduce system pressures. The AWI Rotan Pump should be submerged either over the side, in the ships water supply, or in a water ballast tank. Its maximum practical suction lift is 18 feet. Prior to use, submerge the pump into the water source and pump water into the discharge hose for several seconds to pre-charge it.

Once the hydraulics are connected per the instructions in Section 2 (also refer to Figure 2-9 Hydraulic Flow Schematic), the method for controlling this pump is the same as the method used for the DOP250. The hydraulic supply to the control station is engaged and dialed up to approximately 60 gpm at the HVPU. The flow rate to the AWI pump is adjusted up to a maximum of approximately 9 gpm by turning the control handle for the water pump in the proper direction as shown on the flow control stand. The oil flow rate is then turned up slowly using the other control handle to increase flow rate. The water flow rate should be maintained at a constant 24 to 27 gpm once oil is flowing. The oil flow rate must be brought up slowly. If a long hose run is used, it may take 10 to 20 minutes to reach full flow rate without exceeding the maximum system pressure. The reason for this is that it takes time for the AWIF to provide enough water to develop a tube or continuous ring of water through out the whole length of hose. For instance, with 1300 feet of hose, and pumping at an initial reduced rate of 100 gpm, it would take almost 20 minutes for oil being picked up at the pump to reach the discharge outlet of the hose run. As the pressure is reduced in the system, the flow rate can be increased. The method should be to increase flow rate in 50 gpm (product flow rate) increments for several minutes to allow the pressure to come down and stabilize at each flow rate.

3.4.2 Controlling Head Pressure and Flow Rate: When commencing the pumping operation, the AWI system is started first, allowing water to flood the AWIF and initial section of discharge hose. If the system is clean and no oil has had time to pack itself into the AWI flange, the water pump should come up to its maximum flow rate very quickly. This would be determined by (a) watching the hydraulic flow meter for the water pump and ensure that it is reading between 6 and 9 gpm or (b) by watching the water flow meter in the system to ensure that it is registering the correct flow rate. The water injected flow rate target is 5% to 6% of maximum oil flow. The correct way to do this is to start water first and bring it up to 25-water flow gpm. Then start oil flow and slowly bring it up to 440-gpm product flow. Once the oil flow is close to the maximum it is important to go back and readjust the water flow to its maximum flow (26 gpm water). More water flow than this is counter productive and test data suggests that it will tend to slurry the water and fuel. There is a water flow meter in the system that needs to be inserted in-line in the water discharge line somewhere near the control station so that water flow rate can be observed and monitored during the operation. Should the lightering pump be operated at less than its full capacity, decrease the hydraulic flow to the water injection pump proportionately.

It is important to watch the flow rate and pressure in the system and not to let the system pressure exceed 150 psig. This is best accomplished by always bringing the AWI flow in first to pre-lube the line and then to bring the oil up very slowly. The rate at which you increase flow rate will depend on the amount of hose there is in the discharge. If there is a long hose run e.g., several hundred feet or more, it will take much longer for the AWI system to build up the water ring and to stabilize at a low pressure. In a 1300-foot hose run it could take 10 to 20 minutes to reach full flow at a stable pressure.

3.5 Supplemental Guidance

3.5.1 General: This section contains notes obtained from research data and accepted industry knowledge, which may be useful for field operations.

3.5.2 Supply Power to the Product Suction Pump: Tests have shown that regardless of the type of main product pump used, ensuring that the pump receives its full rated hydraulic drive pressure and flow rate will ensure optimal VOPS performance. Pumps often do not receive their full rated hydraulic pressure and flow at maximum setting due to friction losses in the hydraulic power lines. A way to ensure full capacity is to estimate hydraulic flow rates and using friction loss charts, calculate pressure drop based on the length of hydraulic hose runs. **An easier method is to have the operator set the hydraulic power unit (HPU) at 10% to 15% above the nominal continuous rating of the pump. For most pumps this would cover the line loss without over-pressurizing the pump motor.**

3.5.3 Inflow Enhancement:

This topic is concerned with getting the heavy viscous oil to the inlet of the product pump. Although the VOPS allows typical lightering pumps to transfer highly viscous oil, there has always been a significant problem of maintaining continuous oil flow into the pump. The nature of highly viscous oils and emulsions is such that only the product within the immediate vicinity of the pump is effected and pumpable. Required is a means to "fluidize" the surrounding oil by either mechanical or thermal means.

An option, which has received the most attention, is steam heating the product. Testing has shown that use of steam coils with centrifugal pumps enhances their performance by allowing them to pump at much higher flow rates. Testing has shown that when a steam coil was used with the CCN-150-5C centrifugal pump (not with screw pump) during testing, the pump's flow rate and head capacity were significantly increased. The steam coil was very effective in reducing the viscosity of the product in the center of the coil and in close proximity to the tubing. Viscosity reduction for oil near the coil was 10:1. This reduction in viscosity resulted in doubling to tripling of the maximum flow rate compared with the test with unheated oil. However, the coil assembly will not fit through a standard tank opening, and the area being heated is limited to the center of the coil and within a few centimeters of the pipes.

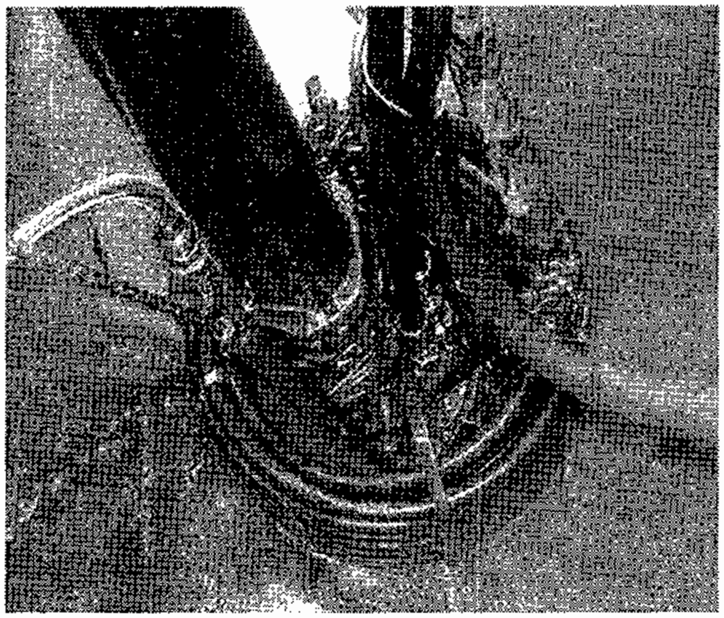


Figure 3-1. Steam Coil on CCN150-5C Pump.

Mechanical means must add sufficient amounts of shear energy to "fluidize" a non-flowing product. Several concepts have been investigated including manually mixing product near the pump suction. Other concepts such as operating a second pump, with no discharge hose attached, in the vicinity of the pump suction to agitate the product are subject to future investigation.

Recently, in 2001, the Ro-Clean Desmi Company of Denmark developed and marketed an injection flange device for mounting to Desmi DOP160 and DOP250 pump inlets. These devices allow for the injection of steam or cold or hot water into the suction of the pump. The flanges are designed to be used on the inlet side of the pump alone, or in conjuction with a discharge-side annular water injection flange. These devices are claimed to offer the following advantages when used:

1. Reduce friction losses within the pump and enhance overall pressure reducing effect while maintaining the water annulus effect
2. Allow use of cold or hot water, or steam injection
3. Works on very low water injection pressure, simplifying the water pumping requirements because water source can be from a low-pressure pump
4. Protects the pump from running dry and eases wear of the pump

This device will be examined for U. S. Coast Guard use.

3.5.4 Screw Pumps vs. Centrifugal Pumps: There is a capacity limit for each type of centrifugal pump. This capacity limit will decrease rapidly as the viscosity of the pumped product increases. There is a point on the pump capacity curve where, at a given flow rate and system pressure, the screw pump will become more effective to use than the centrifugal pump. Every pump scenario that is to be considered should be quickly analyzed to determine the viscosity of the oil to be pumped and also the probability for changes in the viscosity to occur in the course of the off-loading operation. This is to say one must look at the rheology of the product and determine how much the oil will drop in temperature over time, and thus increasing the viscosity.

The problem with using centrifugal pumps to transfer viscous product (product with a viscosity greater than 10,000 centistokes) is that they require a tremendous amount of input energy in the form of hydraulic pressure and flow rate to generate enough torque to spin their impellers at high speed. Such pumps must maintain high operating rpm to achieve both head pressure and moderate flow rate. With even low viscosity oil, they quickly lose rpm as head pressure rises. Screw pump, however are able to maintain fairly constant flow rates out to considerable head pressures with the same oil. They are able to operate much more efficiently in viscous product and better utilize the horsepower available.

The most prudent use of pumps may well be the use of centrifugal pumps in the beginning of a pumping response, and then switch to screw pumps later in the operation. In many offloading scenarios, the product viscosity may be low in the early stages of the response, and the response personnel can achieve high flow rates with a centrifugal pump. As product cools due to the loss of the ship's heating system or power the product viscosity will increase. The capacity output will drop rapidly to the point where the flow rate will be lower than that available with a screw pump.

Given two pumps that have the same casing and motor size, the screw pump will have a much lower flow rate capability than the centrifugal pump, by a ratio of 5 or 6 to 1. The screw pump, however, is much more efficient with viscous fluids, such that the differences in product output with viscous fluids between the two pumps is quickly reversed.

3.5.5 Small Screw Pumps vs. Large Screw Pumps: Testing experience has indicated that there are times when it may be more advantageous to use a smaller pump than a larger one. Using a smaller pump would, of course, be the natural choice when the tank or hatch geometry limits the size of the pump that can be used. Tests have shown an indication that the use of a smaller screw pump over a large one may be better served when there is not enough hydraulic power (pressure) to adequately operate a larger pump. The combination of low input hydraulic pressure and high product line head pressure may have a pronounced detrimental effect on the larger pump vs. the smaller pump. However, at this time there is insufficient data to draw an accurate conclusion. Further testing is required.

3.5.6 Use of Alternative AWI Fluids: Testing of the VOPS Annular Water Injection Flange (AWIF) has included the use of 4 different injection fluids to pump an oil-water emulsion:

1. fresh water
2. glycol / fresh water mixture
3. diesel
4. diesel with emulsion breaker added

Although testing has shown that VOPS performance is successful with the use of fresh water (or salt water) as an injection fluid, there are alternate fluids, which can be used to various degrees of success.

Use of fresh or salt water has been shown to drop system line pressures up to 10 times. However, glycol may be mixed with the injection water. A 50/50 mixture of propylene glycol and water will allow the injection fluid to resist temperatures down to minus 33 degrees Celsius, which is a particularly useful alternative for use in artic climates. Tests have shown that this mixture will drop line pressure 12:1, more than the 10:1 drop when just water is used.

Artic diesel has also been evaluated. Line pressure drop results are not as impressive as with water and water/glycol. Line pressure drops amounted to about 30%. It is likely that the diesel mixes quickly into the emulsion, providing little "annular" effect as with water, but providing some pressure reduction due to its dilution of the emulsion viscosity.

Artic diesel and emulsion breaker together have been tested as an injection fluid. The emulsion breaker was EC2085, produced by Exxon-Nalco. The chemical was mixed with the diesel in a concentration of 1000 ppm chemical volume to total emulsion volume. Testing showed the ability of the demulsifying chemical in breaking the emulsion and reducing its viscosity to initial unemulsified value.

FOR VOPS TECHNICAL SUPPORT, CONTACT:

HYDE MARINE, INC.
28045 RANNEY PARKWAY
CLEVELAND, OH 44145-1144
TEL: 440-871-8104
MOBILE: 440-725-3813

APPENDIX A

APPENDIX A
SYSTEM INVENTORY AND VENDER LIST

USCG VISCOUS OIL PUMP SYSTEM (VOPS)
STANDARD INVENTORY REV B
As of (12/14/00)

The following tables provide an inventory of equipment for the USCG Viscous Oil Pumping System (VOPS). The item numbers on table 1 are referenced in figures 1-3, 1-4 and 2-9 of this document. The list of Vender addresses, for the cage code column, is listed in Table 2. The purpose of this inventory list is to give the VOPS operator a basic list of components for general field stocking and replenishment items. This inventory list covers all major system components and assemblies. If a system operator requires a more detailed parts or component list, they must refer to the US Coast Guard Drawing Number listed in the appropriate column. A complete drawing package can be accessed from any of the Strike team offices or the USCG HQ G-SEC-2 office in Washington DC. The referenced drawing package contains all components of every assembly, except for some miscellaneous items, such as the ROPAK shipping containers which are included in the inventory list but not in the drawing package.

TABLE 1
USCG VOPS KIT INVENTORY

Item	Description	Qty	USCG Drawing Number	Part Number	Vender Cage Code
1	Desmi Discharge Flange	1	177011	Fabricated Item	53711
2	Annular Water Injection Flange 6"	1	177001	Fabricated Item	53711
3	Flange to Male Split Clamp	3	177002	A-ADP-6F-6MS	32142
4	Semi-rigid Hose	1	177007	Assembly Item	53711
5	Hose 6" Lay Flat 150 psig WP (50 foot section) with Hydrasearch End fittings	26	177008	Assembly Item	53711
6	Long Radius Elbow	1	177003	Fabricated Item	53711
7	Female Split Clamp to Flange	3	177002	A-ADP-6FS-6F	32142
8	Temperature Gauge	1	177002	Model J-SF Abbeon 0-200deg F 4" Stem. ½ NPT	15806
9	Aluminum Monitoring Pipe	1	177005	Fabricated Item	53711
10	Pressure Gauge, 0-200 psi	1	177002	PM40C1, ½	7D712

				NPT, 1, P20	
11	1-1/2" Ball Valve	1	177002	SSLBV150	7D712
12	Aluminum Flanged Elbow	1	177004	Fabricated Item	53711
Item	**Description**	**Qty**	**USCG Drawing Number**	**Part Number**	**Vender Cage Code**
13	Camlock Discharge Flange	1	177009	Fabricated Item	53711
14	6" Hose Coupling Split Clamp	33	177002	A-CLMP-6S	32142
15	Plugs 6 inch	3	177002	A-PLG-6MS	32142
16	Caps 6 inch	3	177002	A-CAP-6FS	32142
17	22.5 Deg ANSI Flange elbow	1	177006	Fabricated Item	53711
18	Water Injection Piping Sys.	1	177010	Sub Assembly SK1289	Not Applicable
19	Hydraulic Power System	1	177012	Sub Assembly SK1290	Not Applicable
20	6" Double Female Adapter	2	177002	A-ADP-6FS-6FS	32142
21	6" Double Male Adapter	1	177002	A-ADP-6MS-6MS	32142
22	6" Female Camlock to Male Hydrasearch	1	177002	A-ADP-6CGS-6MS	32142
23	6" Male Camlock to Female Hydrasearch	1	177002	A-ADP-6FS-6CMG	32142
24	Bolts, ¾-10 x 3.5" long w/ Nuts washers and lockwashers	48	177002	Stainless Steel	Commercial
25	Bolts, ¾-10 x 6" long with nuts washers and lockwashers	8	177002	Stainless Steel	Commercial
26	6" Gasket	14	Not Shown	1/16" Buna N Material	Commercial
27	6" O' Ring	40	Not Shown	R-RNG/0.6.438	32142
28	AWI & Flange Piping Assy	1	177010	See Detailed Components in Sub-assembly	See individual items in assembly
29	Hose 1-1/2" X 25'	6	177010	PL96-2 /AC150/AE150	3T043
30	Water Flow Meter 30 GPM	1	177010	H755-030-B	7D712
31	1" Ball Valve w/Locking Handle	1	177010	SSLBV100	24869
32	Dial Gauge S/S 0-200 psi	1	177010	PM40C1	15806
33	Desmi Rotan Internal Gear	1	177040	SX6149D	4B221

	Pump				
34	Injection Pump Base	1	177010	Fabricated Item	53711
Item	**Description**	**Qty**	**USCG Drawing Number**	**Part Number**	**Vender Cage Code**
35	Strainer	1	177010	RH520	3T043
36	1" Hydraulic Hose (25 ft) w/valved Quick disonnects	4	177012	AQ2781-16-4412-25 w/FD56 -1239-16 Ends	7D712
37	Hydraulic Flow Meter 20 gpm	1	177012	H761-020-B	7D712
38	1" Tee Pipe	2	177012	2256-16-16-259	01276
39	1" x ½" Reducer	2	177012	2081-16-8-259	01276
40	Dial Gauge 0-3000 psi	1	177012	PM-25C1	7D712
41	Hydraulic Flow Meter 50 gpm	1	177012	H761-050-B	7D712
42	Dial Gauge 5000 psi	1	177012	4213653-834	3T043
43	Gresen 2 Section Control Valve	1	177012	V40-W4W/RP 30A2200-W4-SSW/RP60	7V940
44	Control Valve Stand	1	177013	Fabricated Item	53711
45	Ro-Pak 70"Lx48"Wx50"H	3	Not Shown on Drawing	FED Stock # 705002	Ropak
46	Ropak Container Lid	3	Not Shown on Drawing	FED Stock # 7048CO	Ropak
47	Rupture Disc Holder	1	177002	2000 psig Rupture Disc Holder Ssin-Ssout 1-1/2"	Lamont Corp.
48	Rupture Disc	5	177002	SS SPEC 210 Psig 1.5" disc	Lamont Corp.
49	Protective Instrument & Gauge Case	1	Not shown on Drawings	STK# 540X165	Specialized Products Co.

TABLE 2
MANUFACTURERS CAGE CODE AND ADDRESS CROSS REFERENCE

Item	Manufacturer /Vender Cage Code	Manufacturer/Vender Name	Address	Telephone
1	53711	ESSM contractor GPC A Joint Venture	Warehouse 12 USN YNWS Cheatham Annex Williamsburg VA 23185	757-887-7403
2	53711	Naval Sea Systems Command Office of Ocean Engineering	2531 Jefferson Davis Hwy. National Center Bldg. 3 Room 11E54 Arlington VA22202-5160	703-602-8206
3	01276	Aeroquip Corporation	631 3000 Strayer Maumee, OH 43537	419-891-8936
4	15806	Abbeon Cal Inc.	123 Gray Ave Santa Barbara, Ca 93101	805-966-0810
5	24869	Dixon Valve and Coupling Co.	800 High St. Chestertown, MD 21620	410-778-4702
6	32142	Hydrasearch Co. Inc.	100 Log Canoe Cir. Stevensville, MD 21666	410-643-8933
7	3T043	B and B Hose And Rubber Co. Inc.	4604 Bainbridge Blvd. Chesapeake VA 23320	757-545-8703
8	4B221	Hyde Marine Inc.	Westlake OH 44145	440-871-8000
9	7D712	Hampton Rubber Co. Inc.	1669 W Pembroke Ave. Hampton, VA 23661	757-722-9818
10	7V940	Berendson Fluid Power Co. Inc.	4030 Yancy Rd. Charlotte, NC 28217	704-525-1354
11	No Cage Code	Empire Machine Co.	711 Howmet DR. Mapton VA 23670	757-827-1440
12	No Cage Code	Lamont Corporation	PO Box 4264 Corpus Christy, Tx 78469	361-883-6672
13	No Cage Code	Linpac (Ropak) Container Co. (not shown in figures)	120 Commerce Court Georgetown KY 40324	704 882-4385
14	No Cage Code	Specialized Products Tools Col. (not shown in figures)	1100 S. Kimball Ave. Southlake Tx. 76092-9009	800-866-5353

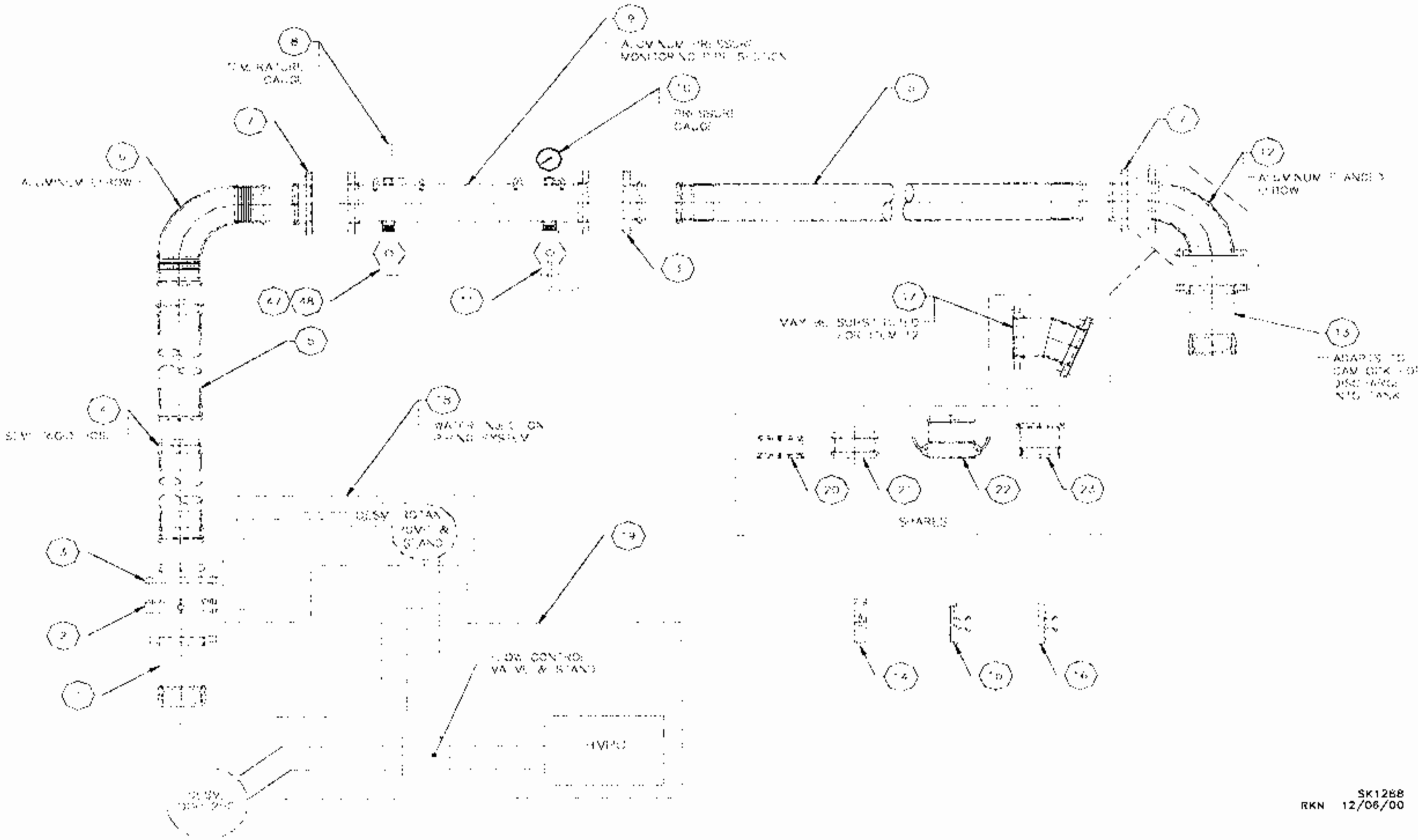


FIGURE 1-3. VOPS KIT MAJOR COMPONENTS

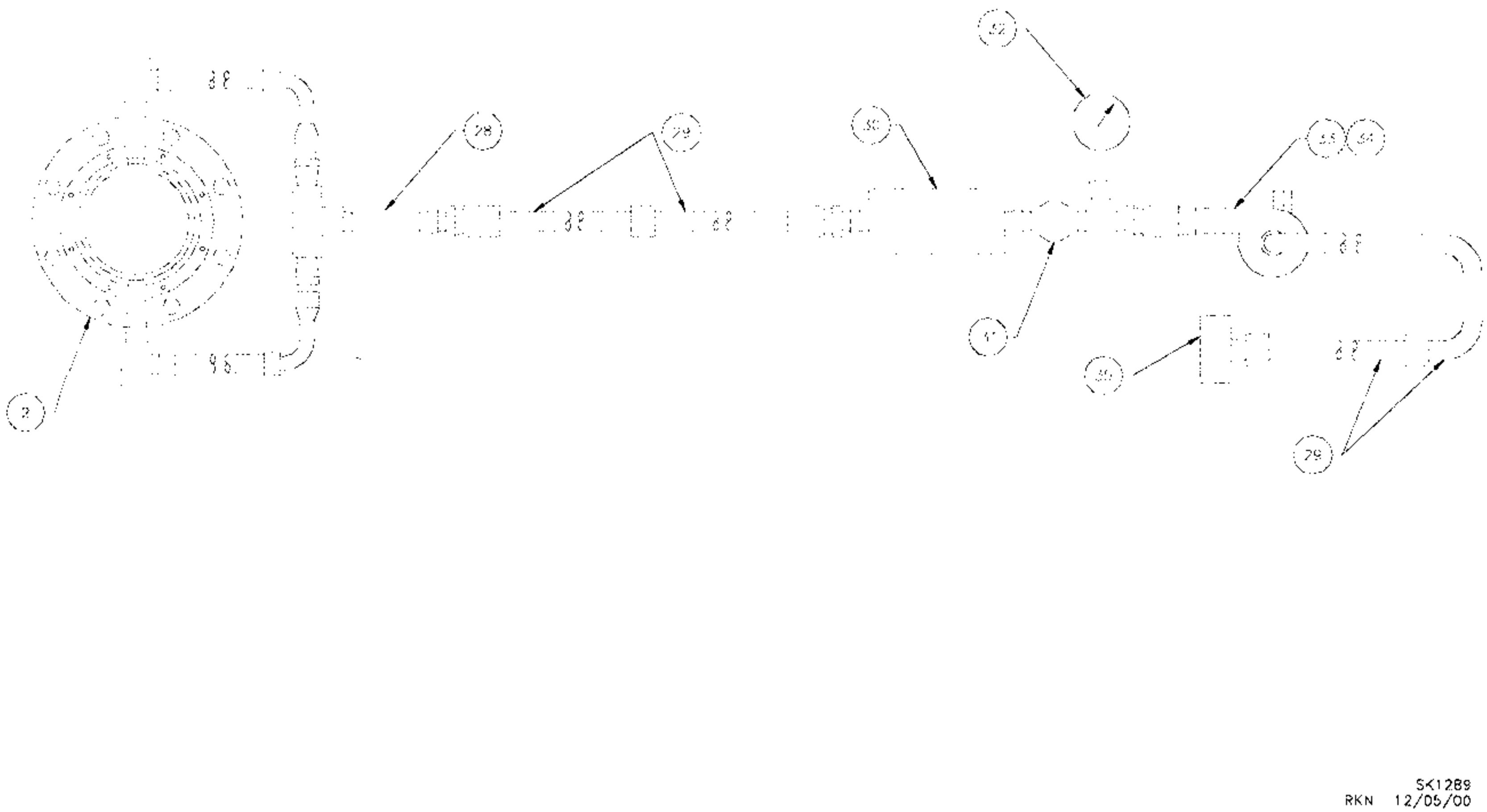


FIGURE 1-4. ANNULAR WATER INJECTION FLANGE AND "WATER SIDE" HOSE AND PIPING SUBASSEMBLY

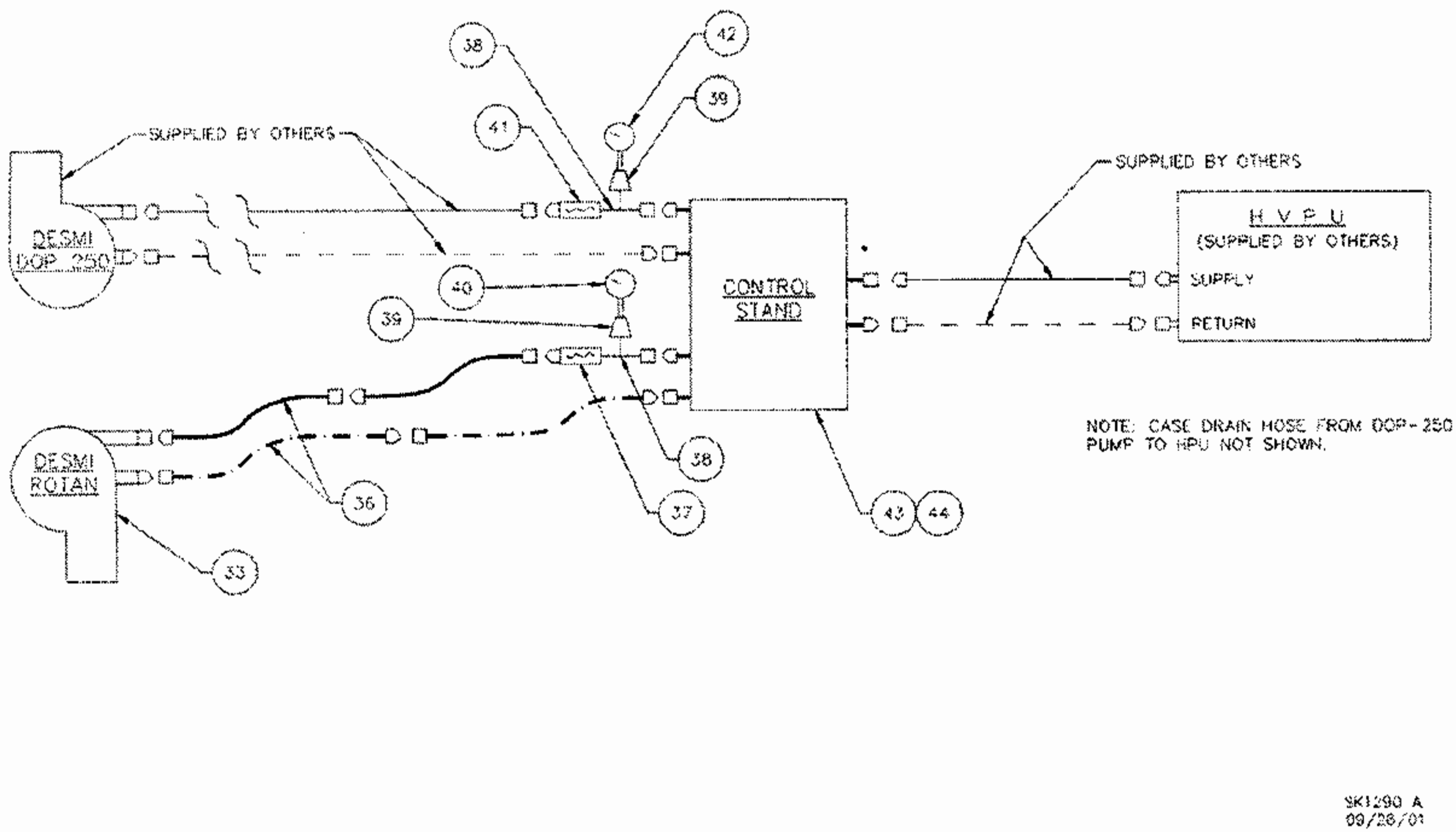


FIGURE 2-9. HYDRAULIC POWER SUPPLY COMPONENT SUBASSEMBLY

APPENDIX B

ANNULAR WATER INJECTION PUMP (AWI PUMP) OPERATION GUIDE

Prepared by:

Hyde Marine, Inc.
28045 Ranney Parkway
Cleveland, OH 44145
440-871-8000

Prepared for:

USCG NSF

OUTLINE

1.0 AWI PUMP

1.1 Background and Description
1.2 Technical Specification
1.3 Performance Specification

Figure 1 *Viscous Oil Pumping System Shipboard Arrangement.*
AWI Water Pump Submerged Operation

Figure 2 *AWI Water Pump General Arrangement Drawing #PSO-007 RevB*

2.0 AWI PUMP OPERATION

2.1 General Operation
2.2 In-Line Operation
2.3 Submerged Operation

3.0 PREVENTATIVE MAINTENANCE

4.0 CORRECTIVE MAINTENANCE

5.0 Appendices

Appendix A Desmi Rotan Pump Manual

Appendix B Excerpts from Rotan Pump Catalog (6 pages)

Appendix C Hydraulic Motor Specifications (3 Pages)

Appendix D Hydraulic Motor Service Instructions (16 pages)

AWI PUMP OPERATION GUIDE

1.0 AWI Pump

1.1 Background and Description

The Hyde Marine **Annular Water Injection Pump (AWI Pump)** is an essential part of the USCG Viscous Oil Pumping System (VOPS) Package. The AWI Pump provides the water (or other fluid), which is injected through the special AWI Flange to form a friction-reducing layer of water on the inside surface of the discharge hose.

When conducted properly, annular injection of water has been proven to dramatically reduce discharge pressure in the product transfer hose. Reducing the pressure increases the pumps discharge rate and increases the distance that viscous oil can be transferred using existing pumps and hoses. In some cases, this technique can make the difference between success and failure of a pumping operation.

The AWI Pump is a DESMI Rotan internal gear pump with a high torque hydraulic motor. The AWI Pump is sized to deliver up to 28 gpm of water @ 160 to 190 psi with a small hydraulic power input. The AWI Pump configuration allows the operator to control the pump discharge flow rate by adjusting the hydraulic flow at the VOPS hydraulic control panel.

The AWI Pump was engineered to provide sufficient lubricating water flow for a DESMI DOP-250 pump when it is operating at maximum flow and discharge pressure. It may also be possible to use the AWI with other pumps in the USCG inventory, such as the CCN-150, when conditions allow and discharge rate is lower than 500 GPM.

The AWI pump assembly is portable and can be moved into any man-access space or lowered over the side of a vessel. The AWI Pump can be operated submerged or in-line and is self priming as long as the pump flanges are horizontal and gears are wetted with water or oil prior to operating. This allows flexibility in where injection water is taken from.

The illustration in Figure 1 shows a VOPS package deployed on a grounded vessel with AWI pump suspended over the side.

1.2 Technical Specification

Pump	Desmi-Rotan Internal Gear Pump. Model CD41ERM-3U832 AA/NPT. The pump has 316 stainless steel external casing and impeller with mechanical seal and relief valve. The arrangement includes a special idler pin/bushing for low viscosity fluid pumping.
Pump inlet connection	Stainless steel 1.5 inch female Kamlok (suction strainer with male Kamlok)
Pump discharge connections	Stainless steel 1.5 inch male Kamlok
Hydraulic Motor	Parker/Gresen hydraulic motor Model UM16-45A-5J4 w/ high pressure shaft seal
Hydraulic quick coupler	Pressure: 1" Aeroquip 5600 female Return: 1" Aeroquip 5600 male
Flexible coupling	Magnaloy Model 200
Base Plate & Coupling Guard	Aluminum
Overall dimensions (approx)	28" L x 15" W x 12" H and Weight 65 lbs.

1.3 Performance Specification

Duty Point	28 gpm @ 160 psi
Water Flow Rate	0 to 28 gpm
Water Discharge Pressure	0 to 190 psig
Suction Capability	Self priming when gears are wetted at startup. Max. suction lift 18 ft. with 1.5" suction hose.
Hydraulic requirement	7.0 gpm @ 2000 psi.
Max. Hydraulic Flow	9 gpm
Max. Hydraulic Pressure	3000 psi

NOTE: The DESMI Rotan Hydraulic flow rate input should not be allowed to go higher than 9 gpm. The pressure limit of 3000 psig is protected by a pressure relief valve incorporated into AWI pump circuit of the VOPS hydraulic flow control stand (4).

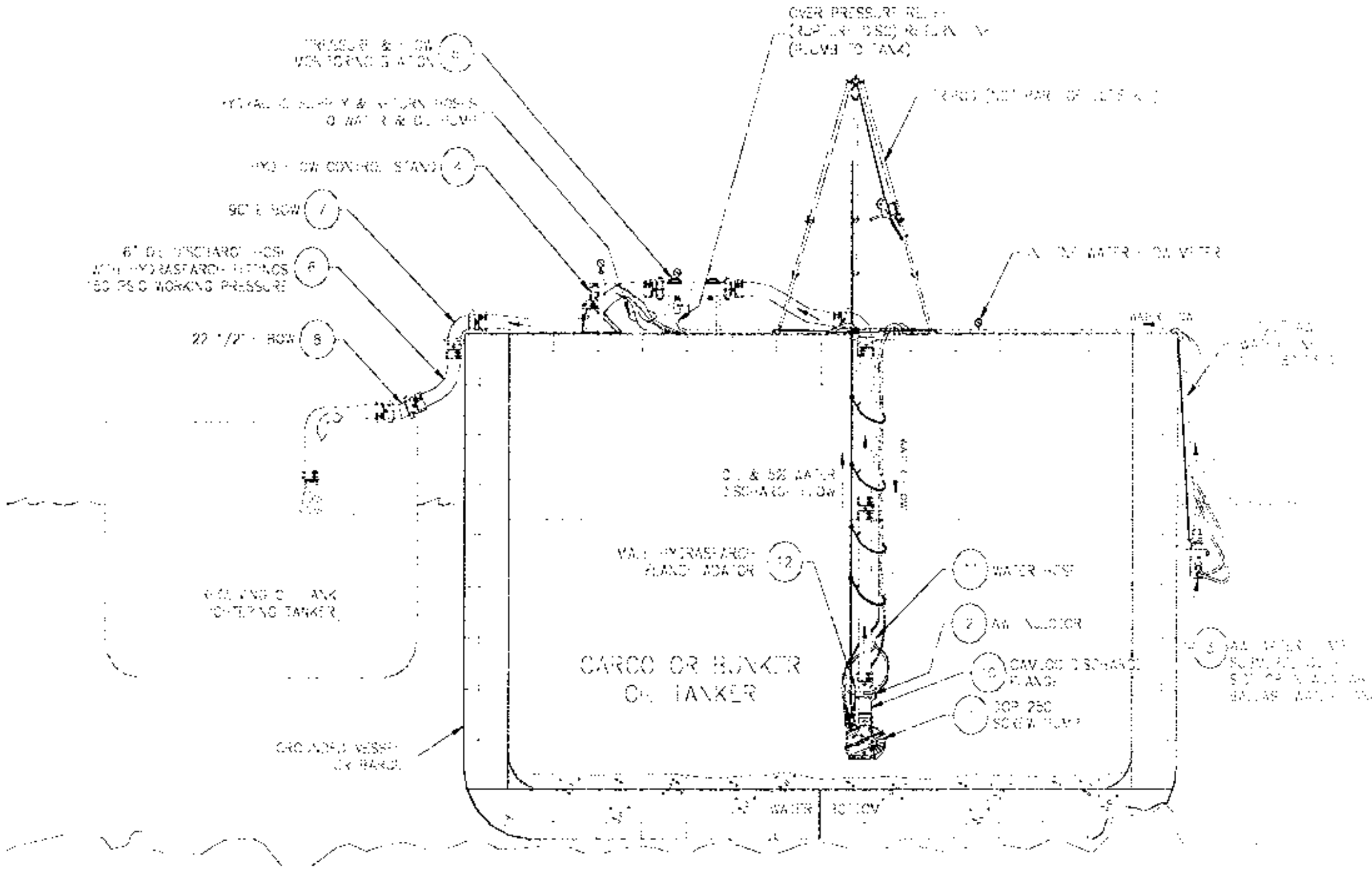
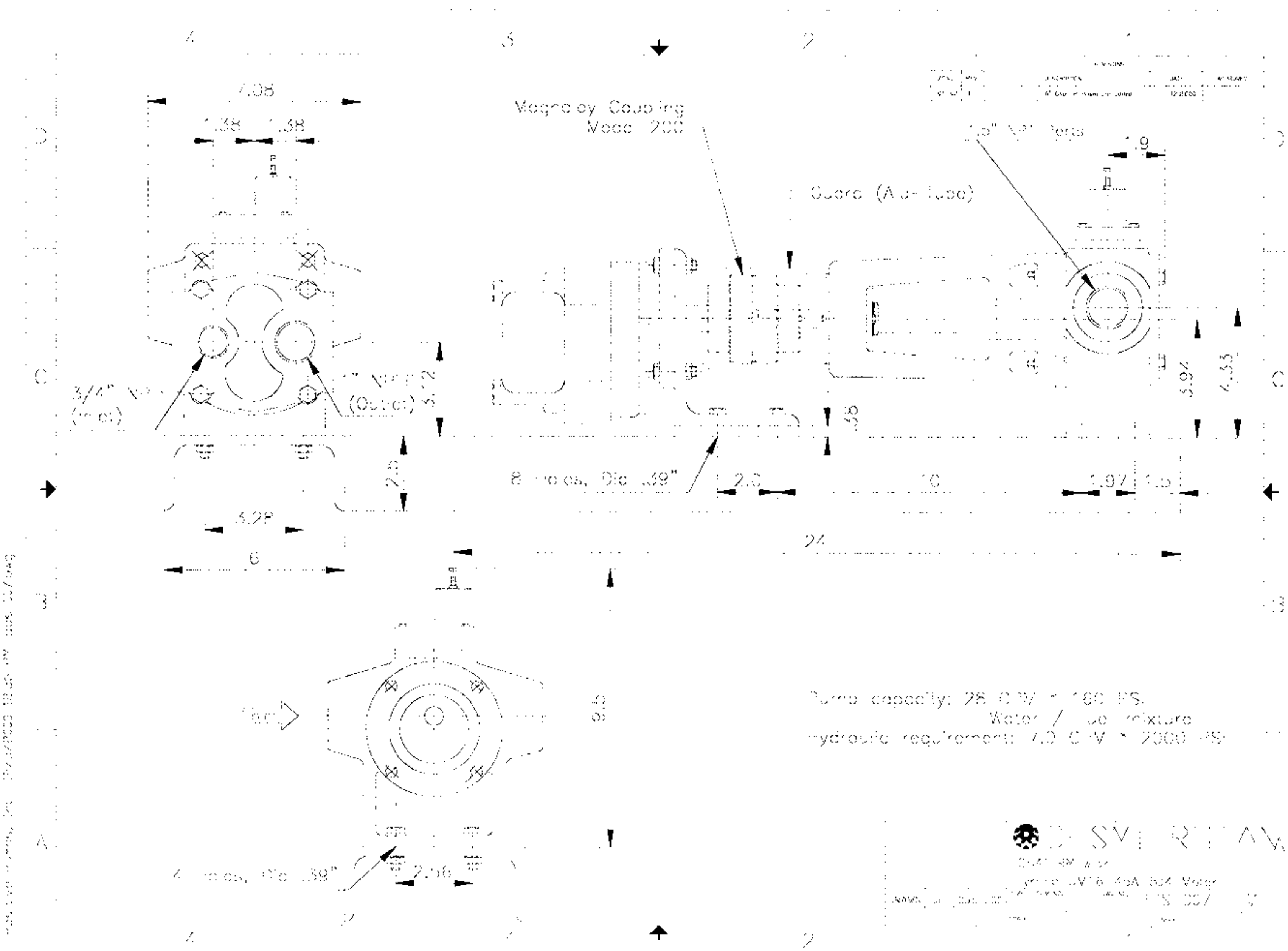


Figure 1. Viscous Oil Pumping System Shipboard Arrangement.
AWI Water Pump Submerged Operation

Figure 2 AWI Water Pump General Arrangement Drawing #PSO-007 RevB
(following Page)


7.08
1.38
1.38
Magnaloy Coupling
Model 200
1.9
Guard (Alu-Tube)
3/4"
(Inlet)
(Outlet)
3.12
.38
5.94
4.33
2.5
8 holes, Dia .39"
2.3
10
1.97
1.5
4.28
6
24
Pump capacity: 28 GPM @ 160 PSI
Water / Glycol mixture
Hydraulic requirement: 7.0 GPM @ 2000 PSI
4 holes, Dia .39"
2.06

2.0 AWI PUMP OPERATION

This AWI PUMP OPERATING GUIDE is supplemental to the VOPS Operating Manual. Observe all safety precautions in the VOPS Operating Manual as well as in the Rotan Pump Manual in a later section.

2.1 GENERAL OPERATION

- Before initial start up, fill the casing with water or machine oil to wet the internal surfaces and allow for self priming.
- The Rotan pump is lubricated by the pumped liquid. Dry running for more than a few minutes should be avoided.
- Operate the flow control valve slowly when starting the pump and adjusting flow.
- Normal hydraulic flow is 6 to 7 gpm if DOP-250 is operated at 42 gpm hydraulic input (440 GPM output).
- Maximum hydraulic input flow is 9 gpm. Do not exceed this or damage to the pump may result.
- After operation, the pump should be drained of liquid, flushed thoroughly with fresh water and lubricated with machine oil.

2.2 IN-LINE OPERATION

It is best to submerge the pump or provide flooded suction whenever possible. If the pump will be used in suction mode:

- Pour a small amount of liquid into the pump in order to wet the gears before connecting the water inlet and discharge hoses.
- The pump is self priming as long as the pump flanges are horizontal and gears are wetted with water or oil prior to operating.
- Place the pump in the lowest possible position and as close to the water source as possible. The suction lift should be the minimum possible height.
- Maximum practical suction lift is 18 ft. with 1.5" suction hose at nominal speed.

2.3 SUBMERGED OPERATION

- Use the suction strainer on the pump inlet.
- Pour a small amount of liquid into the pump in order to wet the gears and test operate the pump before deployment to be sure it is operational.
- The pump, hydraulic hoses and water discharge hose will need to be long enough to ensure that the pump remains submerged at all times.
- It is recommended to secure one or two floats/buoys by a short rope to the pump to suspend it at the desired depth and to mark its location.
- Do not place the pump directly on the bottom in order to avoid pumping sand, mud or silt through the pump, hoses and AWI Flange.
- If possible avoid areas of heavy debris contamination or high concentration of weeds or other marine growth.
- If possible, choose a location as close to the AWI Flange as possible to reduce pressure losses in the injection water.
- Secure the hoses and pump handling lines.

3.0 PREVENTATIVE MAINTENANCE

- The rotan pump is stainless steel but should be flushed thoroughly with fresh water any time it is in contact with salt water.
- The pump should be lubricated with machine oil and the oil left in the pump during storage. Where long storage is intended, steps must be taken to avoid corrosion and drying out, which can damage the mechanical seal upon start up.
- Inspect the Pump assembly for signs of corrosion or mechanical damage and test operate every three months. We recommend operating the AWI Pump as part of inspection process to check operation and flush fluid through the pipes and controls.
- The Ball Bearing (Item CU) is subject to corrosion and should be rinsed with fresh water and lubricated immediately after contact with fresh or salt water. Inspect the Ball Bearing and lubricate quarterly if not operated.

- Inspect the hydraulic fittings for signs of wear, damage, and leaks under pressure. Tighten fittings as required.
- Inspect the internal surfaces of the female Aeroquip quick disconnects for dirt. Wipe these surfaces carefully and check that the O-ring seal is in place and uncut.
- Wipe down the external surfaces of both male and female quick disconnects.
- Follow the Manufacturer's recommended maintenance procedures attached.

4.0 CORRECTIVE MAINTENANCE

- After use in oil, clean all external surfaces with warm water and mild detergent. DO NOT USE CAUSTIC (HIGH PH) DETERGENTS ON BARE ALUMINUM SURFACES. After use in salt water or after cleaning, rinse thoroughly with fresh water and air dry.
- SEE THE ROTAN MANUAL MAINTENANCE SECTION.
- Pour a small volume of light machine lubricating oil into the pump inlet and rotate the pump slowly until all internal surfaces are well coated. Let the oil remain in the pump casing during storage.
- The Ball Bearing (Item CU) is subject to corrosion and should be rinsed with fresh water and lubricated immediately after contact with fresh or salt water.
- Inspect all Quick Disconnect fittings as described in Preventative Maintenance and cover all fittings with a light coating of preservative oil.
- Replace any damaged Hose, Hydraulic Quick Couplings or Kamlok Fittings as required. It is easier to replace than to repair these fittings.

5.0 APPENDICES

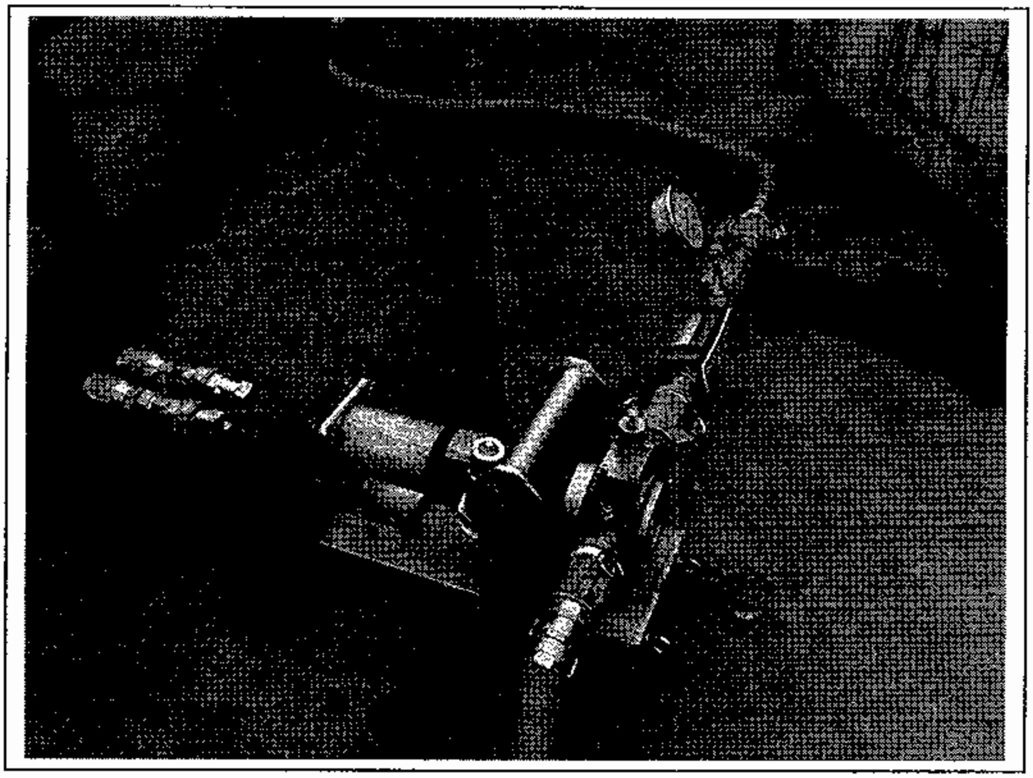
(See attached)

APPENDIX C

Maintenance Manual

USCG VOPS
Water Injection Pump

September 2001



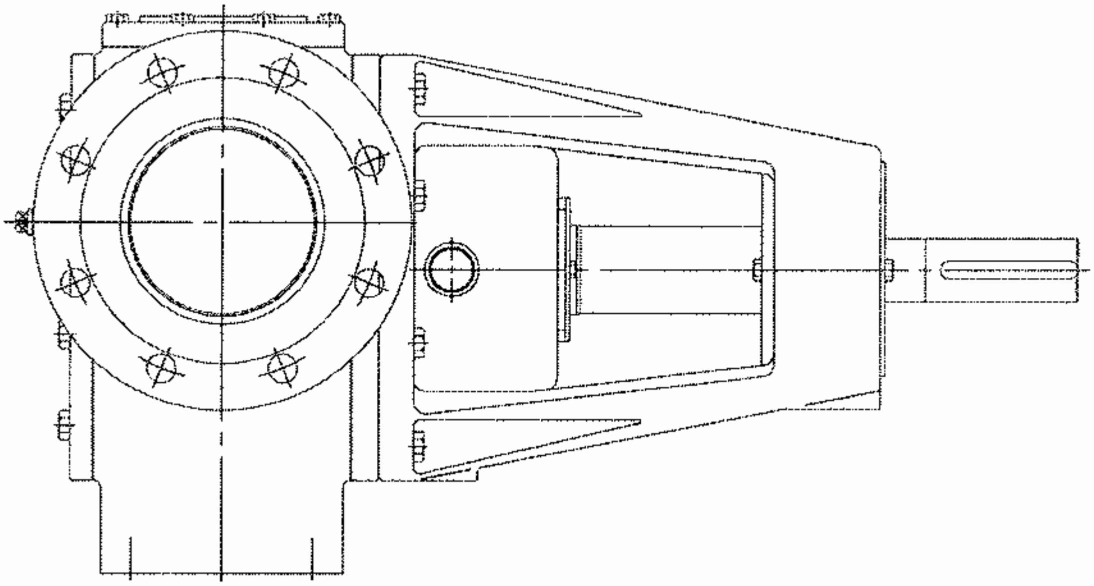
HONEST SOLUTIONS. HONEST EQUIPMENT.

Hyde Marine, Inc.
28045 Ranney Parkway
Cleveland, OH 44145
phone: 440-871-8000
fax: 440-871-8746
www.hydeweb.com

ROTAN PUMP

Installation, Operation and Maintenance Manual

V.O.P.S. Water Injection Pump



Rotan Model CD41ERM-3U522 September 2000

Hyde Marine, Inc.
28045 Ranney Parkway
Cleveland, OH 44145
phone: 440-871-8000
fax: 440-871-8746
www.hydeweb.com

HONEST SOLUTIONS. HONEST EQUIPMENT.

TABLE OF CONTENTS

1. **GENERAL INFORMATION** .... Page 3

2. **TRANSPORTATION/STORAGE** .... Page 4

3. **PUMP TYPES AND VERSIONS** .... Page 5
   3.1 Rotan principle
   3.2 Configurations

4. **TECHNICAL DATA** .... Page 7
   4.1 Shaft seals
   4.2 Bearings
   4.3 Heating
   4.4 Operational conditions
      4.4.1 RPM
      4.4.2 Differential pressure
      4.4.3 Suction head, NPSH
      4.4.4 Temperature
      4.4.5 Viscosity
   4.5 Protective devices
      4.5.1 Relief valve
   4.6 Setting dimensions, end clearances
   4.7 External loads

5. **INSTALLATION** .... Page 10

6. **STARTING-UP** .... Page 11

7. **MAINTENANCE AND OPERATION** .... Page 12
   7.1 Lubrication
   7.4 Dry running

8. **REPAIR AND INSPECTION** .... Page 12
   8.1 Draining the pump
   8.2 Pump parts
   8.3 Mechanical seal
   8.5 Sleeve bearings
   8.6 Flexible coupling
   8.7 Locking the pump shaft
   8.8 Adjustment of end clearance

9. **TROUBLE-SHOOTING** .... Page 15

10. **SPARE PARTS** .... Page 16
   10.1 Ordering spare parts
   10.2 Section drawings of spare parts
   10.3 List of spare parts

1. GENERAL INFORMATION

Warning

To avoid personal injury and property damage, comply with the following while installing, maintaining or operating this equipment:

- Personnel involved in installation, operation and maintenance of this equipment must be technically qualified and familiarize themselves with this manual prior to installing, operating or maintaining the pumps.

- The user is responsible for the proper and safe operation of this and associated equipment, as well as specifically observing safety and other instructions in this manual.

- General safety requirements and considerations, including local safety and operating regulations, are beyond the scope of this manual.. The user is fully responsible for observing and complying with them, respectively.

- The installation, operation and servicing of this and associated equipment must be carried out in strict accordance with existing regulations and good engineering practice.

- The pump must only be used in accordance with the operating conditions specified on the applicable acknowledged customer order. Any deviation must be approved by the manufacturer.

- This manual covers standard designs only. Special designs involving variations in construction or installation, operation and maintenance procedures are not included.

- Contact the supplier for any information not found in this manual.

- The service life and the operating characteristics of the pump are limited by wear, corrosion and other factors that are dependent on the operating conditions. It is the user's responsibility to regularly maintain the equipment, replacing parts as necessary. Use of the pump should be discontinued if it is operating abnormally, or if there is any obvious damage.

- Installations involving applications that may expose operating or other personnel to toxic or otherwise dangerous substances in the event of equipment failure must be equipped with reliable and regularly tested alarm systems, safety procedures and suitable arrangements to shut down the equipment and/or to activate spare units.

- All units pumping foodstuffs must be appropriately cleaned before use.

- Failure to observe the warnings and instructions in this manual can lead to equipment failure and possible injury to personnel or property damage.

- The manufacturer will not be responsible for adverse results if the instructions in this manual are disregarded.

- Never exceed the rated pressure, temperature or input speed of the pump.

-

- If the pump is supplied to a third party, it is absolutely essential that it is accompanied by this manual as well as the operating conditions specified in the order.

2. TRANSPORTATION/STORAGE/HANDLING

On receipt, please check that the unit is complete and undamaged. In the event of shortage or damage, the carrier and the supplier must be advised immediately, for the purpose of submitting a claim.

Warning

Do not put your fingers into the suction/discharge ports of the pump when handling the unit.

The pump must be handled carefully to avoid damage.

Safety rules for the proper use of all slings, chains and other lifting equipment should be observed at all times.

Where long storage is intended, steps must be taken to avoid corrosion and drying out. This can cause seizure of the mechanical seal components, which in turn can result in damage to the seal, when the pump is started.

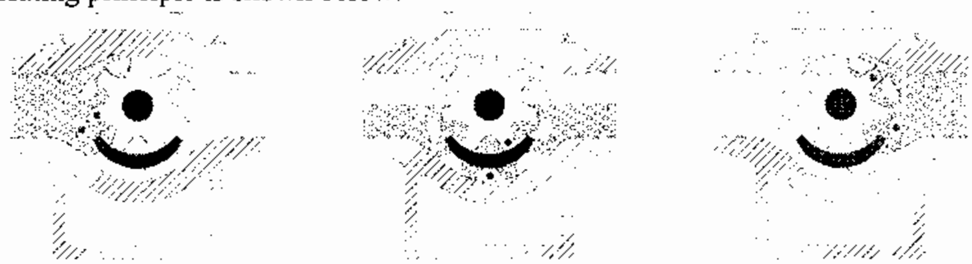
Base coat and/or top coat is applied to the external surfaces of the ***Rotan*** pumps (except stainless steel surfaces, which are not painted).

The pumps are usually lubricated with machine oil from the factory; pumps for foodstuffs are treated with a lubricant appropriate for most food handling services.

3. PUMP TYPES AND VERSIONS

3.1 ROTAN IN GENERAL

The ***Rotan*** pump is a gear pump with an internal idler gear in mesh with a main rotor. The operating principle is shown below:



The modular design of the ***Rotan*** series allows a large number of pump configurations. It is therefore possible to adapt the ***Rotan*** pump for a specific duty.

All ***Rotan*** pumps can be provided with a (recommended) relief valve to prevent the build-up of excess pressure. Most models can be fitted with a heating/cooling jacket for the pump section and shaft seal.

All standard pumps allow reversible pumping. The direction of flow is determined only by the direction of rotation of the motor (and the mounting of the relief valve, if fitted).
The pumps are grouped into 6 main series:

HD: Heavy Duty.
Parts in contact with the liquid are manufactured in cast iron and steel.

CD: Chemical Duty.
Parts in contact with the liquid are manufactured in stainless steel.

PD: Petrochemical Duty.
Parts which contain the liquid are manufactured in steel.

HD, CD, and PD are bareshaft units coupled to a motor and mounted on a common baseplate. Shaft sealing arrangements vary, i.e. stuffing box, a single mechanical seal and double mechanical seals in tandem or back-to-back.

GP: General Purpose.
The pump end is identical to that of the HD pump, but direct coupled to a C-flange motor. The GP models can be fitted with a stuffing box or a single mechanical seal.

CC: Close-Coupled
Newly-developed successor to the GP range, currently available in 1 - 1.5" ports.

MD: Mag Drive.
See separate manual covering magnetically coupled pumps.

3.2 CONFIGURATION

The configuration of a specific pump is shown on the nameplate (see 10.1).

1) Pump type

CD "Chemical Duty" pump in stainless steel

2) Pump size

41 12" NPT Ports

3) Configuration

E Suction/discharge connections in-line

4)

- Hyphen

5) Material codes for main parts/wetted parts

Code	Type	Casing/Covers	Rotor/Idler	Shaft
3	CD	AISI 316	AISI 329	AISI 329

6) Lubrication

U Idler bearing and main bearing lubricated by pump medium.

7) Material codes for idler bearing

Code	Idler bush	Idler pin:
5	Carbon	Al.oxide, polished

8) Material codes for main bearing

Code	Bearing bush	Shaft: GP-HD-PD	Shaft: CD
3	Carbon	Carbon Steel	X 8 CrNiMo 27 5

9) Shaft seal

2 Mechanical shaft seal, DIN 24960-KU, O-ring type

4. TECHNICAL DATA

4.1 SHAFT SEALS

Rotan pumps utilize three types of shaft seals:

- Packing
- Mechanical shaft seal
- Magnetic coupling (not covered by the scope of this manual).

The type of seal fitted in the pump is indicated on the nameplate (see 10.1).

4.1.2 MECHANICAL SEAL

Mechanical seals are virtually leak-free and do not require maintenance. Pumps with mechanical seals should only be run after bleeding and being filled with liquid because if allowed to run dry, the seal faces of the mechanical seal can be damaged. Self-priming of up to one minute's duration, however, is acceptable.

4.2 BEARINGS

The pumps are fitted with sleeve bearings with the exception being the item CU which is a "sealed for life" ball bearing.

The sleeve bearings of the U configuration (see 3.2) are lubricated by the pumped liquid.

4.3 HEATING

Where heating is required for the pump, a heating jacket can be provided for the front and/or rear cover, configuration D and K (see 3.2).

The heating jackets are designed for a maximum working pressure of 150 PSI.

4.4 OPERATIONAL CONDITIONS

The limitations (RPM, pressure, temperature, and viscosity) stated in this section are to be considered as recommended maximum values as the individual ***Rotan*** pump can have further limitations, i.e. due of the medium pumped, the shaft seal chosen, as well as the motor rating.

4.4.1 RPM

The maximum RPM of the individual ***Rotan*** pump sizes for viscosities below 400 cSt are as follows:

Pump size	Maximum RPM
26, 33, 41	2,500

4.4.2 DIFFERENTIAL PRESSURE

The total discharge pressure (inlet pressure + differential pressure) may not exceed:

- 250 PSI for the types 26 - 41.

4.4.3 SUCTION HEAD, NPSH

In order to ensure cavitation-free pumping, the suction conditions should be such that the absolute pressure available on the inlet side is higher than the $NPSH_r$ of the pump at the specific operating conditions.

4.4.4 TEMPERATURE

The operating temperature limitation is, among other factors, dependent on the elastomers used in the pump.

FPM - Viton approx.) 10 / +340°F (maximum 275°F in water)

4.4.5 VISCOSITY

Rotan pumps in standard configurations can be used in the viscosity range 1-7,500 cSt. For thin liquid duty (less than 5 cSt), it is possible to execute the pumps with reduced clearances.

4.5.1 RELIEF VALVE

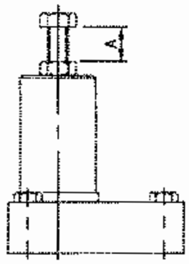
In the event a ***Rotan*** pump is operated against a closed discharge outlet, an unlimited pressure build-up can occur. To avoid this possibility, the pump, piping, valves etc. should be protected by the integral relief valve, or by an external device limiting the pressure.

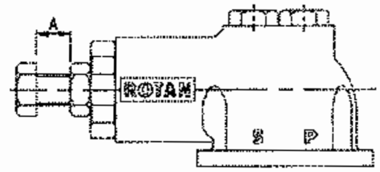
The integral relief valve leads the pumped liquid from the discharge side back to the suction side when the set pressure is exceeded. The pump must not operate in "by-pass" mode for a long time, as this will cause excessive heating of both liquid and pump.

The standard relief valve (configuration R) provides protection in only one pumping direction. The adjusting screw of the relief valve should point towards the suction side of the pump. In the case of a valve with a vertical adjusting screw, it will point to the pressure side of the pump. Normally the valves are stamped with a "P" for pressure side and a "S" for suction side.

The opening pressure should be 15-45 PSI above the normal operating pressure.

The adjustment of the safety valve from the factory may appear on the order. If the valve is readjusted, the adjusting screw should be re-sealed with thread tape.





Setting dimensions for the relief valves are shown in the following table.

ROTAN TYPE	SPRING NO. (**BOLD** denotes Std.)	OPENING PRESSURE PSI (Differential)							
		30	60	90	115	150	175	200	230
		SETTING DIMENSION A (inches).							
CD, PD, CC 26, 33, 41	0043020LA102	.46	0.36						
	0043020QA102		.43	.34	.26	.17			
	0043020TA102					.39	.35	.31	.28

4.6 SETTING DIMENSIONS, END CLEARANCE

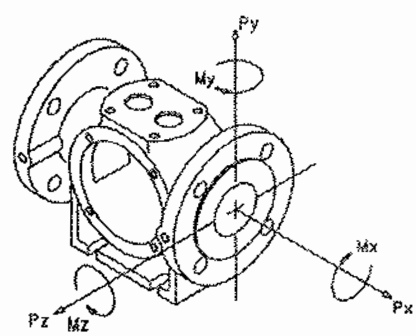
The end clearance is the distance between the rotor/idler and the head.(See 8.8 regarding adjustment.)

The normal end clearance for Model CD41ERM is .004".

5.7 EXTERNAL LOADS

Permissible force and torque loads on the pump flanges.

Pump size	Force in lbf			Torque in lb.ft.		
	Px	Py	Pz	Mx	My	Mz
41	245	220	190	70	90	90



5. INSTALLATION

The following should be considered to avoid operating problems:

Site:

- The base must be such that the unit is solidly supported and is not stressed when installed.
- The suction height of the pump (see 4.4.3) should be taken into consideration.
- Normally the pump is mounted with the flanges horizontal. If the pump is placed with the flanges up/down, it will not self-prime. Normally, the pump should be installed so that the shaft is horizontal.

Piping:

- All piping must be free of any contamination.
- Plugs in the pump ports must be removed.
- The pump must be installed in such a way that stresses in the pump casing caused by the pipework are kept to a minimum. See 4.7 for permissible pump flange loads.

Mounting pump and motor:

- Alignment of pump and motor is to be checked after installation. The procedure is described in 8.6.
- Check that the pump shaft rotates easily and smoothly.
- The coupling between motor and pump is to be completely guarded.
- Check direction of rotation of the motor. If the direction of rotation of the motor is clockwise, then the flow direction is from right to left as seen from the driving end.

Relief Valve:

- Check that the valve points in the correct direction (see 4.5.1).

Controllers:

- The control equipment is to be adjusted and checked.

6. STARTING-UP

Because of the sleeve bearings and shaft seals, ***Rotan*** pumps can only be permitted to run without a flow of liquid for the short period during self-priming. The faces of the sleeve bearings and shaft seals must not be allowed to become dry during prolonged storage. When starting-up, please check:

- that shut-off valves on the suction and discharge sides are open.

- that on first start-up the pump, the casing is filled with a small quantity of liquid to ensure self-priming capability.

-

- that cooling/lubricating devices, etc., if any, are operational.

- that the control equipment is operational.

- that the direction of rotation is correct. If the direction of rotation of the motor is clockwise, then the flow direction is from right to left as seen from the drive end.

- that the pump is drawing the liquid.

- that the pump does not vibrate or is noisy.

- that the pump does not leak.

- that the relief valve opens at the required pressure.

- that seal and bearings do not overheat; lip seals will normally cause a heating of the shaft during running-in (approx. 2 hours).

- that the operational pressure and power consumption are correct.

7. MAINTENANCE AND OPERATION

Operating conditions under section 4 should be checked regularly.

7.1 LUBRICATION

Pump internals are lubricated by the product being pumped. The ball bearing, item CU is greased and sealed for life. However, if the pump has been exposed to salt water, it is recommended to remove the bearing covers CR and CS to wash and apply a rust inhibitor to the bearing externals.

7.4 DRY RUNNING

The sleeve bearings and the shaft seal of ***Rotan*** pumps are lubricated by the pumped liquid, and consequently dry running longer than a few minutes should be avoided.

8. REPAIR AND INSPECTION

⚠ **Before attempting any work on the pump, ensure that it cannot be started accidently or unintentionally.**

⚠ **The system must be completely de-pressurized and drained of liquid.**

⚠ **The service person must know which liquid has been pumped as well as which precautions he must take when handling the liquid.**

⚠ **All safety equipment, such as coupling guards, pressure relief devices, must be in place before the pump unit is restarted.**

8.1 DRAINING THE PUMP

After the piping has been drained, some liquid will remain at the bottom of the pump and in the seal area.

The pump can usually be fully drained by removing the head or by placing the pump with the suction/discharge ports up/down and rotating the shaft.

⚠ **Where toxic liquids are handled, precautions should be taken before dismantling the pump, e.g. circulating neutralizing liquids in the pump, or using appropriate safety clothing and breathing apparatus.**

8.2 PUMP PARTS

The rotor, idler, pump casing, head and idler bearing can be inspected simply by removing the head. There is no need to remove the pump from the piping.

The head should be placed so that the crescent is at the bottom of the pump.

The replacement idler pin should be secured by an anaerobic adhesive to ensure tightness.

8.3 MECHANICAL SEAL

Before replacing the mechanical seal and prior to dismantling, the position of the rotating parts on the shaft should be measured and noted so that the new seal can be fitted correctly.

8.5 SLEEVE BEARINGS

The sleeve bearings must be lubricated during assembly as they will not withstand dry operation.

8.6 FLEXIBLE COUPLING

The pump are coupled to the motor by means of a flexible coupling. To perform the alignment, first remove the hydraulic motor and the coupling guard, and then reinstall the motor. The alignment between the pump and motor must be checked by means of a straight edge over the coupling halves at 2 or 3 points on the coupling. Any misalignment will appear as a gap between the straight edge and the coupling flange. A feeler gauge must be used to check that the gap is constant all the way around the coupling. Permissible clearances for eccentricity and parallelism appear in the supplier's instructions. For correct alignment of the motor and pump suitable shims must be fitted between the base of the pump and motor and the baseplate. Inaccurate alignment of the pump and motor will result in increased wear on the coupling elements. Finish by removing the motor and reinstalling the guard and motor.

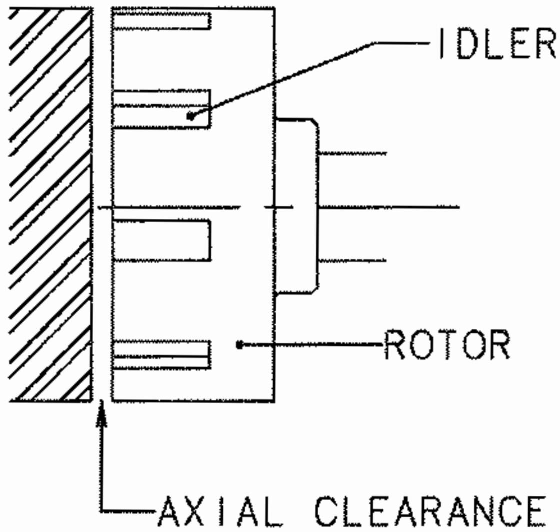
8.7 LOCKING THE PUMP SHAFT

On disassembly/assembly it may be necessary to block the pump shaft. This is done by means of a piece of wood or soft metal placed between the teeth of the rotor through one of the pump ports.

8.8 SETTING OF END CLEARANCE

The end clearance is checked with a feeler gauge between rotor/idler and head. Access is gained through one of the ports. See 4.6 for setting dimensions.

If the pump is installed, the following method of adjusting the axial clearance can be used, avoiding the need for using a feeler gauge. Remove the coupling guard as described under 8.6. Adjust the pump shaft so that the rotor touches the head, then adjust the clearance between the rotor/idler and head using the adjusting screws in accordance with the following table:



- Screw rotation in degrees=End Clearance*360/.032 (ie for .004" back the screw off by 45°)
- The clearance is adjusted by means of the bearing covers, items CS and CR. Ensure that the screws, item CT, are tightened crosswise so that the bearing will be pushed squarely into the housing.
- After the adjustment is made, check that the pump shaft rotates easily and smoothly.

9. TROUBLE-SHOOTING

The following chart will assist in locating causes of problems:

Failure	Possible causes
-The pump does not prime	1-3-4-8-9-13
-The pump is unable to maintain flow	1-5-14
-The capacity is too low	2-3-5-7-8-9-14
-Noisy pump operation	2-5
-Overloading of motor	4-10-14
-The pump becomes jammed	4-10-14
-The pump is subject to excessive wear	8-10-11

Codes

1. Too high vacuum
2. Cavitation
3. Too high viscosity
4. Too high temperature
5. The pump draws air
6. Too high pressure
7. Valve defective
8. The pump is corroded
9. The pump is worn
10. Impurities in the liquid
11. Seal overcompressed
12. Defective motor
13. Pipe diameter too small or pipes clogged.
14. Insufficient hydraulic pressure or flow.

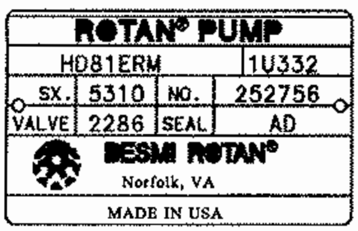
10. SPARE PARTS

10.1 ORDERING SPARE PARTS

When ordering spare parts, please provide the following information:

	Example
- Serial number	252756
- Item list number (SX-No.)	5310
- Type designation	CD41ERM-3U335
- Code of mech. seal, if any	AA
- Number of magnetic coupling, if any	-
- Number of by-pass valve, if any	-
- Item reference of spare part	Item CJ
- Designation of spare part	Mech. seal

The serial number of the pump, SX No., type designation and code of mechanical seal and bypass valve, if any, appear on the nameplate. In addition, the serial number is stamped on the left hand port of the pump, viewed from the coupling end. The item reference and designation of the spare part are found on the section drawings (see 10.2) and the spare parts list (see 10.3).



The example shows the information necessary for specifying a mechanical seal to be supplied for a given CD41 pump.

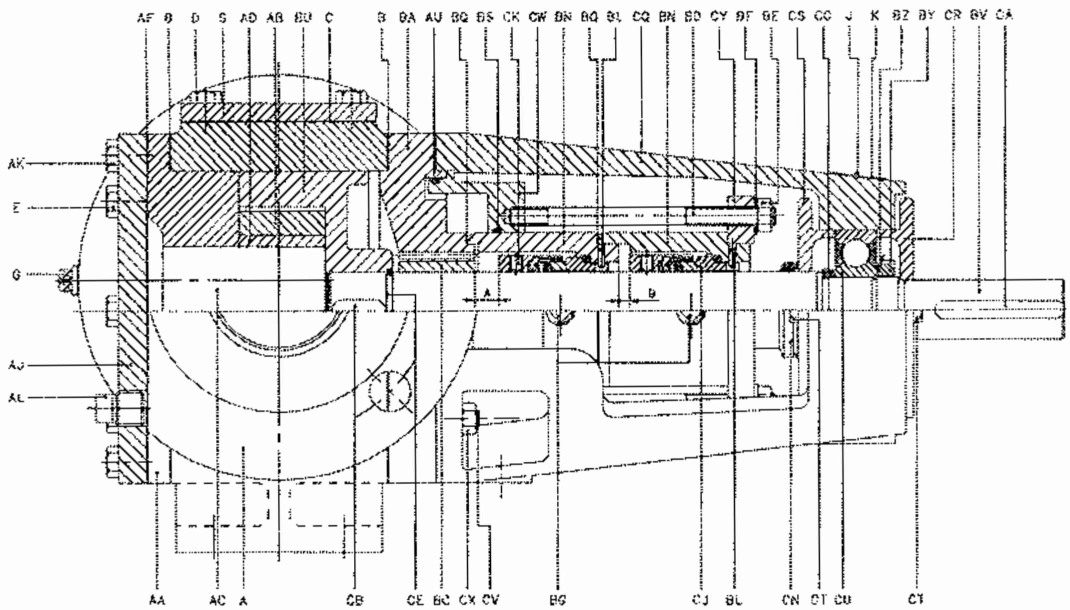
For Technical assistance or Spare Parts Ordering, please contact:

Hyde Marine, Inc.
28045 Ranney Parkway
Cleveland, OH 44145
phone: 440-871-8000 x156
fax: 440-871-8104
e-mail: jmackey@hydeweb.com

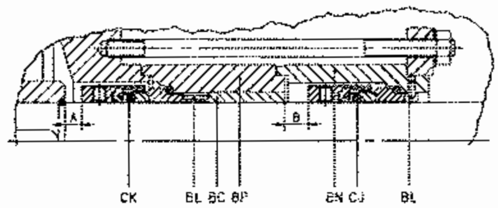
10.2 SECTIONAL DRAWINGS OF SPARE PARTS

The following pages show a representative selection of ***Rotan*** assembly drawings. Not all pump configurations are represented, but the drawings show all item references and configurations that generally apply.

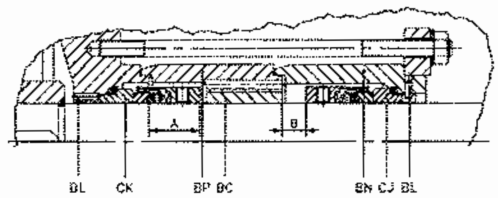
CD/PD..EDKMMW



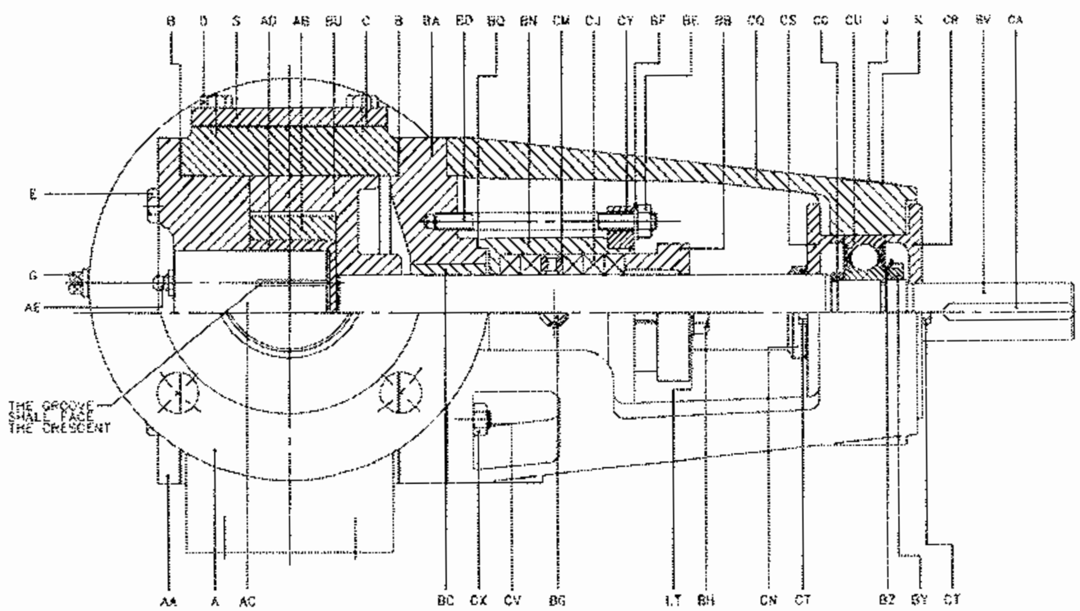
MM



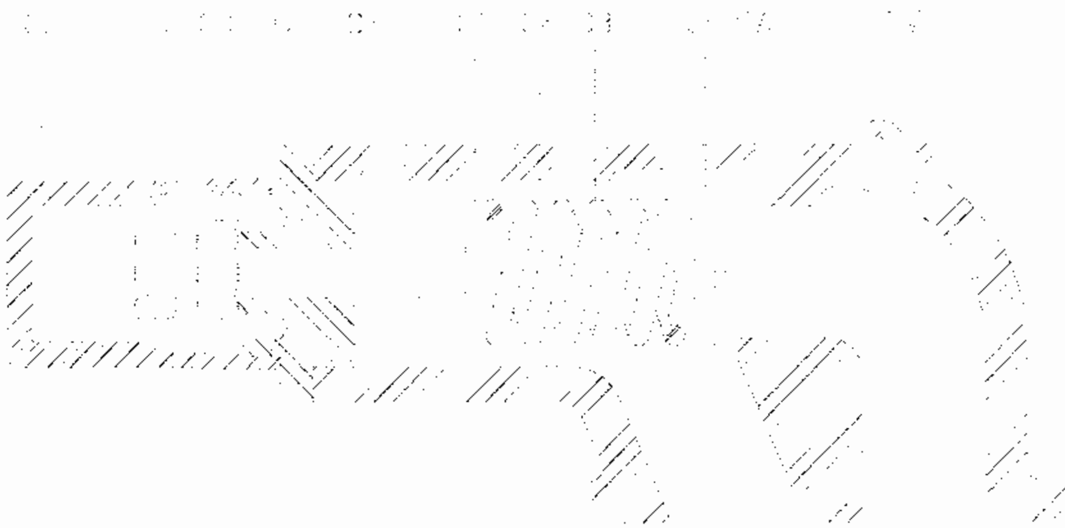
MMP



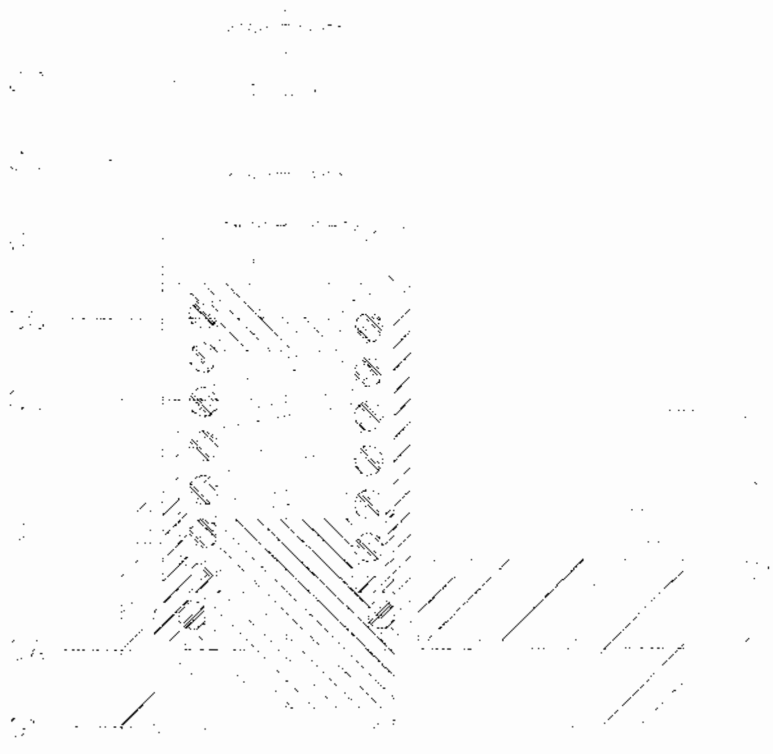
CD/PD..E



Relief valve for
HD, GP (CD, PD, MD).



Relief valve for
CD, PD - 26/33/41.

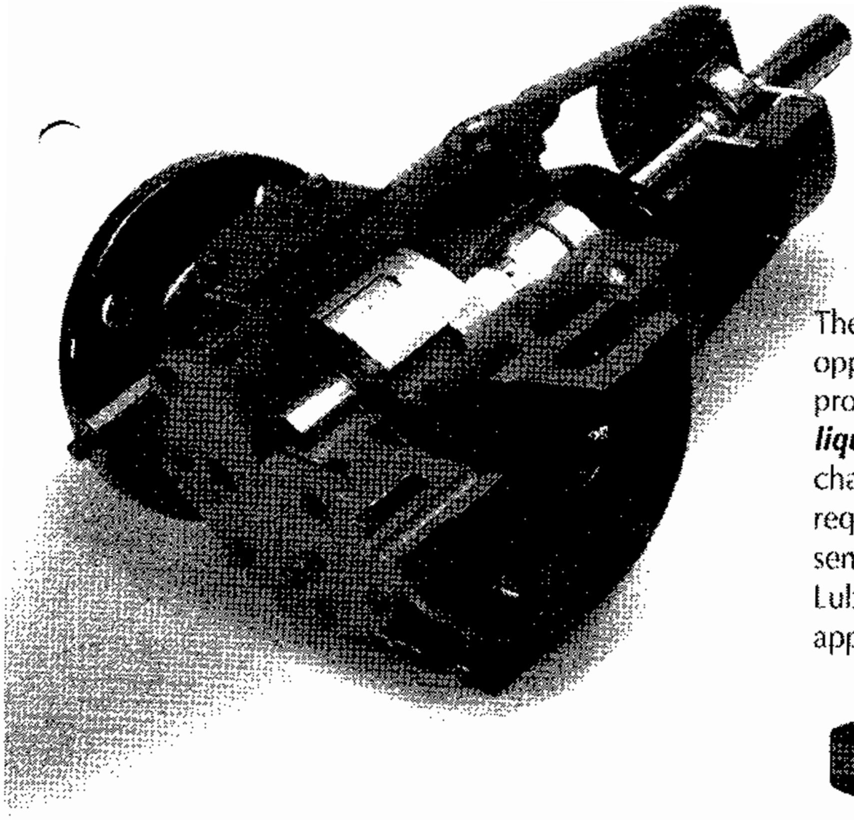


10.3 LIST OF SPARE PARTS

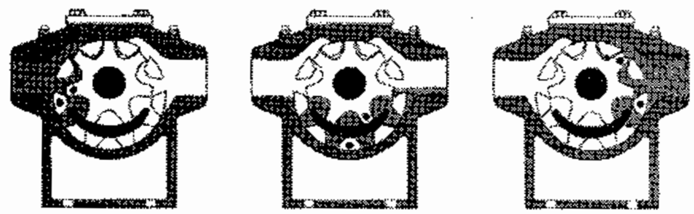
Item	Designation
A	Pump casing
B	Joint ring/O-ring
C	Joint ring
D	Bolt
E	Bolt
F	Bolt
G	Pipe plug
J	Drive screw
K	Name plate
S	Blind cover
T	Pipe plug
U	Joint ring
AA	Head
AB	Idler
AC	Idler pin
AD	Idler bearing
AE	Lub.nipple/Pipe plug
AF	Joint ring
AJ	Heating jacket
AK	Bolt
AL	Pipe plug
AU	O-ring
BA	Rear cover
BB	Packing gland/bearing cover
BC	Main bearing/ball bearing
BD	Stud bolt/bolt
BE	Nut
BF	Washer

Item	Designation
BG	Pipe plug/lub.nipple
BH	Bolt/pipe plug
BJ	Bolt
BL	Pin
BN	Seal housing
BP	Intermediate bearing
BQ	Gasket
BR	Distance ring
BS	O-ring
BU	Rotor
BV	Shaft
BY	Ball bearing nut
BZ	Ball bearing locking ring
CA	Key
CB	Key
CC	Fixing ring/distance ring
CD	Threaded screw
CE	Snap ring
CJ	Packing rings/mech.seal
CK	Mech.seal
CM	Lantern ring
CN	V-ring
CQ	Bearing bracket
CR	Bearing cover
CS	Bearing cover
CT	Bolt
CU	Ball bearing
CV	Stud bolt

Item	Designation
CW	Heating jacket
CX	Nut
CY	Flange
DA	Motor bracket
DB	Coupling
DC	Threaded screw
DD	Threaded screw
EF	O-ring
EG	Seal ring
EJ	Bolt
GA	Valve
GB	Spring
GC	Adjusting screw
GD	Nut
GE	Cap
GF	Joint ring
GG	Pressure plate
GH	Pressure plate
GJ	Valve cover
GK	Valve casing
GM	Pipe plug
GN	Joint ring
GQ	Bolt
GR	Washer
HD	Shield
HE	Bolt
JL	Joint ring
KX	Bolt
KY	Bolt
LT	Washer
MA	O-ring



The ***ROTAN*** internal gear pump standard in-line, opposing connection design with oversized ports provides ***superior self-priming capability*** with ***gentle liquid handling*** as the direction of the liquid flow is changed only slightly. In addition to reduced NPSH requirements, this means high viscosity and shear sensitive materials may be readily pumped. Lubricating and non-lubricating liquids, with appropriate provisions, can be pumped.

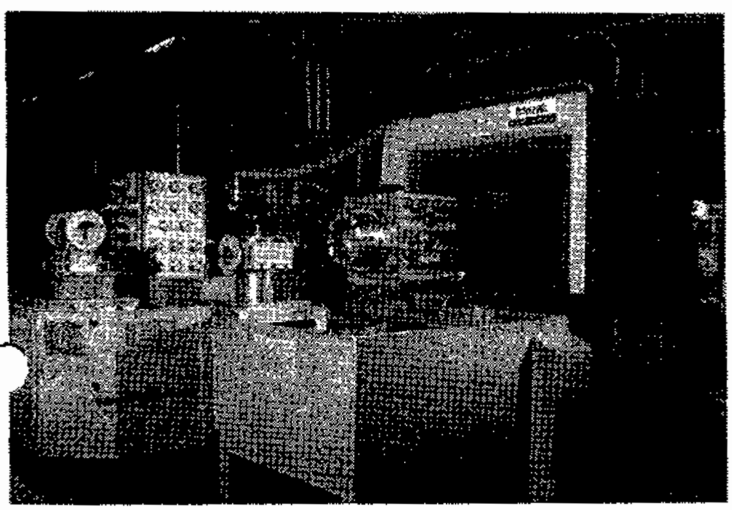


Liquid inlet Passage of liquid Liquid outlet

Method of operation

Every pump is hydrostatically and performance tested

ISO 9001 certificate



Manufacturing with state-of-the-art CNC equipment

ROTAN pumps offer the following, additional advantages and benefits:

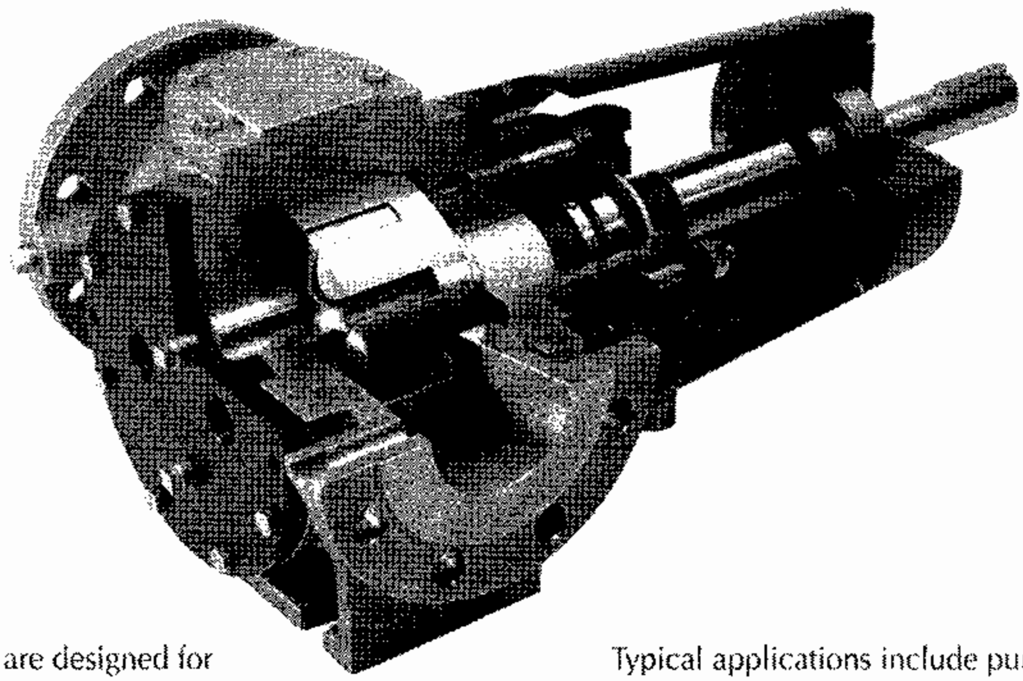
- Pumping capability in either direction (all models) allowing installation flexibility
- Modular, back pull-out (except GP) design makes inspection and maintenance easy
- Construction is uncomplicated and rugged with only two rotating parts and a shaft seal, enhancing service life
- External axial adjustment of rotor/shaft for wear and repositioning after maintenance saves time and expense
- Large choice of configurations provides flexibility to handle a wide range of applications
- Substantial inventories are maintained, including stainless steel and mag drive pumps, to meet customer schedules
- Competitively priced, helping our customers reduce initial and operating costs
- Computerized selection program available for customers wanting immediate sizing and related application information
- Standard, integral relief valve mounted on casing saves space and simplifies piping

ROTAN®

CD

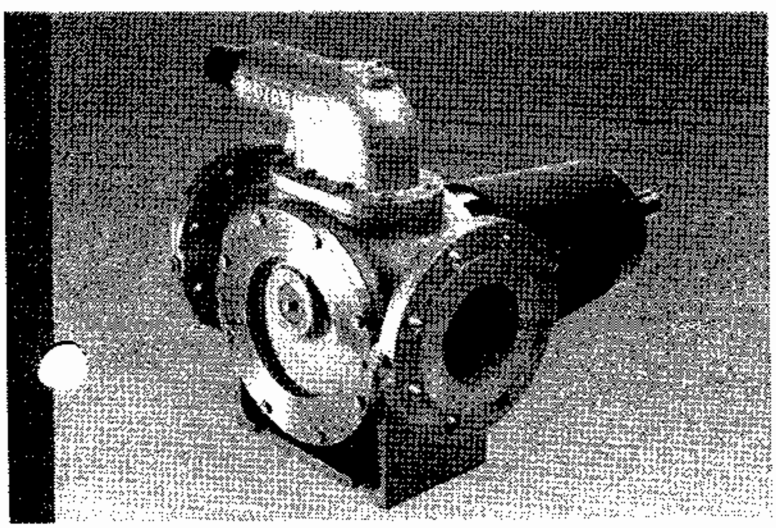
SERIES

Chemical Duty pumps in stainless steel, designed to handle corrosive liquids



CD pumps are designed for handling corrosive liquids, primarily handling in the chemical processing, food, and pharmaceutical industries.

Typical applications include pumping organic acids, fatty acids, alkalis, caustic soda, polymer solutions, soap, shampoo, animal fat, vegetable fat, chocolate, and other special fluids.



Capacity range:	Up to 750 gpm
Speed:	Up to 1750 rpm
Differential pressure:	Up to 250 psi
Suction lift:	Up to 15″ Hg vacuum while priming Up to 24″ Hg vacuum while pumping
Viscosity range:	Up to 75,000 cSt
Temperature:	Up to 500°F

ROTAN®

By indicating the options in the order below, the complete pump can be identified

1) Pump series

- **GP** General Purpose, mono block pump in cast iron
- **HD** Heavy Duty pump in cast iron
- **PD** Petrochemical Duty pump in carbon steel
- **CD** Chemical Duty pump in stainless steel
- **MD** Mag Drive pump, magnetically coupled, in cast iron, carbon steel or stainless steel

2) Pump sizes

- **26** DN 25 – 1"
- **33** DN 32 – 1¼"
- **41** DN 40 – 1½"
- **51** DN 50 – 2"
- **66** DN 65 – 2½"
- **81** DN 80 – 3"
- **101** DN100 – 4"
- **126** DN125 – 5"
- **151** DN150 – 6"
- **152** DN150 – 6"
- **201** DN200 – 8"

Available with flanges* or NPT tapped dependent on the size and material. GP and MD pumps are through available size 101: CD and PD are not available in size 152.

* Flange connections according to:
ANSI B 16.1/B 16.5 ISO 2084 DIN 2501 BS 4504 1969

3) Configurations

- **E** Suction/discharge connections in-line
- **B** Suction/discharge connections at 90° angle (optional)

Add: Choice of additional options, see page 12.

Add: Only for MD pumps:

- **A** Magnetic coupling for pump sizes 26 - 41
- **G** Magnetic coupling for pump sizes 41 - 66
- **H** Magnetic coupling for pump sizes 51 - 81
- **I** Magnetic coupling for pump sizes 81 - 101

– ***Hyphen***

5) Material codes for wetted parts

Code	Type	Casing/Covers	Rotor/Idler	Shaft
1	GP/HD	Cast iron	Cast iron	Carbon steel
3	CD	316 SS	329 SS	329 SS
4	PD	Cast steel	Cast iron	Carbon steel

For MD pumps, all material codes may be used.

6) Lubrication

- **U** Idler bearing and main bearing lubricated by pump medium
- **M** Externally lubricated idler bearing and main bearing

7) Material codes for idler bearing

Code	Idler bush	Idler pin: GP-HD-PD	Idler pin: CD
1	Cast iron	Hardened steel	329 SS
2	Bronze	Hardened steel	329 SS
3	Carbon	Hardened steel	329 SS
4	Al.oxide	Cr.oxide coated steel	329 SS
5	Carbon	Al.oxide, polished	Al.oxide, polished
8	Tungsten carbide	Tungsten carbide	Tungsten carbide

8) Material codes for main bearing

Code	Bearing bush	Shaft: GP-HD-PD	Shaft: CD
1	Cast iron	Carbon steel	329 SS
2	Bronze	Carbon steel	329 SS
3	Carbon	Carbon steel	329 SS
4	Al.oxide	Cr.oxide coated steel	Cr.oxide coated 329 SS
8	Tungsten carbide	Coated Steel	Cr.oxide coated 329 SS
9	Silicon carbide	Silicon carbide bush or Cr.oxide coated Steel	Silicon carbide bush or Cr.oxide coated 329 SS
B	Ball bearing	Steel	Not applicable

9) Shaft seals

- **B** Teflon-impregnated, non-asbestos packing
- **2** Single mechanical shaft seal Bellows or O-ring type
- **22** Double mechanical seal, O-ring type

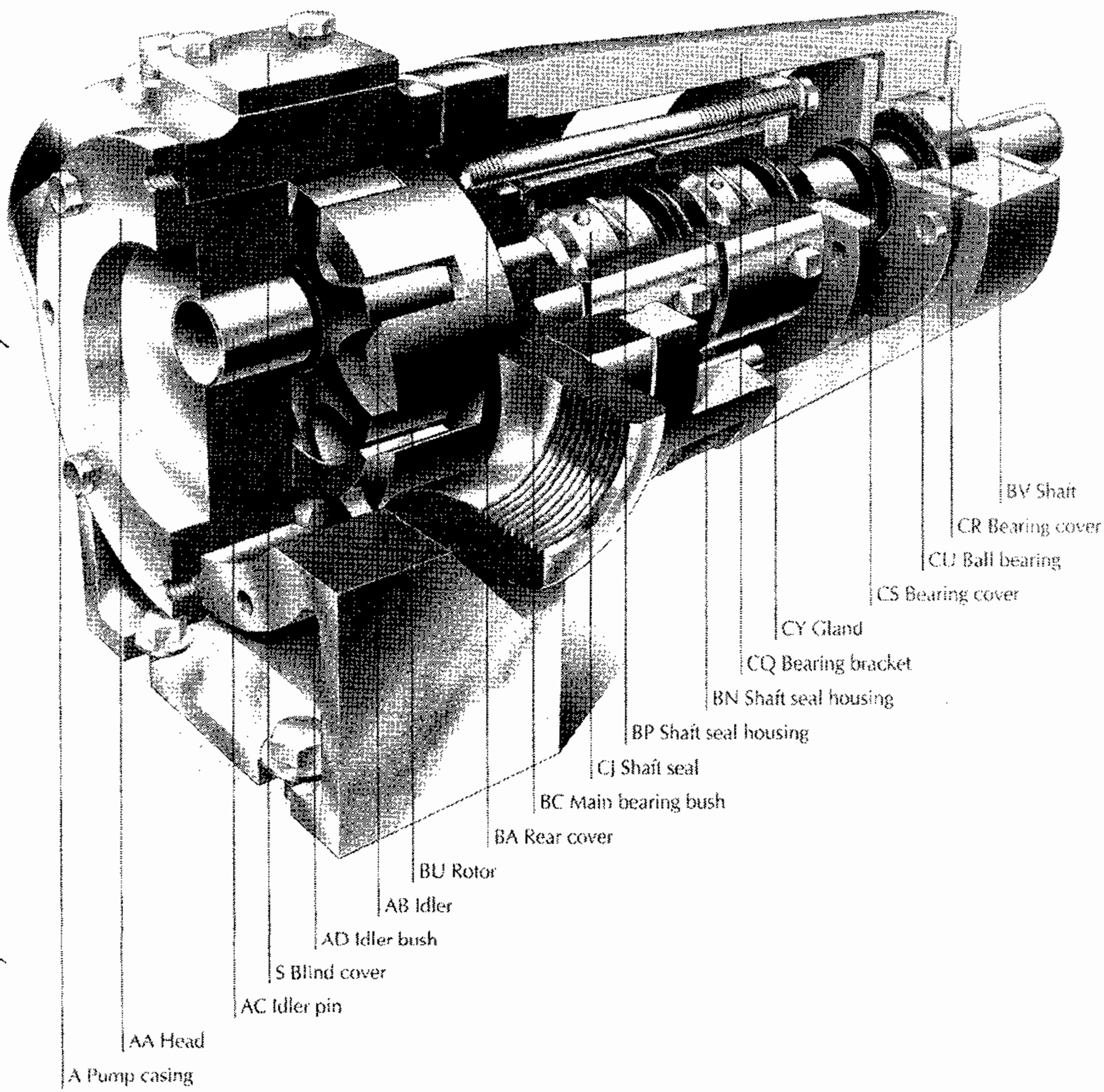
Only for MD pumps

- **/2** 1" magnet length
- **/3** 1½" magnet length
- **/6** 2" magnet length
- **/8** 3" magnet length
- **/10** 4" magnet length

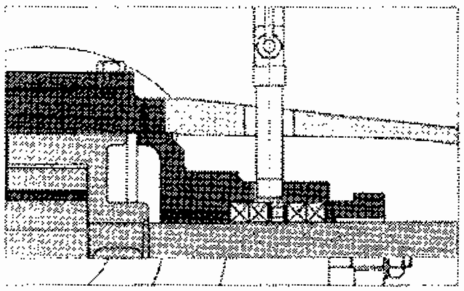
10) Special configurations

- **S** All special configurations are marked with: S

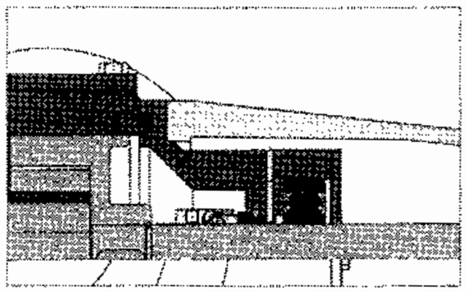
Item references and descriptions



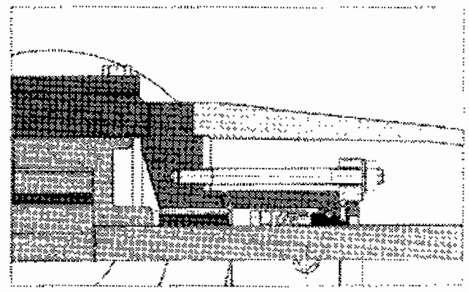
Configurations



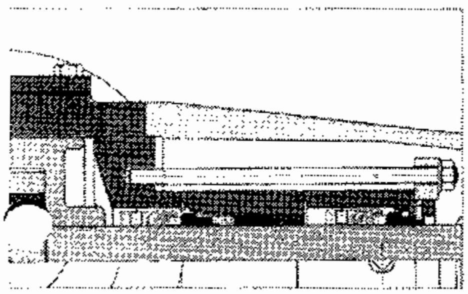
Sealing with stuffing box, with or without lantern ring, for use of external lubrication. Used for high viscosities and where some leakage is allowed.



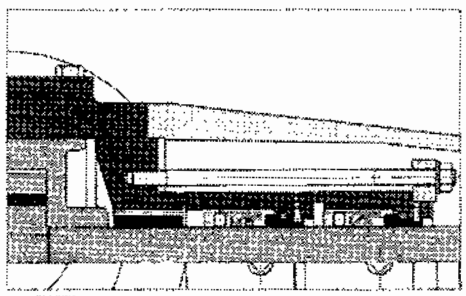
M - *GP/HD*
Sealing with single mechanical shaft seal, combined with a permanently lubricated ball bearing as the main bearing. Used where only minute leakage is allowed.



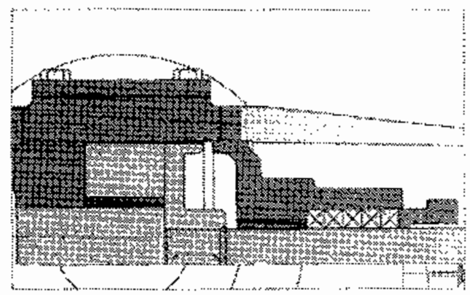
M - *PD/CD*
Sealing with single mechanical shaft seal, combined with a product lubricated sleeve bearing as the main bearing. Used where only minute leakage is allowed.



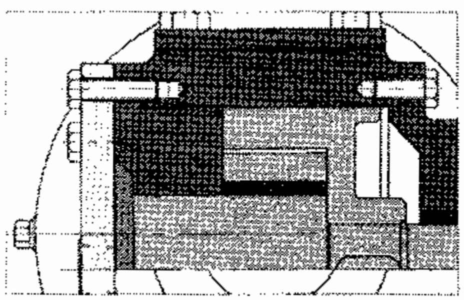
MM *(tandem)* - **MMP** *(back to back)*
Tandem or double mechanical shaft seals, with main bearing in the barrier fluid. Used where no leakage is allowed. Up to 100 psi differential pressure.



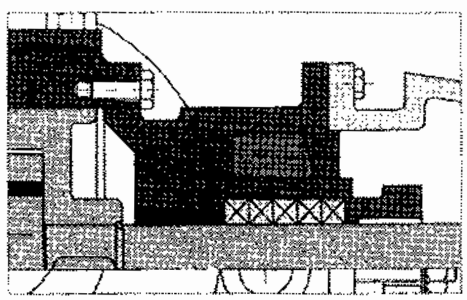
MMW *(tandem)* - **MMPW** *(back to back)*
Tandem or double mechanical shaft seals, with product lubricated main bearing. Used where no leakage is allowed Up to 250 psi differential pressure.



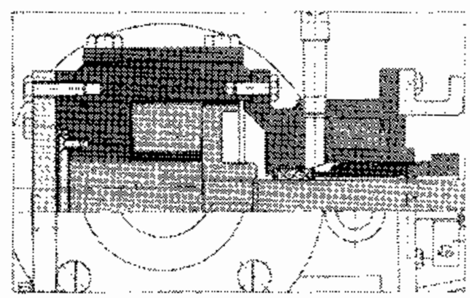
T
Special clearances. Increase of tolerances used for liquids with a viscosity above 7.500 cSt or a temperature above 300°F.



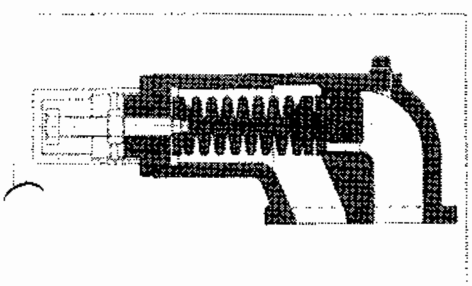
D
Heating jacket on the front cover, often required prior to start-up when pumping high viscosity liquids and liquids which tend to solidify.



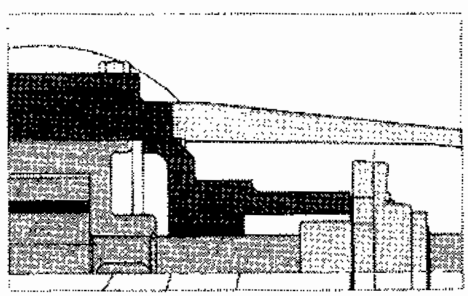
K
Heating jacket on the rear cover, often required prior to start-up when pumping high viscosity liquids and liquids which tend to solidify. This jacket is also used as a seal cooling jacket.



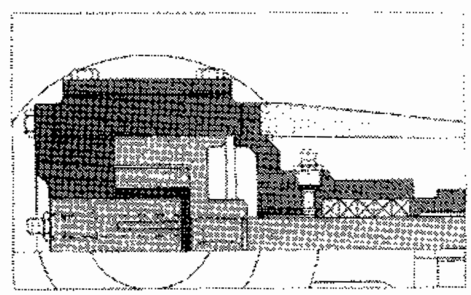
CHD
Combination of special clearances and heating jackets together with external lubrication of the main bearing, used in the chocolate industry.



R
Safety valve, single acting (one direction), used to protect the pump and the complete installation against excess pressures.

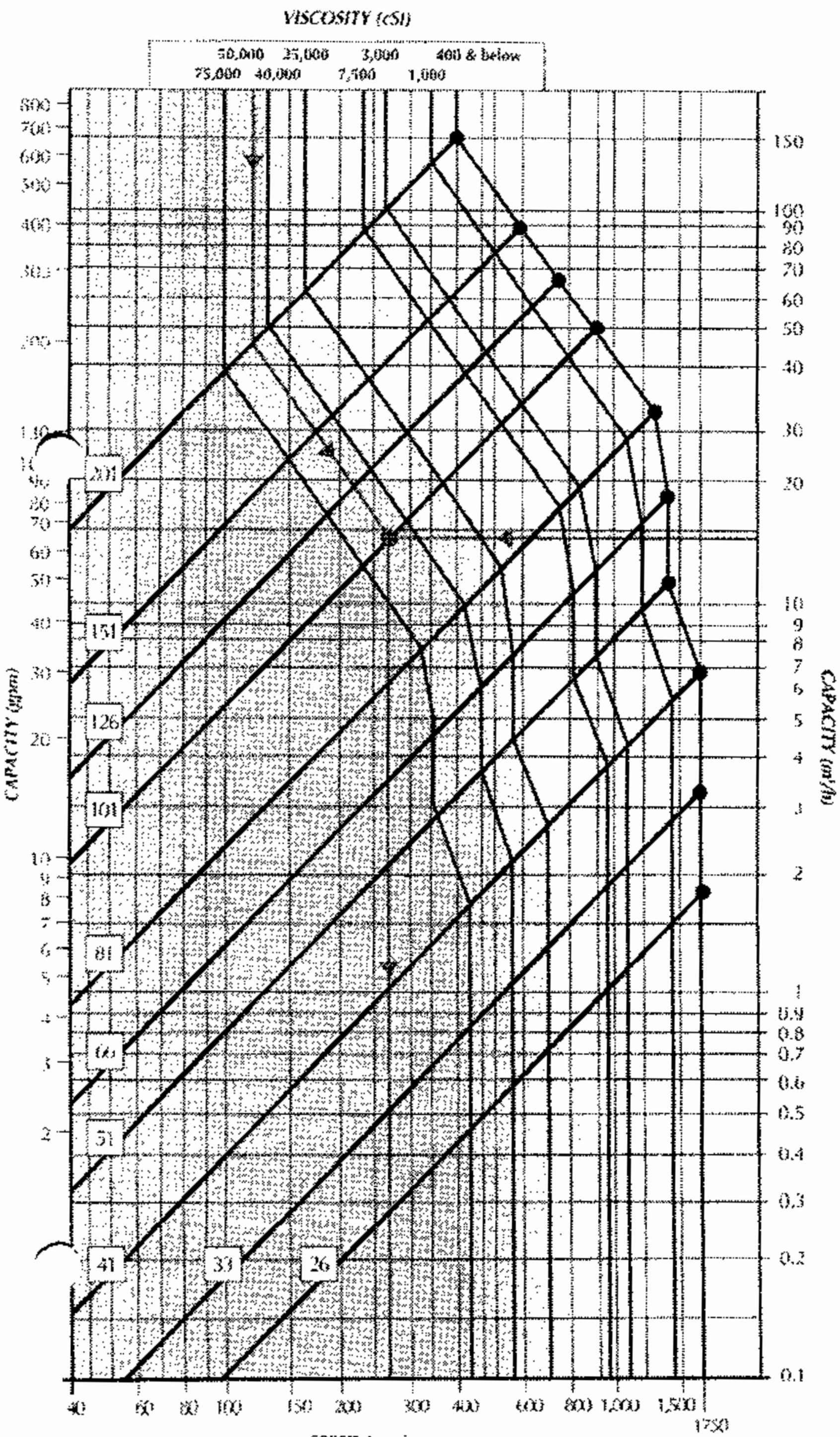


Special configurations
Example: Customer specified or provided seal-cartridge or component.



Lubrication
Idler and main bearing externally lubricated. Used when pumping non-lubricating or very viscous fluids.

Selection of pump size



To select the appropriate pump size, locate the intersection of the horizontal ***CAPACITY*** line and ***VISCOSITY*** curve applicable to the design conditions. If this point does not intersect a diagonal ***PUMP*** curve (pump size is noted in a box just above each diagonal line), consider the pump sizes indicated by the lines passing closest to this point. The corresponding pump speed can be read from the ***SPEED*** scale vertically below this resulting position on the selection chart. (Recognizing that the pump capacity is directly proportional to the pump speed, consideration should be given to the driver and speed reduction device, if necessary, prior to the final pump selection.) Maximum allowable speeds for each pump model can be found vertically below the end of each pump line. This maximum value is assigned for clean, non-abrasive liquids and must be reduced 25% for slightly abrasive liquids or 50% when handling moderately abrasive liquids or emulsions.

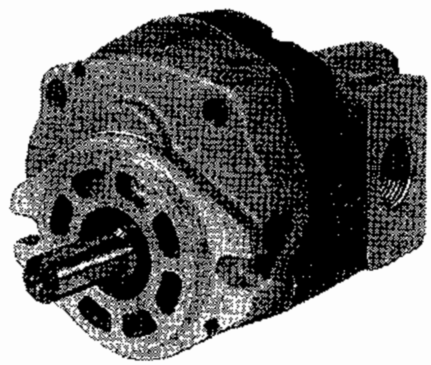
Approximate brake horsepower required when pumping liquids with viscosities of approximately 1000 cSt, when differential pressure is known, can be calculated by:

BHP = 0.0015 x flow (gpm) x differential pressure (psi)

The resulting value is based on a typical pump efficiency and should be increased or decreased when handling a higher or lower viscosity liquid, respectively. Specific application horsepower requirements should be confirmed with your local ***ROTAN*** representative or ***DESMI***.

An MS-Windows computer program ideal for evaluating selections and determining horsepower requirements is available on request. Two useful aids are included -- a system loss calculation utility and a list of liquids with helpful information for specifying pump design, materials, and accessories.

Series **UM16**



Series UM16
Rear Ported

Description .... Gear Motors

Flow Range .... To 42 GPM

Displacements .... To 3.90 C.I.R.

Maximum Pressure to .... 3000 PSI

Maximum Speed to. .... 3600 RPM

Rotation. .... Uni-Directional

Bearings .... Journal

Construction. .... Aluminum Flange & Cover with Cast Iron Gear Section

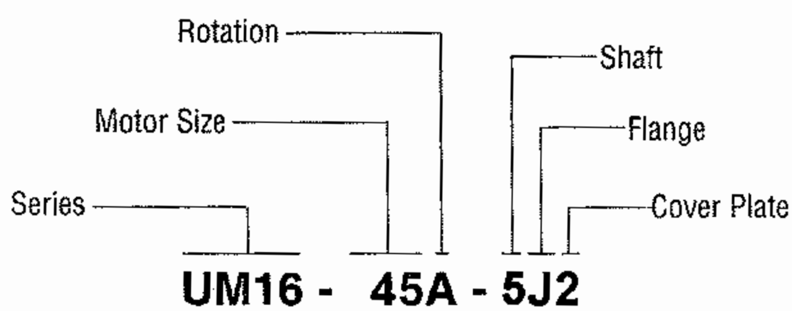
Performance Data

MOTOR SIZES	DISPLACEMENT/REVOLUTION (Theoretical)					Lb-In. Torque at 3000 PSI[2]		H.P. at Max. RPM	Max. Limits		
	US Gallons	*Cubic Inches*	*Liters*	*Cubic Centimeters*	*Imperial Gallons*	*Start*	*Run*	*Max. PSI[3]*	Pressure *PSI*	Pressure *BAR*	Speed *RPM*
UM16 - 45	.0038	.878	.0144	14.388	.003	324	374	21	3000	207	3600

Notes: (1) Consult factory for approval. (2) Average values from performance curves. (3) All motors are available with Viton Seals for use with phosphate ester base fluids. (4) All data based on SAE 10W Oil at 135°F. (5) M16 motors are not suitable for series operation.

How To Order

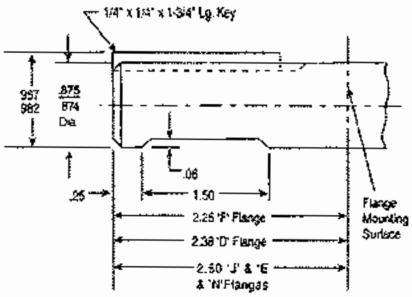
'A' denotes counterclockwise rotation
'C' denotes clockwise rotation
When viewed from drive shaft end



Note: Add prefix 'V' to pump model number (VUM16-) when ordering pumps with Viton Seals for use with phosphate ester base fluids.

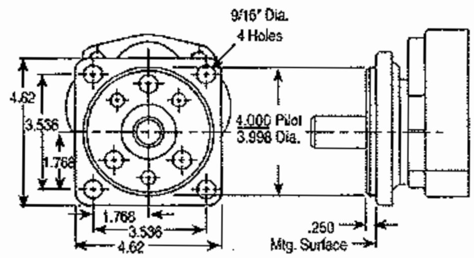
Shaft

5 **7/8" Straight Shaft**
Torque Limit 184 Lbs. Ft.



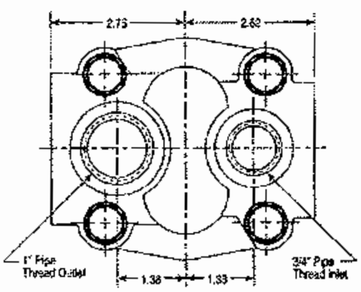
Flange

J **SAE 'B' 4-Bolt**



Cover Plate

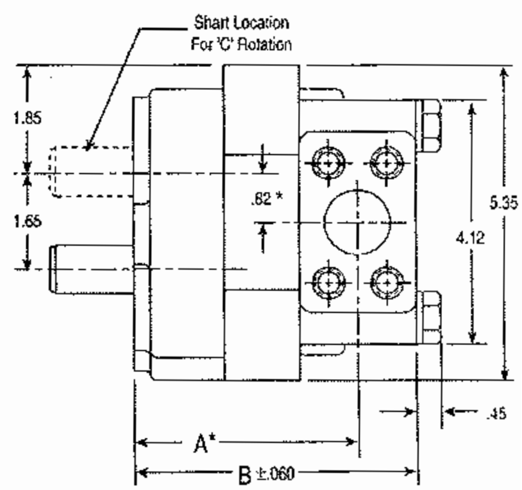
2 **Rear Ported NPTF**



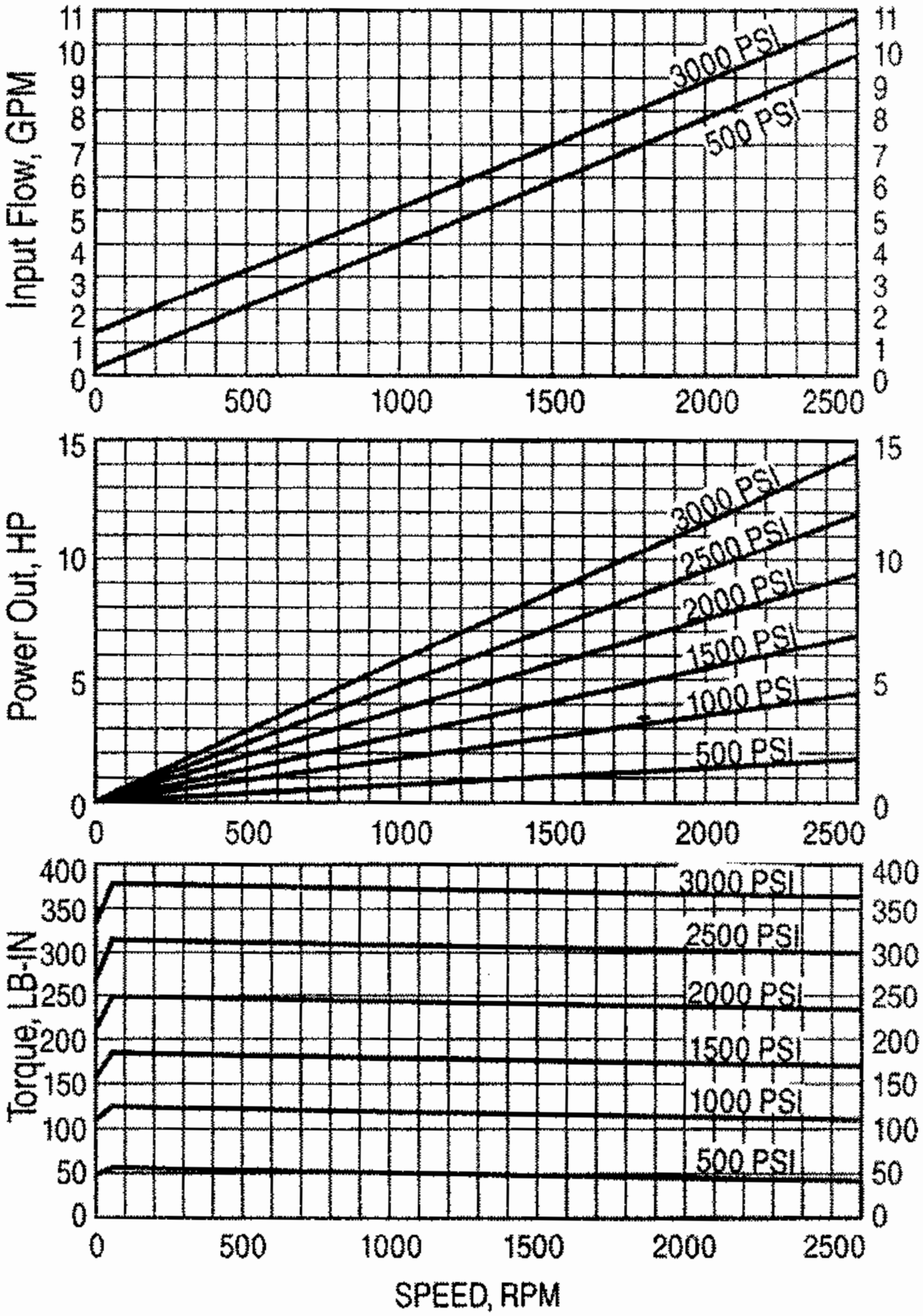
Dimensional Data

Mounting Dimensions

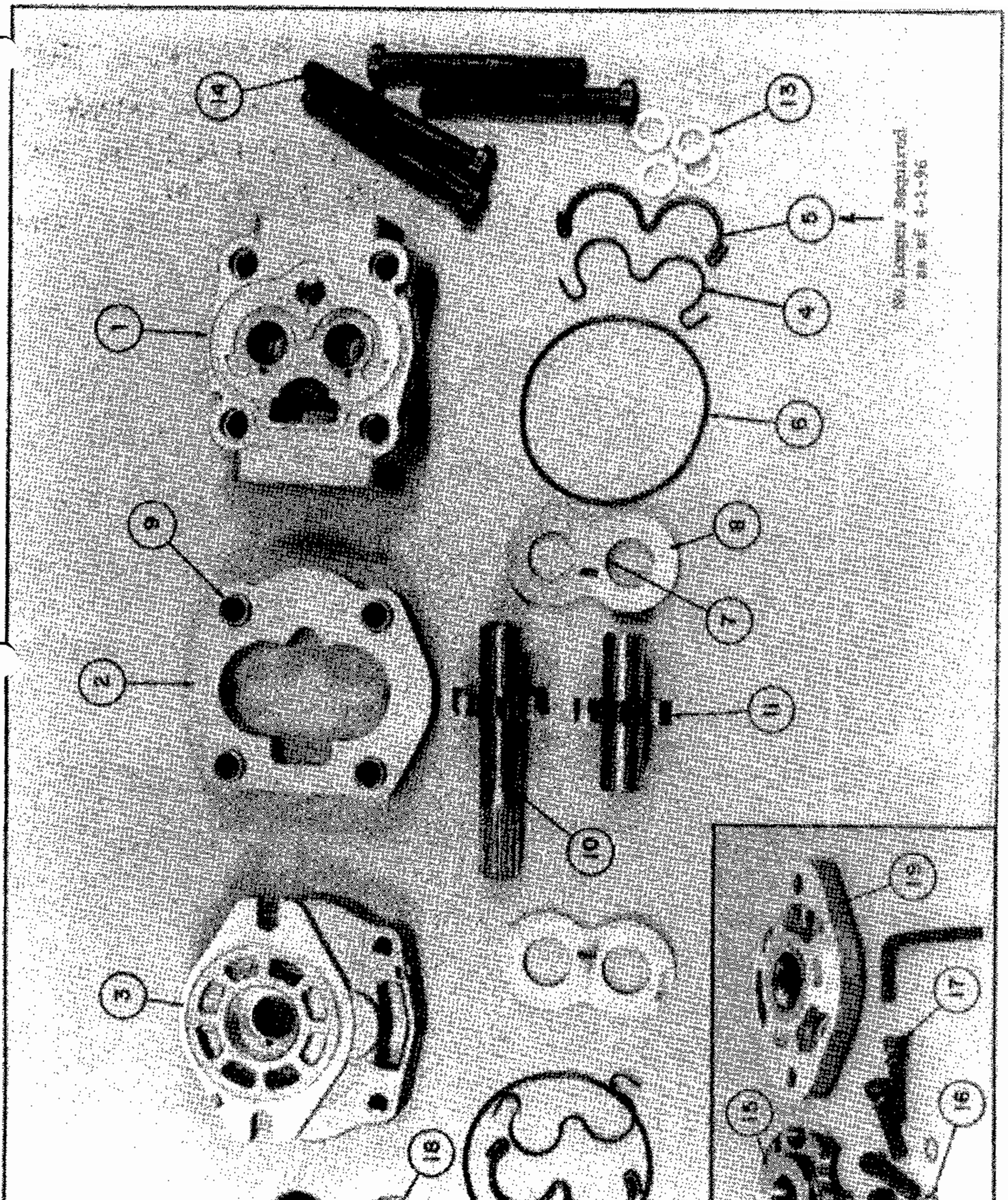
MOTOR SIZES	*FLANGE TYPE J*				*SHIPPING WEIGHTS (Approx.)*	
	A		*B*			
	IN	*MM*	*IN*	*MM*	*lbs.*	*kgs.*
UM16-45	4.66	118.4	5.67	144.1	8	3.5
UM16-65	4.88	123.6	5.89	149.6	8	3.5
UM16-85	5.09	129.3	6.10	154.9	8	3.5
UM16-100	5.25	133.3	6.26	159.0	9	4.0
UM16-115	5.41	137.4	6.42	163.1	9	4.0
UM16-150	5.78	146.8	6.79	172.5	9	4.0
UM16-180	6.10	154.9	7.11	180.6	10	4.5
UM16-200	6.31	160.3	7.32	185.9	10	4.5



* These dimensions locate ℄ of bolt pattern only


Input Flow, GPM
3000 PSI
500 PSI
Power Out, HP
3000 PSI
2500 PSI
2000 PSI
1500 PSI
1000 PSI
500 PSI
Torque, LB-IN
3000 PSI
2500 PSI
2000 PSI
1500 PSI
1000 PSI
500 PSI
SPEED, RPM

UM16-45


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
No Longer Required
as of 4-1-96

P16

5. Using 3/4 wrench, loosen and remove capscrews (14) and washers (13). (Fig. 5)

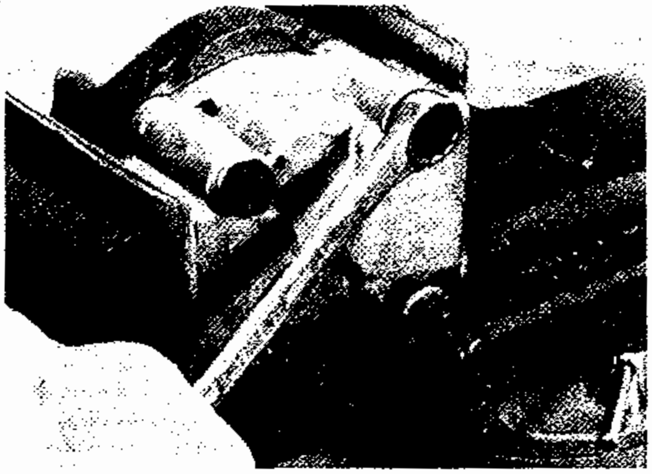


Fig.5

6. Remove pump from vise. Using wood mallet or plastic hammer, tap connector bosses to loosen cover plate (1). Lift plate straight up off gear journals. (Fig. 6)

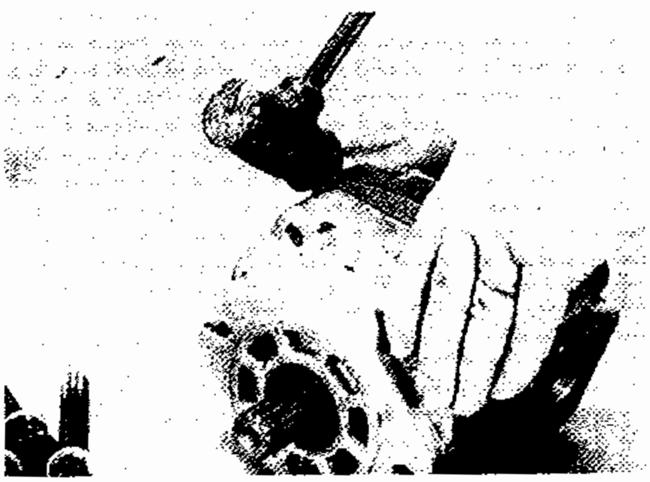


Fig. 6

7. Remove body o-ring (6), pressure balance o-ring (5), and back-up ring (4). (Fig. 7)

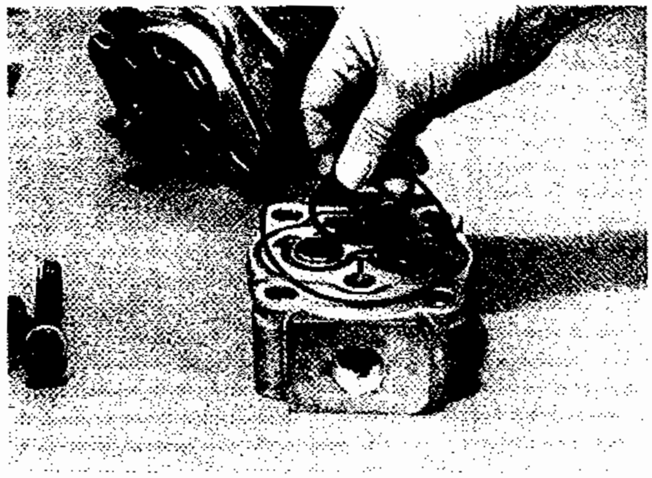


Fig. 7

8. Remove pressure plate (8). Remove o-rings (7) from journal bores of pressure plate. (Fig. 8)

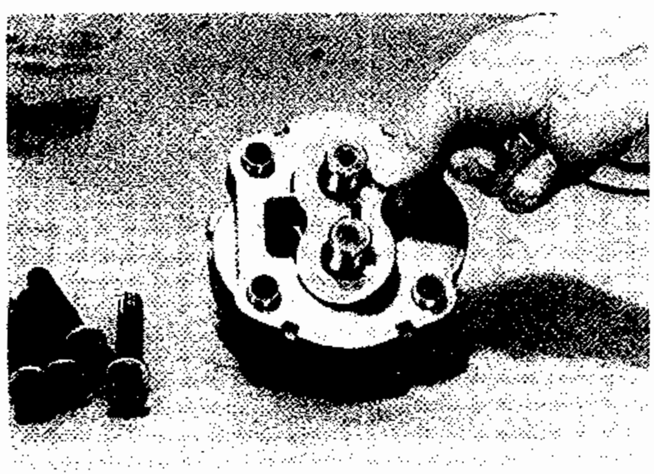


Fig. 8

DISASSEMBLY AND ASSEMBLY INSTRUCTIONS FOR P16 PUMP

DISASSEMBLY INSTRUCTIONS

1. Using solvent and brush, clean outside of pump thoroughly. (Fig. 1)

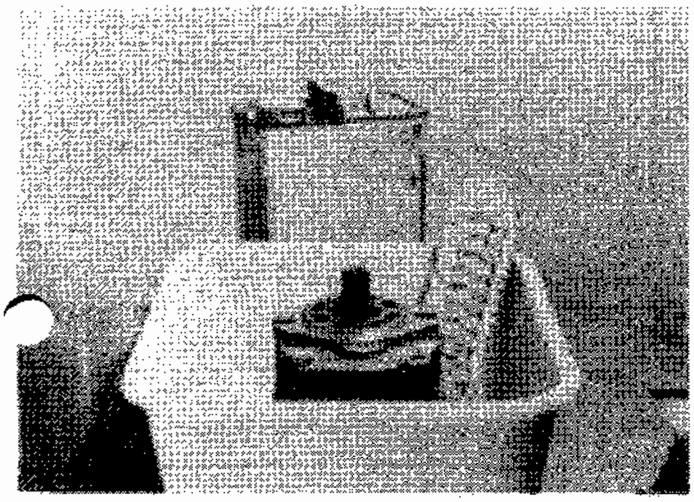


Fig. 1

3. Mark the pump plates nearest to drive shaft extension side. These marks can be used for matching in reassembling pump. (Fig. 2)

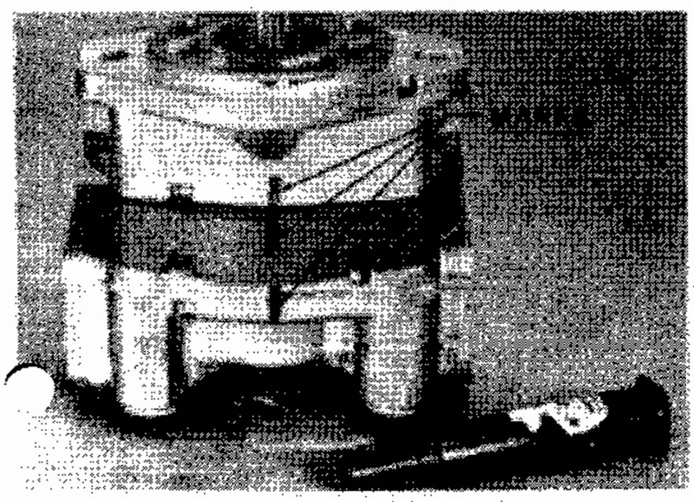


Fig. 2

3. Place pump in machinist vise. Use blocks of wood or cardboard between pump and vise jaws. (Fig. 3)

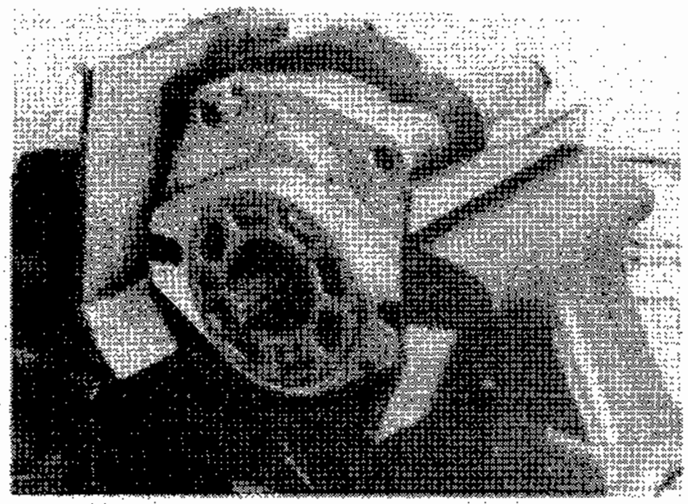


Fig. 3

4. If your pump has a mounting adapter (15), remove allen-head capscrews (17), washers (16) and flange adapter (19). (Fig. 4)

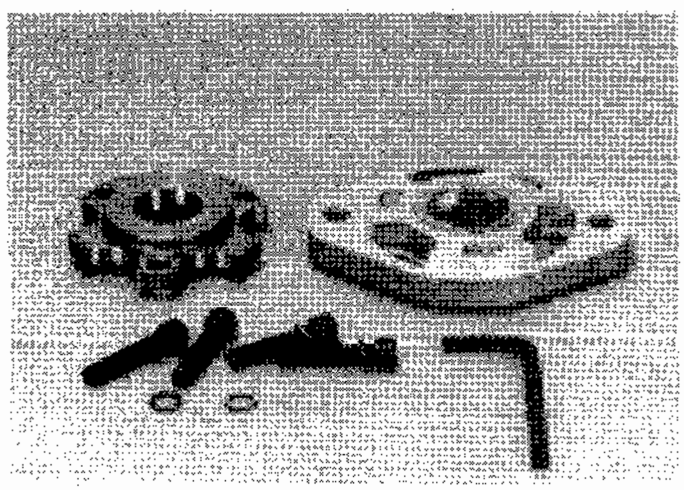


Fig. 4

9. Lift drive gear (10) and idler gear (11) straight up out of gear plate. (Fig. 9)

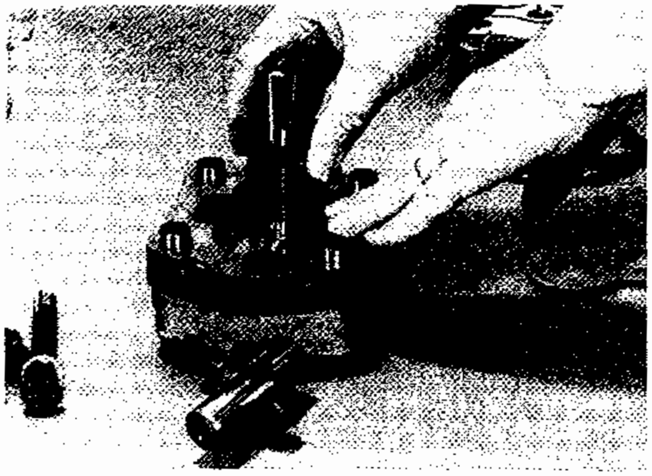


Fig. 9

10. Tap edges of gear plate (2) with wood mallet or plastic hammer to loosen. If gear plate does not move by this method, lift the plates up off work bench slightly and tap the ears of flange plate lightly. (Fig. 10)

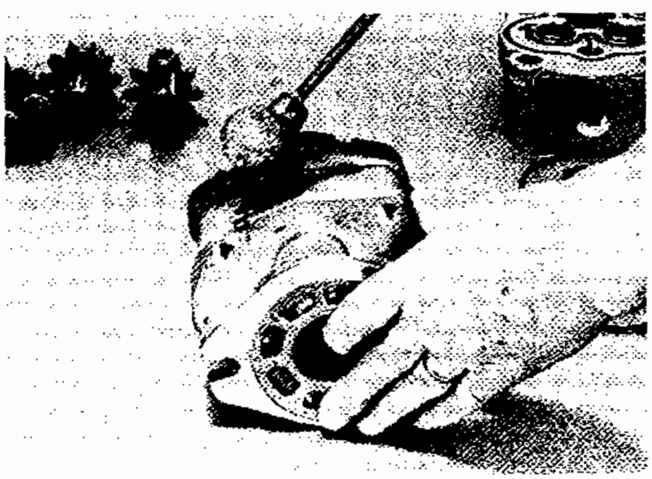


Fig. 10

11. Dowels (9) are pressed into gear plate. There are four dowels on each side and unless gear plate is replaced it is not necessary to remove them. To remove the dowels use a rod or punch and hammer to drive them out. Place driver inside of dowel and against end of dowel on opposite side and tap it out. (Fig. 11)

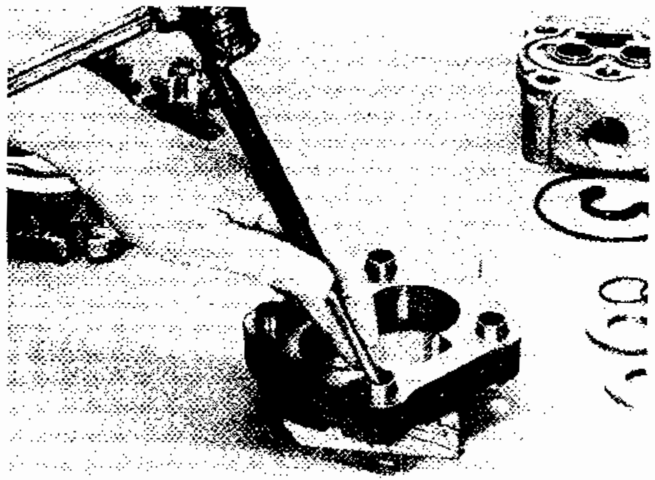


Fig. 11

12. To complete the disassembly, follow steps 7 and 8. (Fig. 12)

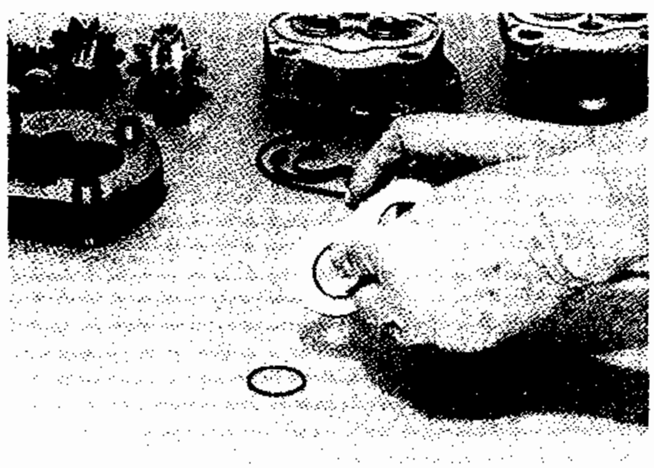


Fig. 12

13. For shaft seal removal and replacement, see seal replacement section.

14. Wash all pump parts in clean solvent and wipe dry with clean shop towel or blow dry with shop air.

15. Visually inspect all parts. For detailed instructions, see parts inspection section.

ASSEMBLY INSTRUCTIONS

16. Each pump is assembled and tested for a specific direction of rotation. Direction of rotation can not be changed without changing flange (3).

17. Install o-ring (6) in cover plate (1). After o-ring has been placed in groove, spread a light coat of clean heavy grease on the o-ring to hold it in place. (Fig. 13)

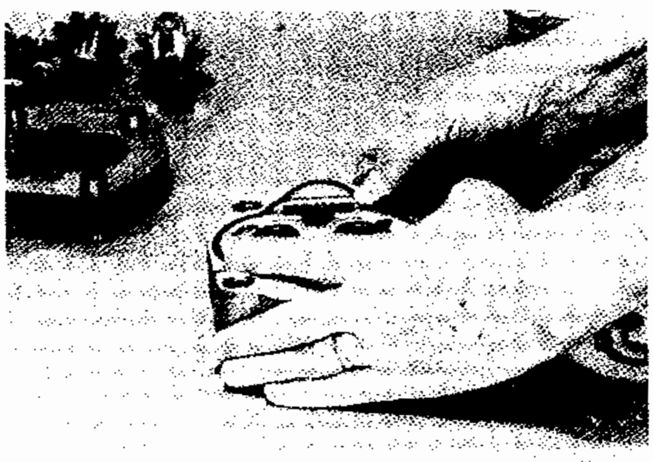


Fig. 13

18. If for any reason gear plate (2) had to be replaced, dowels (9) must be pressed into both sides of replacement gear plate before assembling it to cover plate (1). Dowels can be tapped in with hammer, but it is best to use dowel guide and press. Whichever method is used, make sure they are straight in dowel bores. If press is used, do not apply rapid force on dowels. If hammer is used, do not drive the dowels in aggressively. Tap them lightly until they are against shoulder. (Fig. 14)

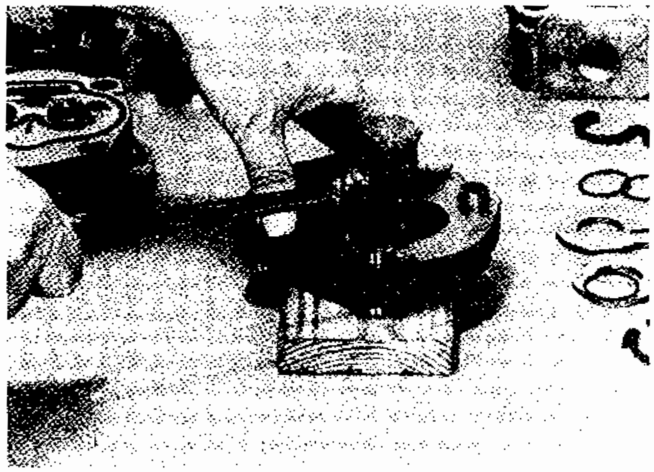


Fig. 14

19. With matching marks made in step 2 toward you, and the four cast recesses in the outer edge of gear plate toward cover plate, line up dowels. Tap gear plate lightly until it is against O-ring in cover plate. (Fig. 15)

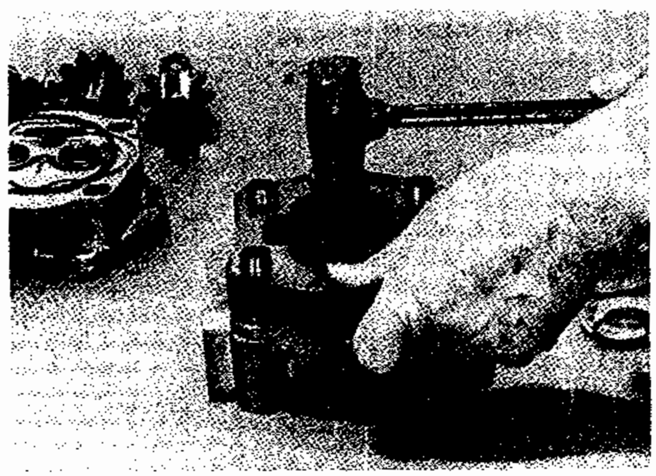


Fig. 15

20. Install back-up ring (4) and o-ring (5) as shown in figure 16.

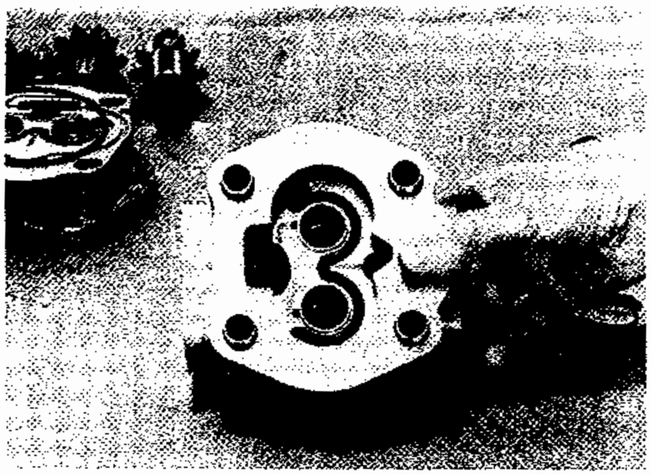


Fig. 16

21. Install o-ring (7) in pressure plate (8). With trap (small oblong hole) in pressure plate toward discharge side of gear plate and bronze side up, slide pressure plate down gear bores. (Fig. 17)

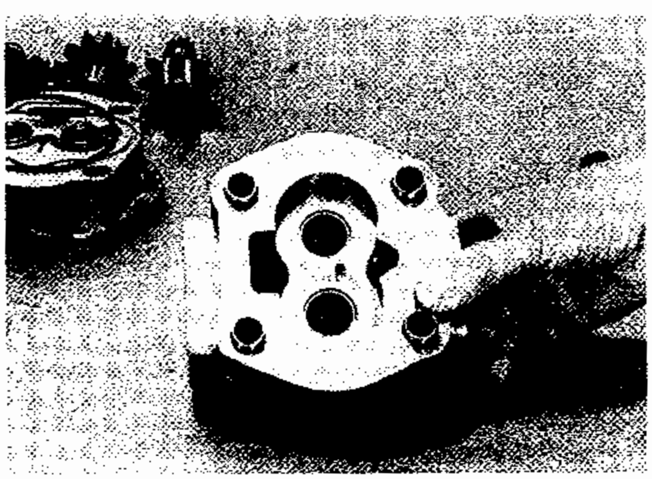


Fig. 17

22. Install drive gear (10) in gear bore nearest to matching mark and idler gear (11) in opposite bore. (Fig. 18)

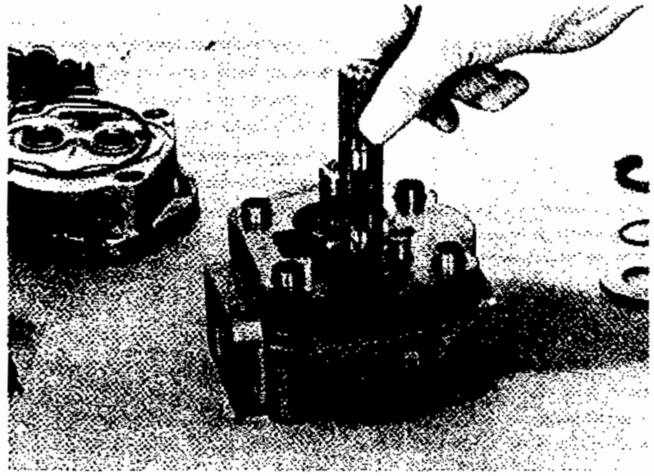


Fig. 18

23. Install o-ring (7) in pressure plate (8). With trap toward discharge side and bronze side down, place pressure plate down against gear faces. (Fig. 19)

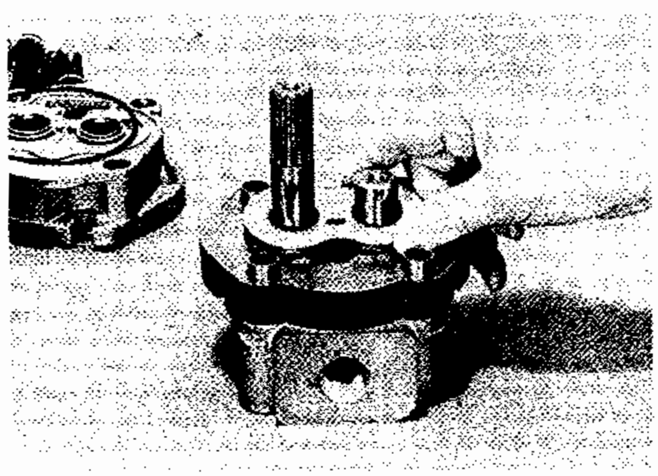


Fig. 19

24. Install back-up ring (4), and o-ring (6) in flange plate (3). Use clean heavy grease to hold o-rings in grooves. (Fig. 20)

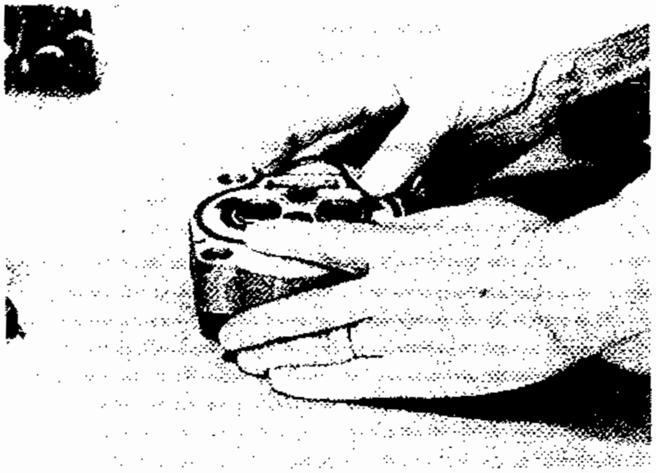
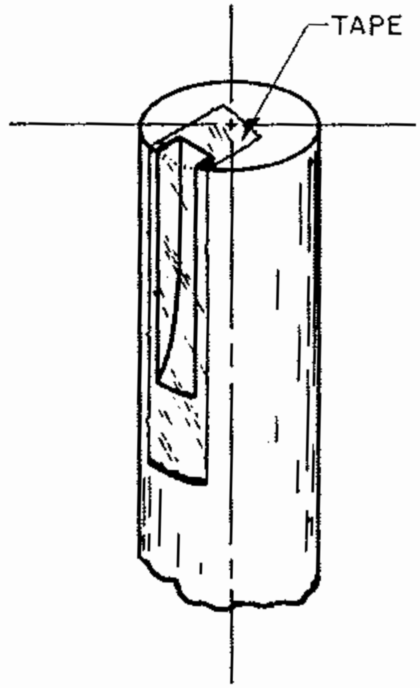


Fig. 20

NOTE: Use tape to cover keyway before installing flange to avoid nicking seal lip.



25. If extension end of drive shaft is splined, coat splines with clean heavy grease to protect seal as flange plate (3) slides down shaft. If extension end is keyed, use a piece of tape to cover keyway to protect seal. (Fig. 21)

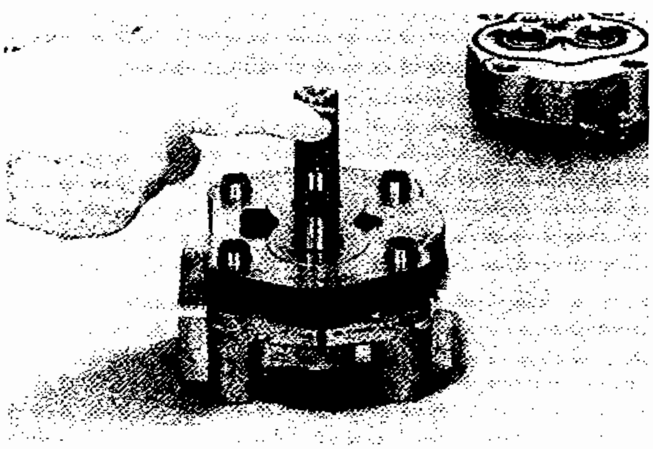


Fig. 21

26. With o-rings in flange plate (3) facing down and keeping plate true with shafts, slide it down until it contacts dowels in gear plate. Bump flange very lightly with hands or plastic hammer to force the plate down on dowels, at the same time making sure grease is holding o-rings in grooves. Once plate is in position if keyway protection was used, remove from shaft. (Fig. 22)

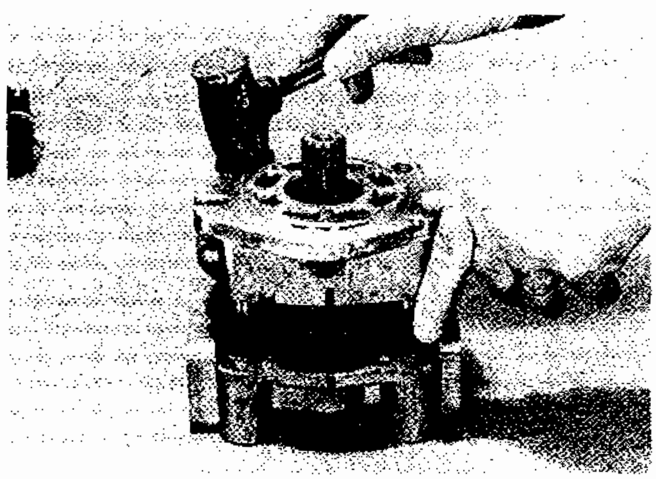


Fig. 22

27. Coat capscrew (14) threads with clean hydraulic oil. Install washers (13) on capscrews and screw them in and torque to 80 ft. lbs. (Fig. 23)

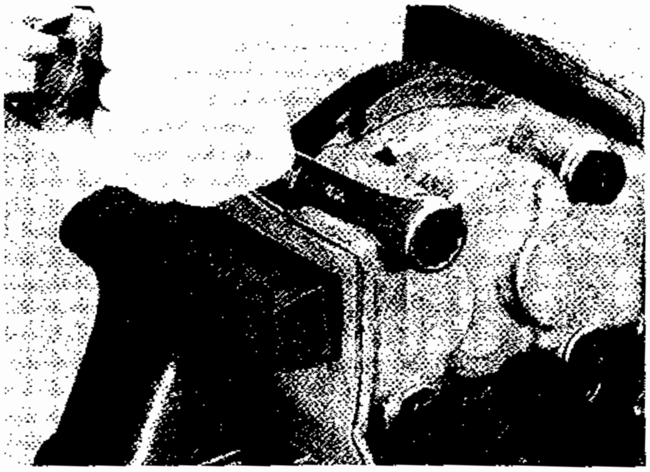


Fig. 23

28. Using twelve inch wrench, check to see if shaft will turn. It will be tight but should turn free with a 15 lbs maximum of force on wrench. (Fig. 24)

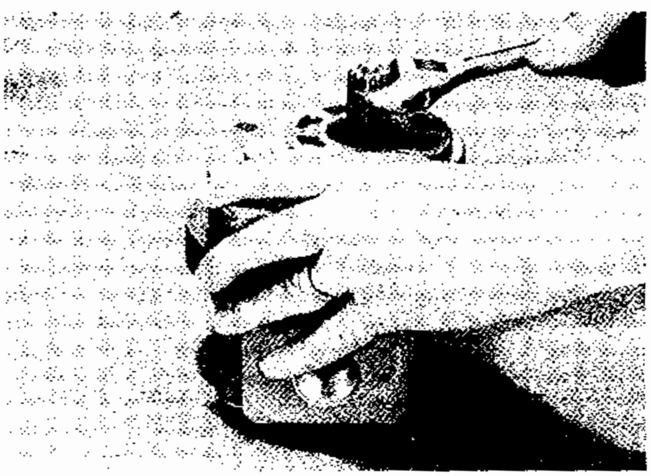


Fig. 24

SHAFT SEAL REPLACEMENT INSTRUCTIONS

FOR P16 SERIES

1. Remove pump from machine. Plug the suction and discharge ports and wash the pump thoroughly. If shop air is available, blow all contaminants from shaft seal area.

2. If only shaft seal replacement is to be made, it is not necessary to completely disassemble the pump.

3. For adaptor equipped models, loosen and remove capscrews and washers. Tap the mounting adaptor loose with a soft hammer and slide it off the shaft. Remove the flange adaptor also, if one is used.

4. Loosen and remove the four capscrews from the rear of the pump. Hold the gear plate and valve body together and tap the flange plate with a soft hammer to loosen (Fig. 1)

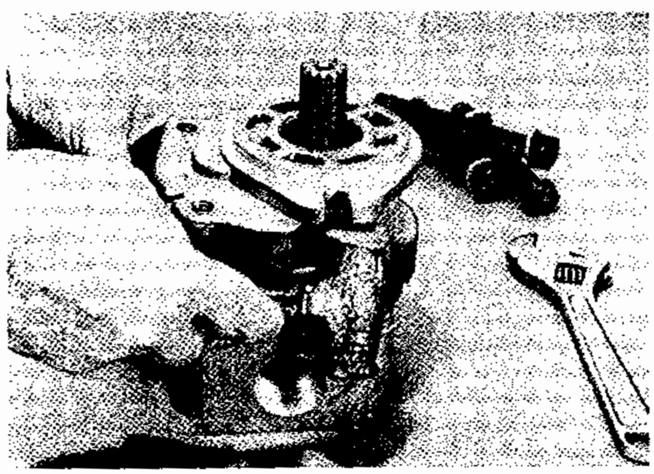


Fig. 1

5. Slide flange plate off the shafts and remove the plate o-ring, "E" shaped o-ring, and back-up strip. Also remove the shaft seal snap ring from seal bore. Pumps with mounting adaptors do not get shaft seal snap ring. (Fig. 2)

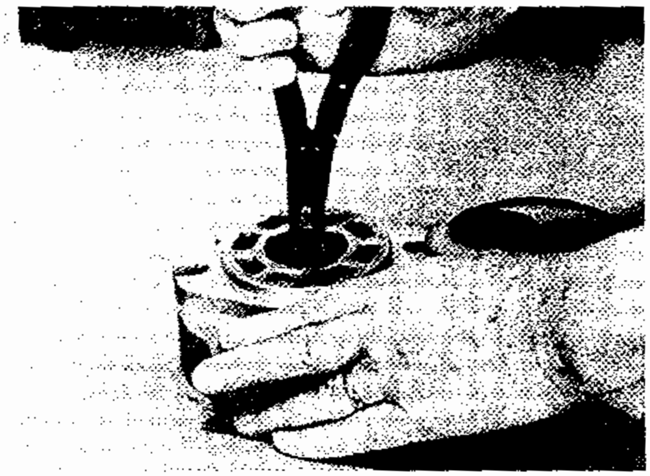


Fig. 2

6. Place flange plate in machinist vise. Use cardboard between jaws of vise and flange plate. (Fig. 3)

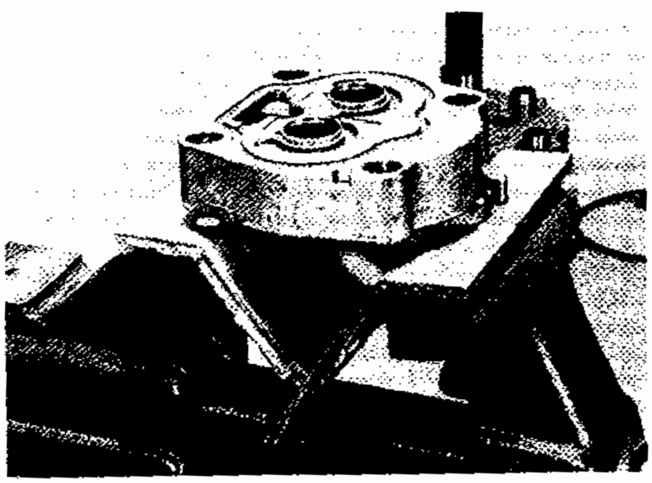


Fig. 3

7. Slide a punch of appropriate size through the bearing and against the seals metal casing. Hold the punch away from the bearings and drive the seal out without damaging seal bore or bearing. Move the punch around the seal as it is driven out. Do not allow the punch to rest against the seal bore or bearing while driving the seal out. (Fig.4)

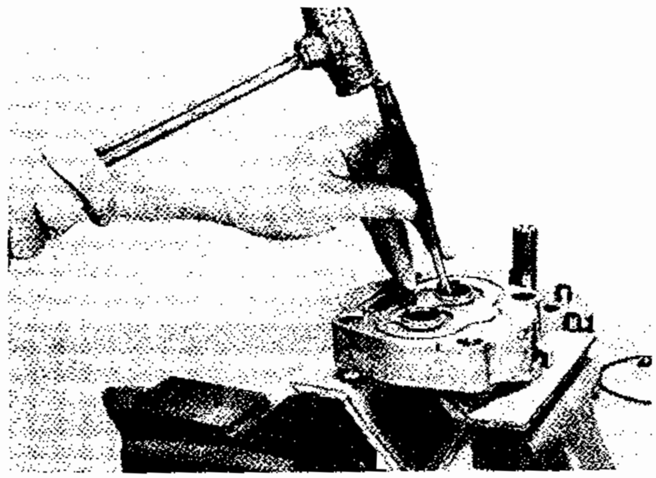


Fig. 4

8. Check the seal bore for scratches. If scratches are apparent, us a four hundred grit sandpaper to clean up the bore. Do not use coarse grit sandpaper. It will cut heavy grooves in the bore and will allow the seal to leak around the O.D.

9. Wash the flange plate in clean solvent and wipe it dry with clean shop towels or blow it dry with shop air.

10. If an arbor press is available, use it to press the new seal into flange bore. If the press is not available, place the flange in a machinist vise with the seal bore facing the movable jaw. Arrange blocks of wood on each side of the protruding ends of the bearings at the side next to fixed jaw to prevent pressing on the bearings while the seal is being pressed in. (Fig. 5)

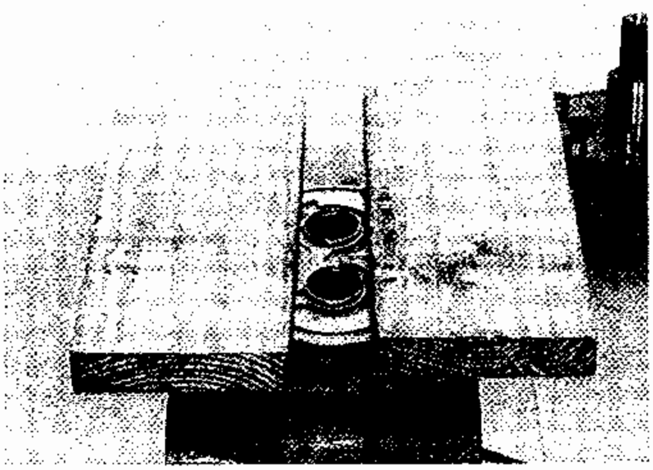


Fig. 5

11. Center the seal over the seal bore with metal face of the seal facing movable jaw. Place clean block of wood against seal and tighten the vise slowly until wood block is against the flange. Make sure the seal is started and pressed straight into the bore. (Fig. 6)

Fig. 6

12. Loosen the vise and remove the block of wood. Place a socket wrench (having an O.D. just slightly smaller than seal bore) against seal. Tighten vise against socket and press seal in until seal has just cleared snap ring groove in seal bore. Apply two or three drops of #290 Loctite against seal bore and O.D. of seal. Hold the flange at a 45 degree angle and rotate it slowly to allow the loctite to flow all the way around the O.D. of the seal. If your flange gets snap ring in seal bore, install the snap ring and wipe the excess loctite out of seal bore and any that might have gotten on seal lip. (Fig. 7)

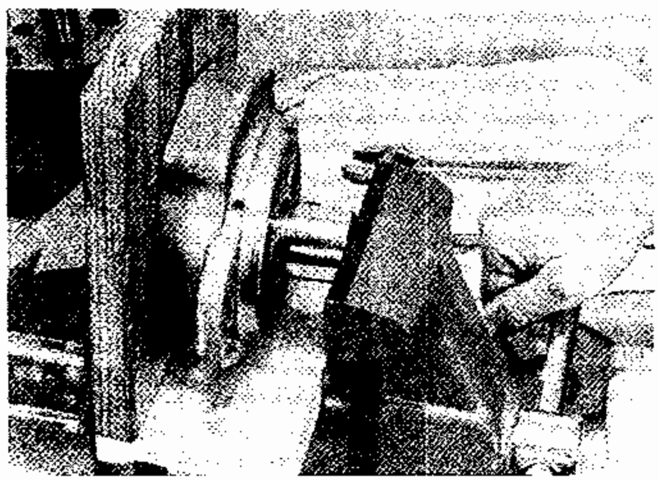


Fig. 7

13. Install flange o-ring, and "E" shaped back-up strip. Use clean heavy grease to hold the o-rings and back-up strip in position. (Fig. 8)

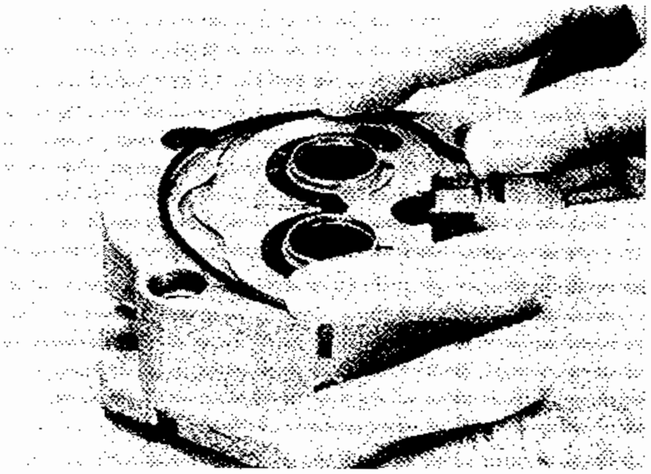


Fig. 8

14. If extension end of the drive shaft is splined, coat the spline with clean grease. If is has keyway, cover the keyway with transparent tape. This will protect the rubber sealing lip as it slides down the shaft. If tape is used, make sure all of the tape is removed from the shaft.

15. After flange plate has been installed, screw the capscrews in and torque them to 70 to 75 lb. ft.

16. If your pump uses the adaptor and flange mount arrangement, reinstall the adaptors, capscrews, and washers. Torque the capscrews to 35 lb. ft.

INSPECTION OF PARTS

1. Visually inspect all parts. It is not necessary to set up gauges to check the amount of wear on the pump parts. After a visual inspection those parts which are in questionable condition should be replaced with new ones.

2. Note the bores in the gear plate. On the discharge side you will see a milled groove in the center of the plate. During the initial break-in at the factory, the gears cut into the suction side. Nominal depth of this cut is .008" and should not exceed .015". Small bits of metal are sometimes pulled out of the surface during break-in. This is not detrimental. If the cut is deeper than .015" or the plate is cracked or damaged in some other way, it should be rejected.

3. Examine the gears. If excessive wear is visible on the journals, sides, or faces of the gears, or at the point where the drive gear shaft rotates in the lip seal, reject them. If splines or keyways are excessively worn, replace the drive gear.

4. Examine the pressure plates. They should not show excessive wear on the bronze side. If deep curved wear markes are visible, replace the plate with new ones.

5. Shaft seals should be replaced. All o-ring seals and back-up rings or strips should be replaced with new.

6. Bearing i.d.'s should have a gray coating. If bronze can be seen shining through the teflon on the suction side, the bearings and plate they are in, should be replaced.

TROUBLESHOOTING GUIDE FOR GEAR TYPE HYDRAULIC PUMPS

IDENTIFICATION	CAUSE	CORRECTIVE CHECKS
1. Sandblasted band around pressure plate bores 2. Angle groove on face of pressure plate 3. Lube groove enlarged and edges rounded 4. Dull area on shaft at root of tooth 5. Dull finish on shaft in bearing area 6. Sandblasted gear bore in housing	I. Abrasive wear caused by fine particles. 1. Dirt (fine contaminants, not visible to the eye)	1. Was clean oil used? 2. Was filter element change period correct? 3. Were correct filter elements used? 4. Cylinder rod wiper seals in good condition? 5. Cylinder rods dented or scored? 6. Was system flushed properly after previous failure?
1. Scored pressure plates 2. Scored shafts 3. Scored gear bore	II. Abrasive wear caused by metal particles. 1. Metal (coarse) contaminants, visible to the eye	1. Was system flushed properly after previous failure? 2. Contaminants generated elsewhere in hydraulic system? 3. Contaminants generated by wearing pump components?
1. Any external damage to pump 2. Damage on rear of drive gear and rear pressure plate only	III. Incorrect Installation	1. Did shaft bottom in mating part? 2. Any interference between pump and machine?
1. Eroded gear plate 2. Eroded pressure plates	IV. Aeration — Cavitation 1. Restricted oil flow to pump inlet 2. Aerated oil	1. Tank oil level correct? 2. Oil viscosity as recommended? 3. Restriction in pump inlet line? 4. Air leak in pump inlet line? 5. Loose hose or tube connection near or above oil level in tank? 6. Excessive operation of relief valve?
1. Heavy wear on pressure plate 2. Heavy wear on end of gear	V. Lack of Oil	1. Was oil level correct? 2. Any leaks in piping inside tank? 3. Any oil returning above oil level?
1. Gear plate scored heavily 2. Inlet peened and battered 3. Foreign object caught in gear teeth	VI. Damage caused by metal object	1. Metal object left in system during initial assembly or previous repair? 2. Metal object generated by another failure in system?
1. Pressure plate black 2. O-rings and seals brittle 3. Gear and journals black	VII. Excessive Heat	1. Was a valve stuck? 2. Was relief valve too low? 3. Was oil viscosity correct? 4. Was oil level correct?
1. Broken shaft 2. Broken gear plate or flange	VIII. Over Pressure	1. Relief valve setting correct? 2. Did relief valve function?

APPENDIX D

APPENDIX D

Pump Chart Information

- Figure D-1 Pump Availability Matrix
- Figure D-2 Oil Viscosity Properties
- Figure D-3 DOP250 Hydraulic Input to Product Output
- Figure D-4 DOP160 Hydraulic Input to Product Output
- Figure D-5 Distance pumping curve with DOP250 using VOPS AWIF
- Figure D-6 Centrifugal Pump Performance Summary
- Figure D-7 Diesel Pressure Drop Through 6-Inch Hose
- Figure D-8 Friction Losses at Various Viscosities with Water Injection at 6%
- Figure D-9 Centrifugal Pump Capacity Pumping Fresh Water
- Figure D-10 USN CCN-150 POL Pump Diesel Fuel Pumping Range Via 6 Inch Hose
- Figure D-11 DOP 250 Pump Curve for 24,000 cSt. Viscosity
- Figure D-12 KMA333 Pump Curve for 17,000 cSt. Viscosity
- Figure D-13 USCG CCN150-5C with US Navy Wrap-arwound Steam Coil at 1,200 cSt.
- Figure D-14 USCG CCN150-5C Pump Curve for 16,000 cSt. Viscosity

Pump	Size inches	Weight lbs	Power Req'd Gpm,Psi Horsepower	Capacity w/water	Capacity w/Low visc oil 1 –25K cSt	Capacity w/ Medium visc oil 25K– 50K cSt	Capacity w/High visc. Oil 50K – 100K cSt
DOP250	22 L 18 W 29 H	170	42 gpm 3000 psi (81 HP)	380 gpm	440 gpm @ 150 psi	440 gpm @ 150 psi	440 gpm @ 150 psi
DOP160	15 L 12 W 21 H	75	21 gpm 3000 psi (40 HP)	110 gpm	120 gpm @ 150 psi	120 gpm @ 150 psi	120 gpm @ 150 psi
DS-150 Horizontal Auger	54 L 32 W 15 H	284	30 gpm 3000 psi (52 HP)				
DS-250 Top Loading Screw pump/wier	47 L 30 W 24 H	250	*30 gpm 3000 psi (52 HP)	160 gpm	160 gpm	160 gpm	160 gpm
KMA333 Centrifugal	33" 12 " Dia	280	70 gpm 4500 psi (184HP)	2240 gpm @ 20 psi			
CCN150 Centrifugal	56" H 12" Dia	200	52 gpm 2375 psi (72 HP)				
CCN150-3C Centrifugal	33"H 12" Dia	200	52 gpm 2500 (76 HP)				
CCN150-5C Centrifugal	33" H 12" Dia	200	70 4000 (163)				

All weights are in lbs. All dimensions are in inches unless specified otherwise.

* **Can be higher for lightering operations**

Figure D-1. Pump Availability Matrix (Data is limited and based upon USCG/US Navy tests to date)

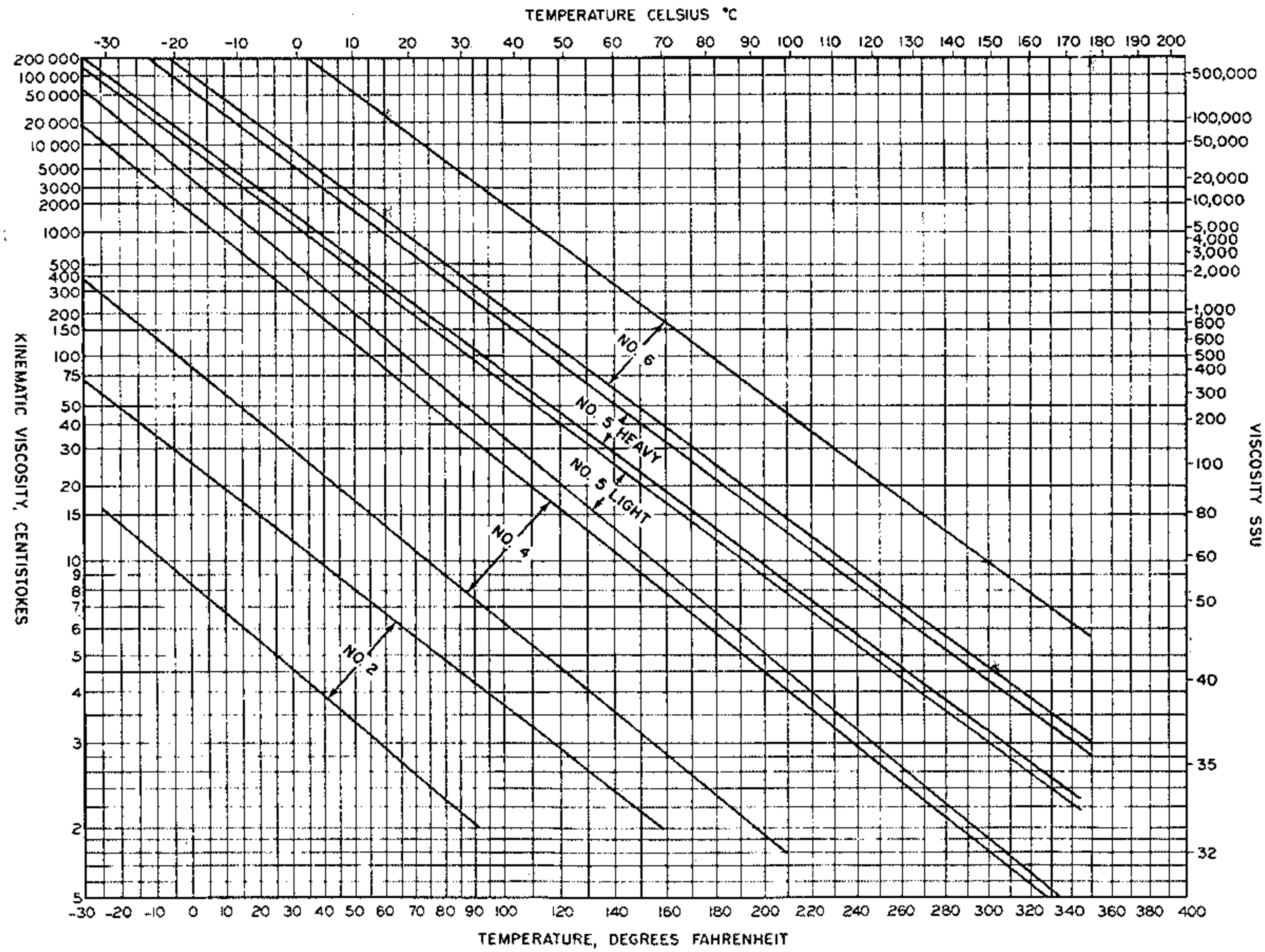


Figure D-2. Oil Viscosity Properties in Centistoke (cSt.) Units and Seconds Saybolt Universal (SSU) Units

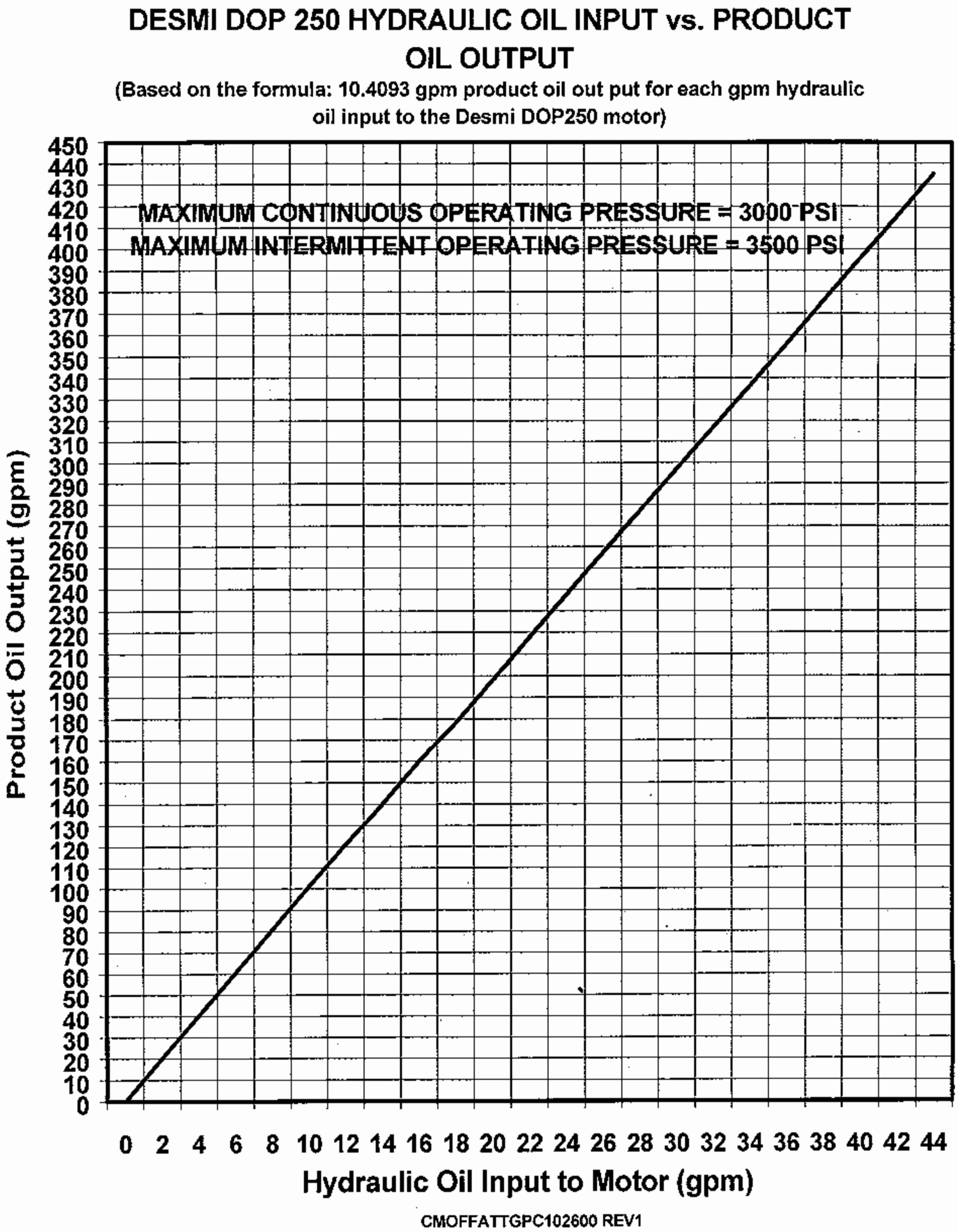


Figure D-3. DESMI DOP250 Hydraulic Input Flow Rate vs. Product Out-Put Flow Rate

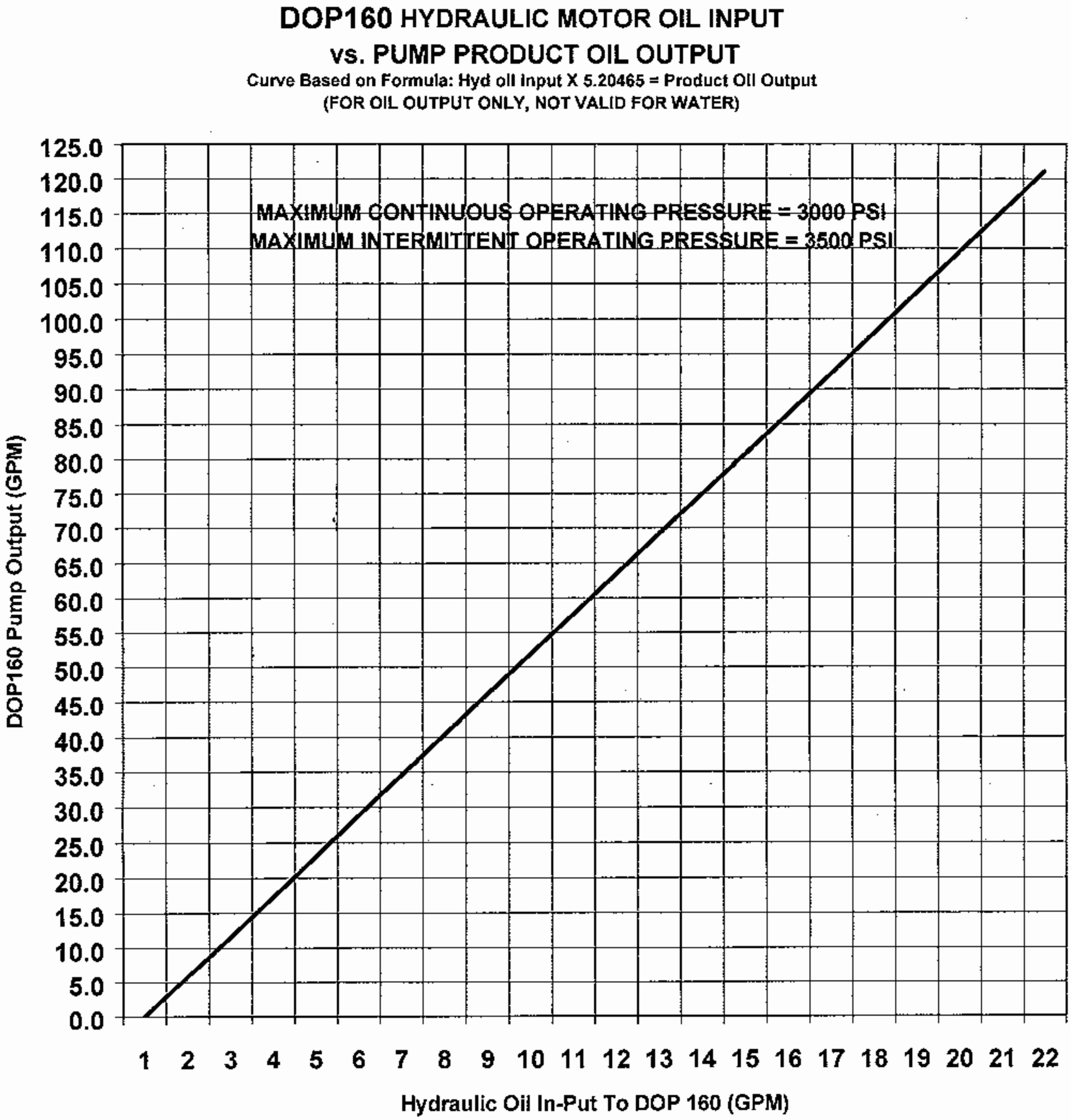


Figure D-4. DESMI DOP160 Hydraulic Oil Input to Product Oil Out put ratio.

NOTE: The following curves are based on conservative linear extrapolations of the combined data retrieved from the Seattle Viscous Oil Workshop (September, 1119) and the Viscous Oil Pump Tests at the Mineral Management Service OHMSETT facility (March, 2000). The curves are based on a general viscosity range of 15,000 to 25,000 cSt. The average amount of water injected for each of these tests was 5% for the higher flow rate and 15% for the lower flow rates, but the optimum percentage is 5.5% for any flow rate based on collective results.

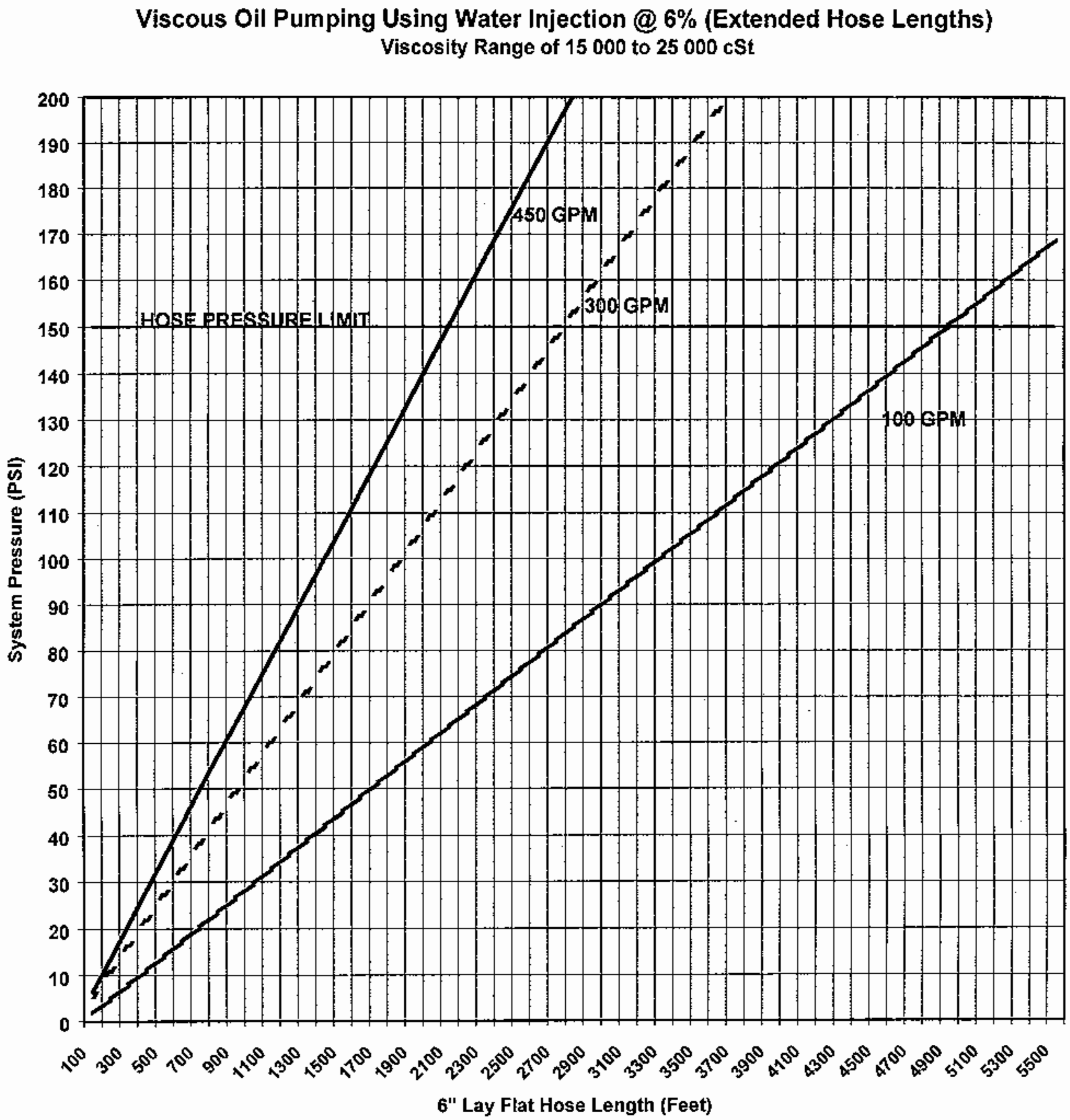


Figure D-5. Maximum expected pumping distances pumping 25 000 cSt Viscosity Oil at Various Flow Rates Using a DOP250 Pump Using the Annular Water Injection Flatnge (AWIF).

NOTE: The following pump curves listed in this manual represent data that has been taken from oil pumping tests conducted by the US Navy SUPSALV and the USCG at various facilities over a period of several years. Some of these results may be lower or higher than other published data. They may also differ from data produced by the manufacturers of these pumps.

The data presented serves to show only indications of performance which may be expected under certain specific conditions. There is presently insufficient data available to draw any but the most general conclusions regarding equipment capabilities in other than the specific conditions of the tests.

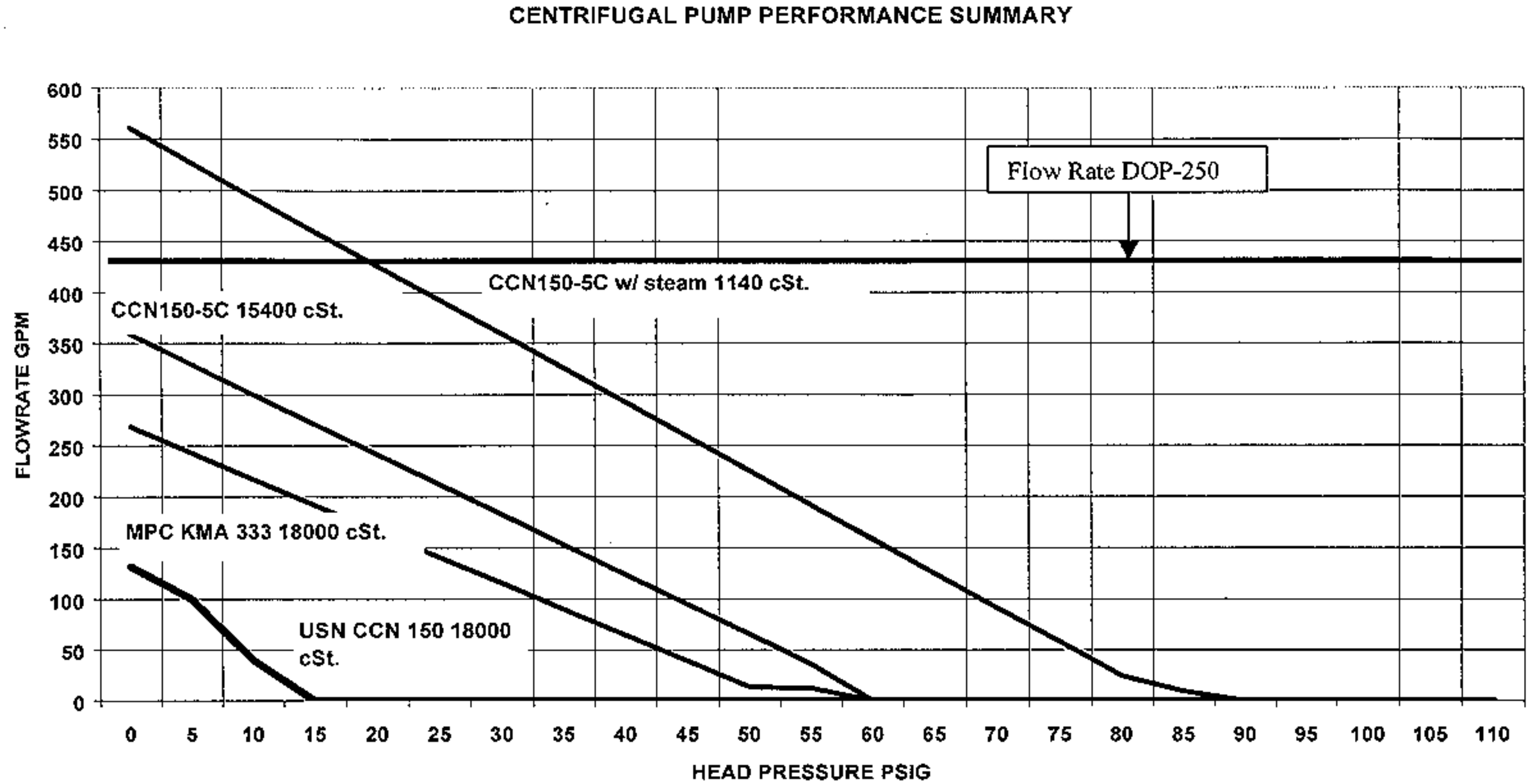


Figure D-6. Centrifugal Pump Performance Summary. From tests conducted at the Mineral Mangement Service OHMSETT facility, March 2000. Test loop consisted of 100 meters of 15 cm (6-inch) lay flat hose with Hydrasearch fittings. The addition of steam heat with the use of the CCN150-5C yielded a 150% increase in performance. The steam dropped the viscosity of the surrounding oil from 15,400 cSt. to 1,140 cSt. Steam temp. was 100 deg. F at 50 psi. The CCN150 is designed primarily for water and light oils. The CCN150 and MPC KMA 333 are part of the U.S. Navy's POL off-load kit inventory. Note: there is not enough data here to fully determine centrifugal pump limitations. Such a determination would required more testing, however, based on this testing a general determination can be made that for oil products with viscosities of much greater than 1,000 cSt., it is prudent to consider the use of a screw pump over a centrifugal pump for an off-loading scenario. **NOTE:** Positive-displacement screw pump data was obtained and analyzed from available test data but was determined to be inconclusive for use as a summary. Future testing will seek to establish standard performance.

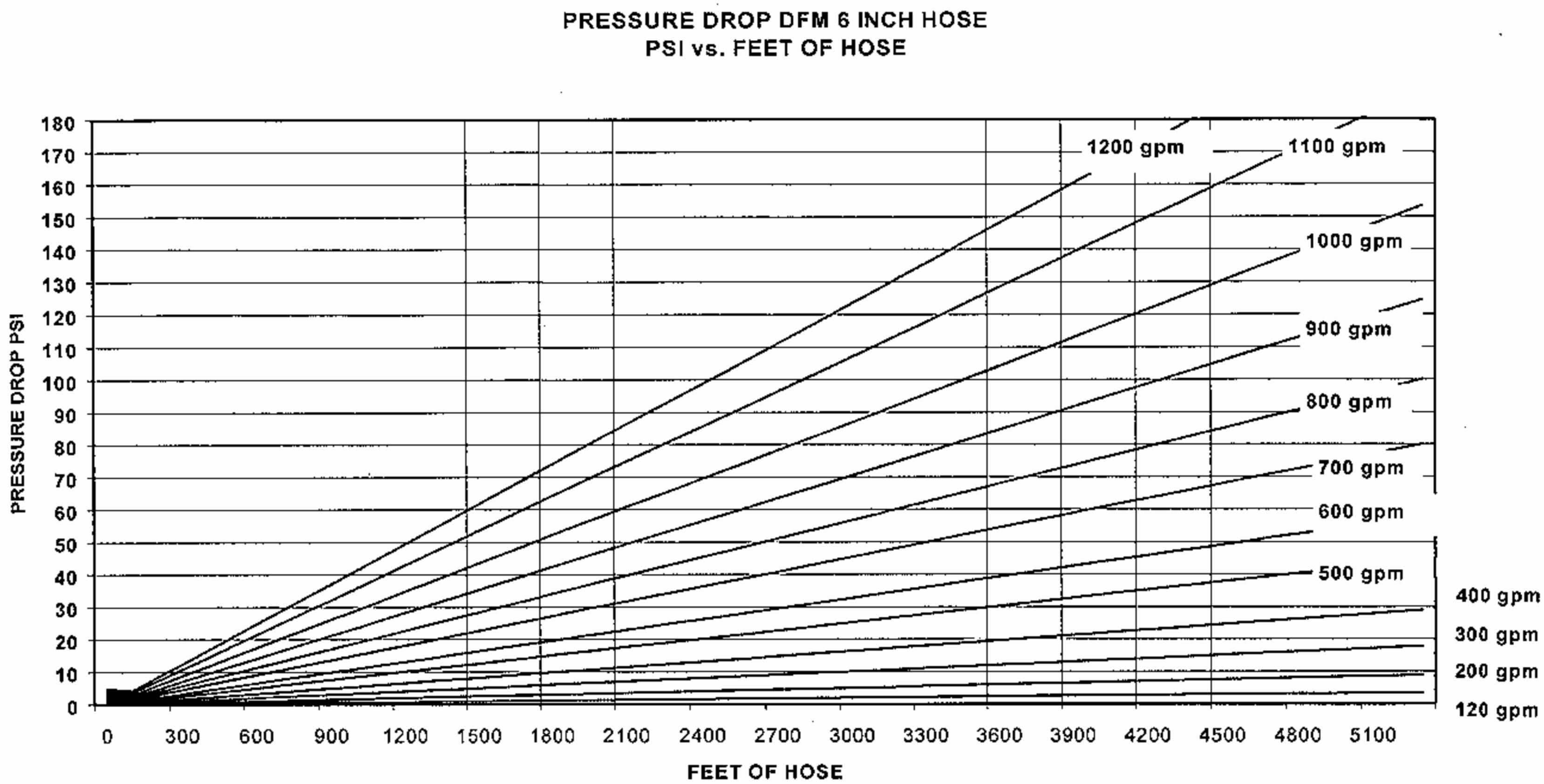


Figure D-7. Pressure Drop of DFM Through 6 Inch Hose. From data extrapolated from the Testing of the VOPS Prototype at the Mineral Management Service OHMSETT facility, November 1999.

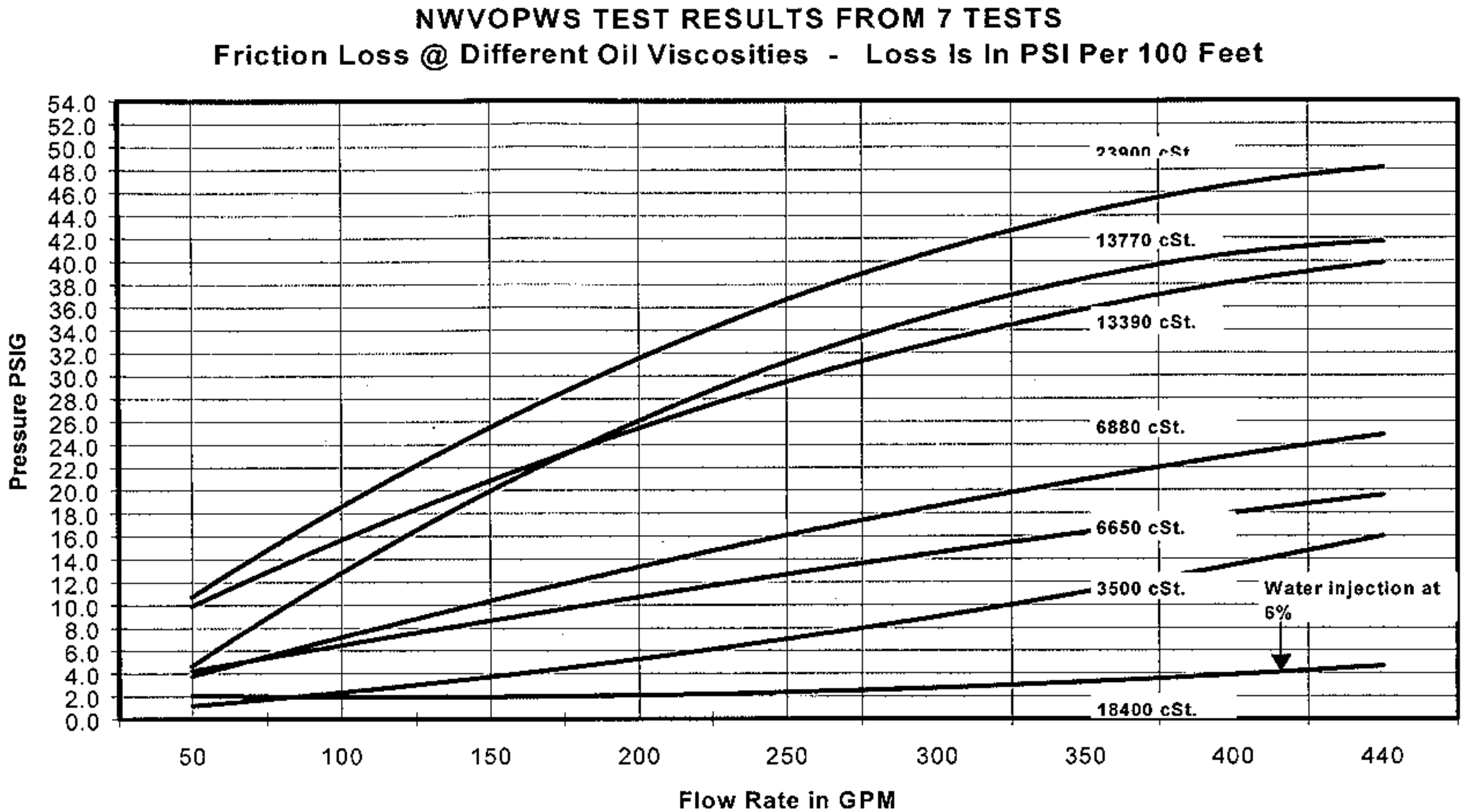


Figure D-8. Friction Losses at Various Viscosities with 6% Water Injection. From Northwest Viscous Oil Pumping Workshop, Seattle, WA, September 1999. Testing consisted of a DOP250 pump with and without the use of the AWIF pumping across a test circuit of 200 feet of 6-inch lay flat hose. Note that the difference in friction loss per 100 feet of hose at 440 gpm with water injection is on the order of 10 to 1.

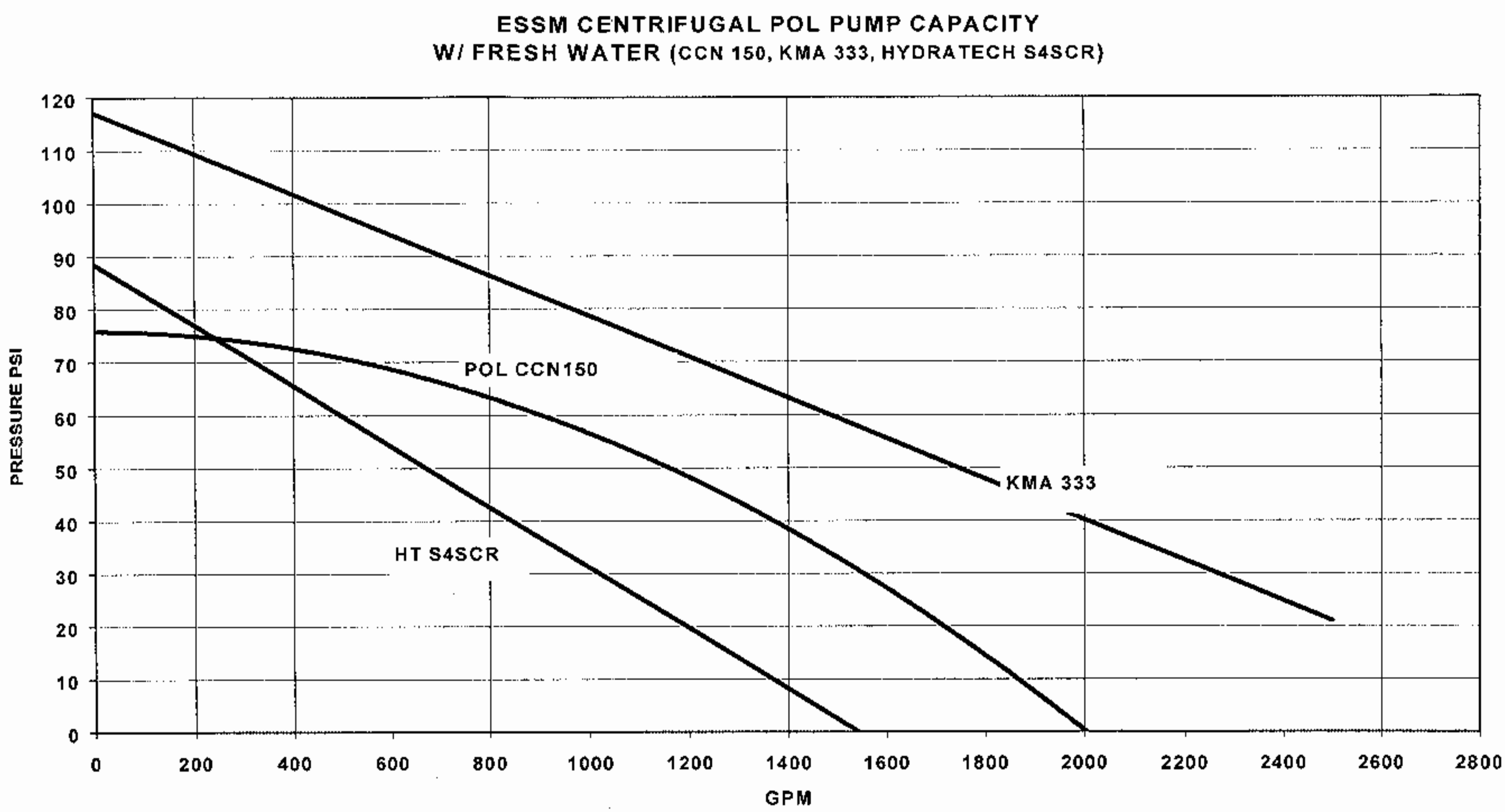


Figure D-9. Centrifugal Pump Capacity Pumping Fresh Water. . From tests conducted at the Mineral Mangement Service OHMSETT facility, March 2000. All three pumps are centrifugal and part of the U.S. Navy standard POL off-loading kit inventory.

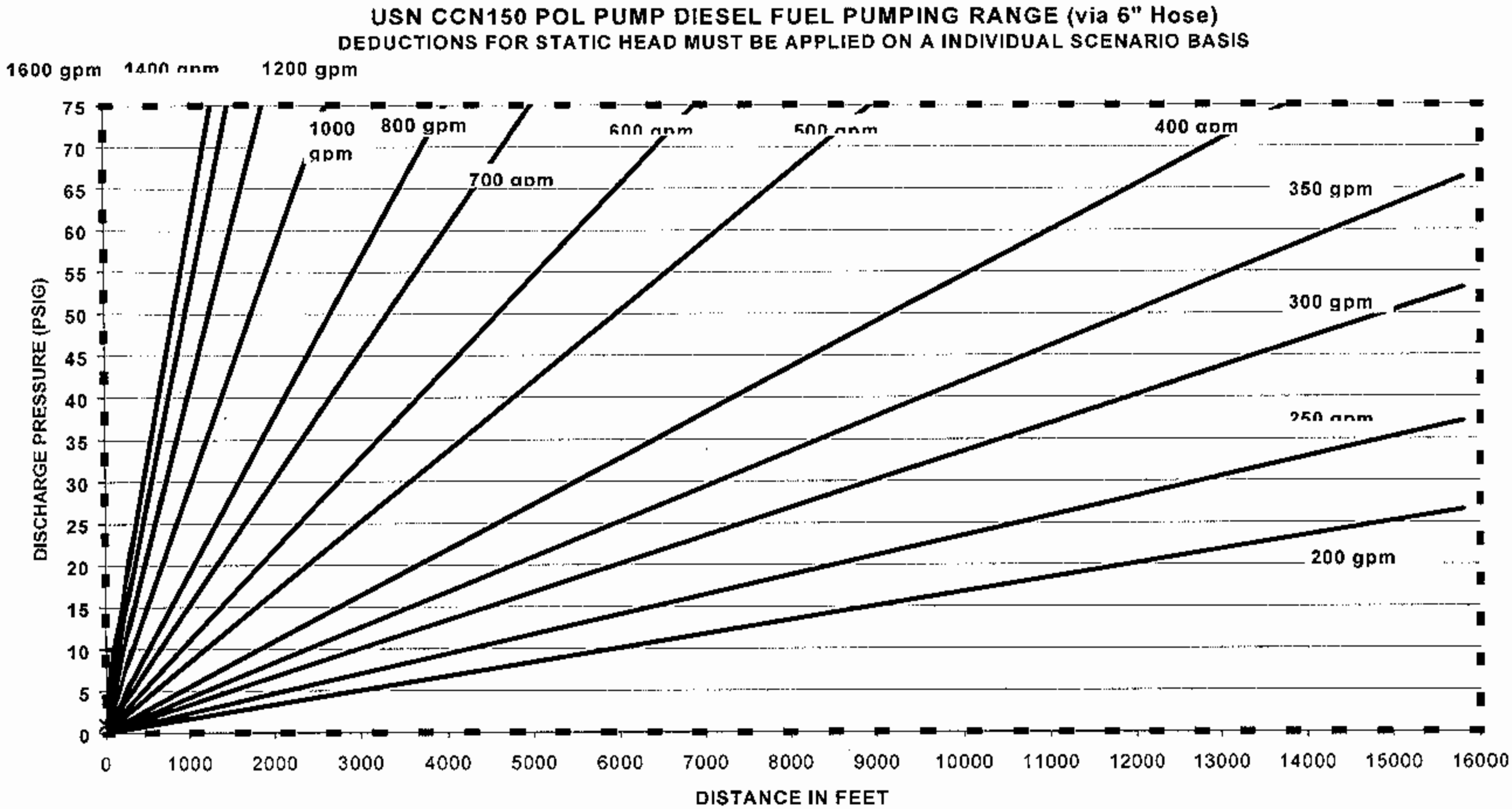


Figure D-10. USN CCN-150 POL Pump Diesel Fuel Pumping Range Via 6 Inch Hose.

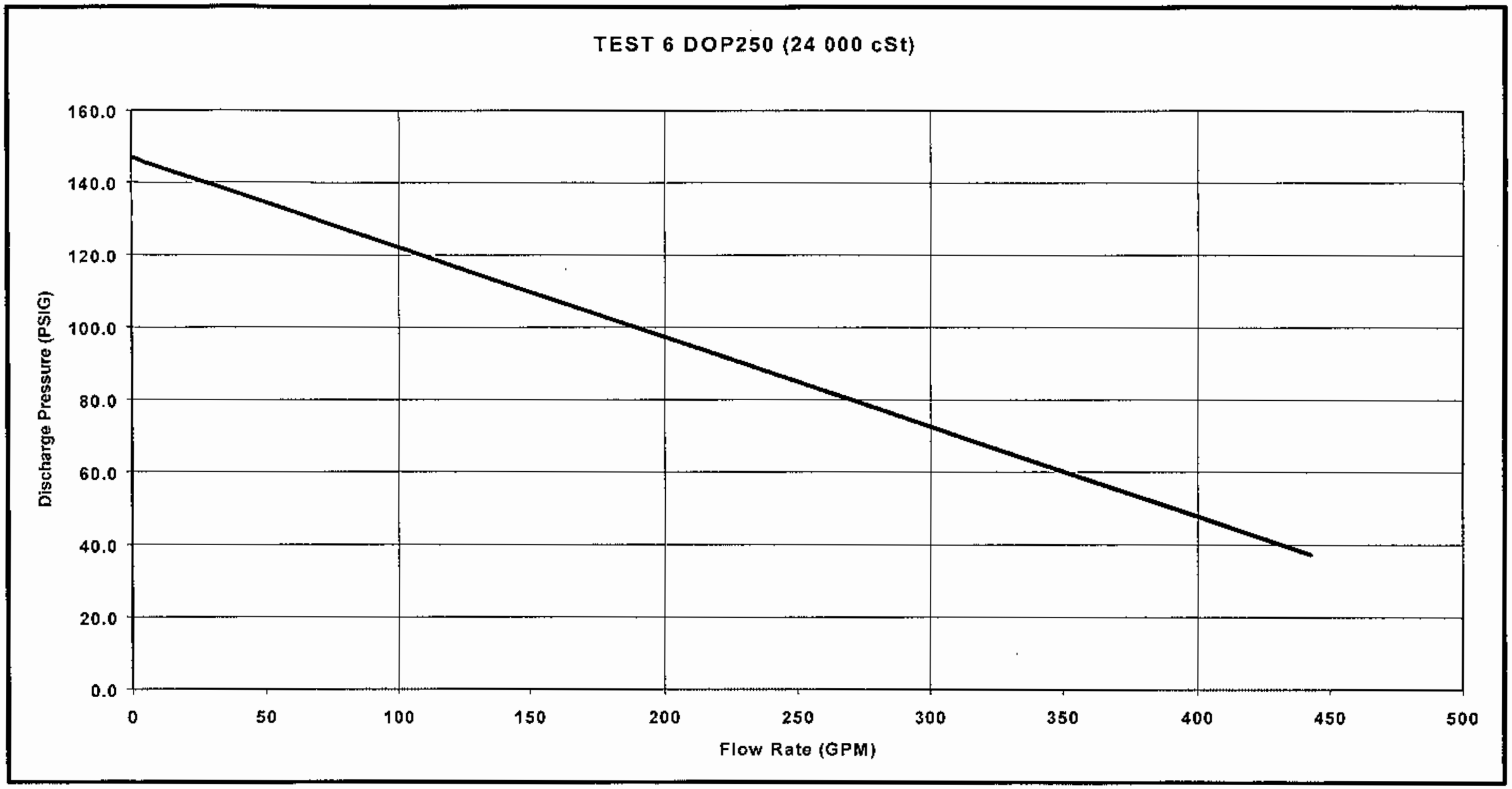


Figure D-11. DOP 250 Pump Curve for 24,000 cSt. Viscosity.

PARTS IDENTIFICATION — P16

ITEM NO.	NAME OF PART	ITEM NO.	NAME OF PART
1	COVER PLATE	28	
2	GEAR PLATE	29	
3	FLANGE PLATE	30	
4	BACK-UP RING	31	
5	O-RING, PRESSURE BALANCE	32	
6	O-RING, FLANGE & COVER	33	
7	O-RING, PRESSURE PLATE	34	
8	PRESSURE PLATE	35	
9	DOWEL	36	
10	DRIVE GEAR	37	
11	IDLER GEAR	38	
12	SEAL, SHAFT	39	
13	WASHER	40	
14	CAPSCREW	41	
15	ADAPTER, MOUNTING	42	
16	WASHER	43	
17	CAPSCREW		
18	SNAP RING		
19	ADAPTER, FLANGE		
20			
21			
22			
23			
24			
25			
26			
27			

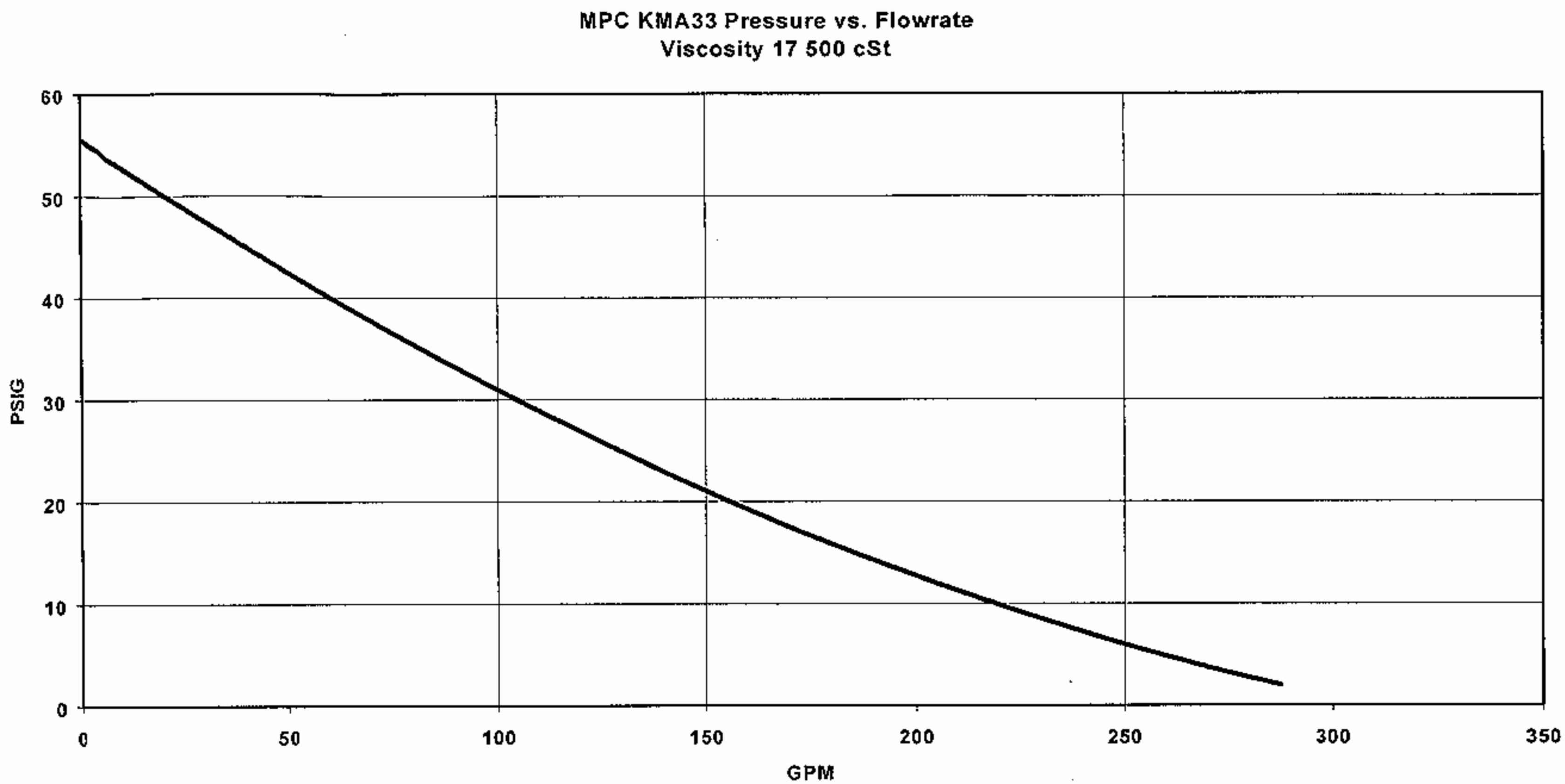


Figure D-12. KMA333 Pump Curve for 17,000 cSt. Viscosity. The MPC KMA 333 is a pump in the U.S Navy POL off-loading kit.

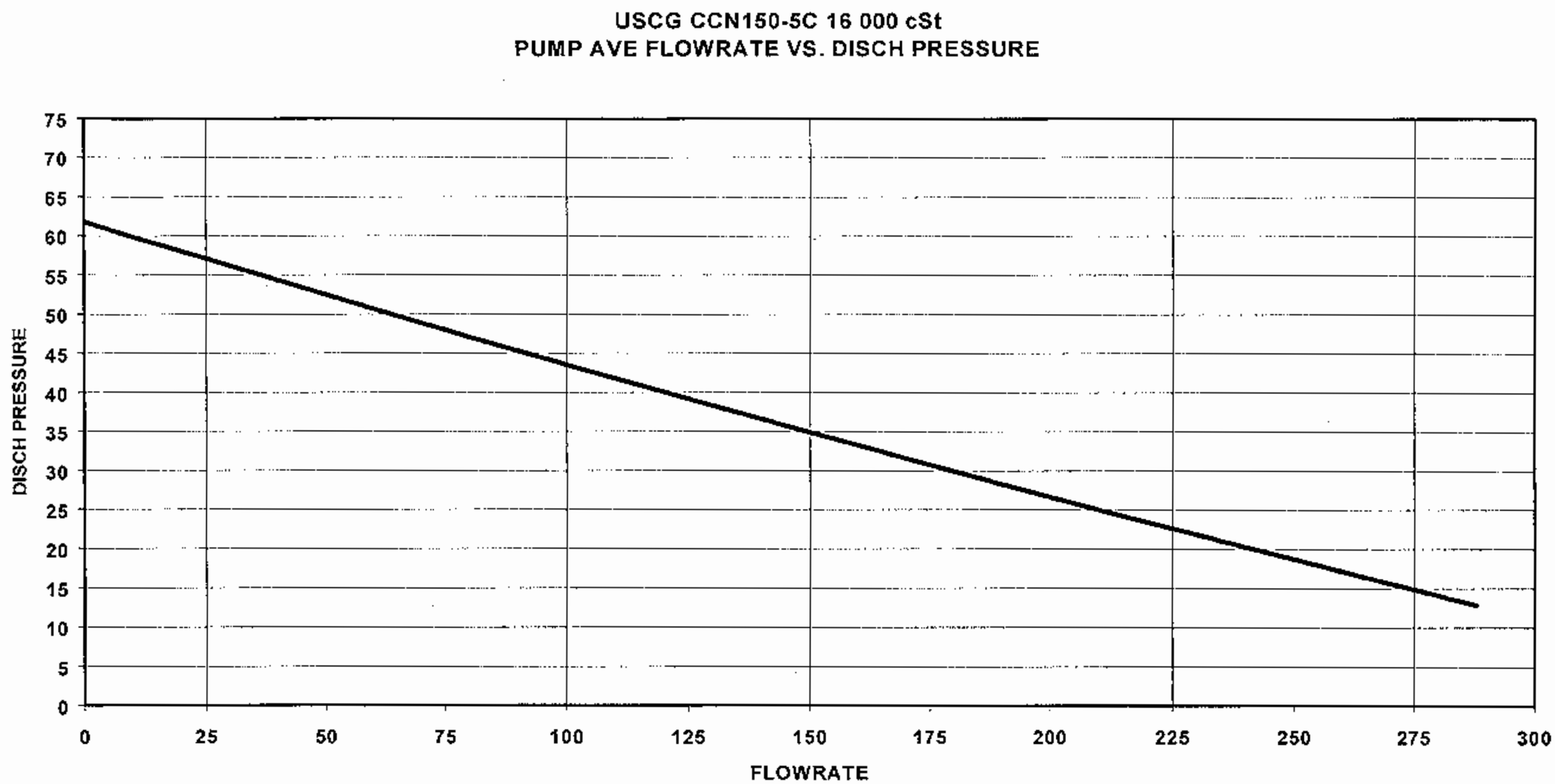


Figure D-13. USCG CCN150-5C with US Navy Wrap-Around Steam Coil at 1200 cSt.

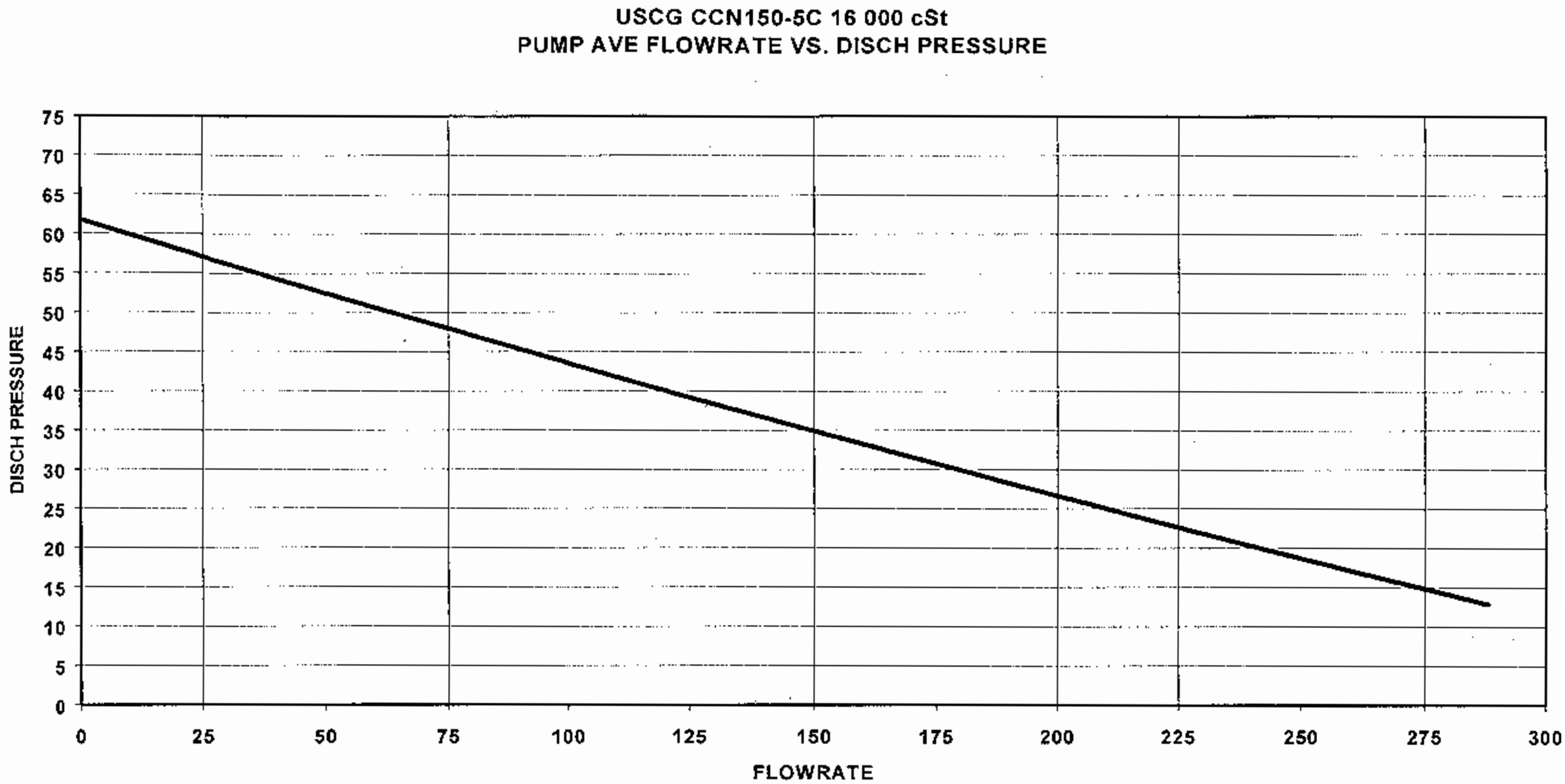


Figure D-14. USCG CCN150-5C Pump Curve for 16,000 cSt. Viscosity.