GARDNER DENVER®

300WPD996 Revision B
April 2005

OPI-600

WELL SERVICING PUMP

OPERATING AND SERVICE MANUAL

Gardner Denver

ECN 1025325

OPI-600
WELL SERVICING PUMP

MAINTAIN PUMP RELIABILITY AND PERFORMANCE WITH GENUINE GARDNER DENVER PARTS AND SUPPORT SERVICES

Gardner Denver® genuine pump parts are manufactured to design tolerances and are developed for optimum dependability. Design and material innovations are the result of years of experience with hundreds of different pump applications. Reliability in materials and quality assurance is incorporated in our genuine replacement parts.

Your authorized Gardner Denver Sales Office offers all the backup you'll need. The Fort Worth Manufacturing Facility maintains a large inventory of genuine parts.

Gardner Denver supports your needs with these services:

1. Trained parts specialists to assist you in selecting the correct replacement parts.
2. Repair and maintenance kits designed with the necessary parts to simplify servicing your pump.

Authorized service technicians are factory trained and skilled in pump maintenance and repair. They are ready to respond and assist you by providing fast, expert maintenance and repair services.

For the location of your local authorized Gardner Denver distributor, refer to the yellow pages of your phone directory or contact:

Factory (Tulsa):
Gardner Denver Well Servicing Pumps
4747 South 83rd East Avenue
Tulsa, Oklahoma 74145

Phone: (918) 664-1151
(800) 738-8099

Fax: (918) 664-6225

Service Center (Odessa):
Chaparral
2121 West 44th Street
Odessa, Tx 79768

Phone: (432) 366-5433
(800) 368-1134

Fax: (432) 363-9940

Service Center (Ft. Worth):
Geoquip
7533 Kathy Lane
Ft. Worth, Texas 76126

Phone: (817) 249-6400
(800) 824-0271

Fax: (817) 249-6401

INSTRUCTIONS FOR ORDERING REPAIR PARTS

When ordering parts, specify Pump MODEL and SERIAL NUMBER (see nameplate on unit). The Serial Number is also stamped on top of the fluid end connecting plate of the frame (cradle area).

All orders for Parts should be placed with the Tulsa or Ft. Worth facility.

Where NOT specified, quantity of parts required per pump or unit is one (1); where more than one is required per unit, quantity is indicated in parenthesis. **SPECIFY EXACTLY THE NUMBER OF PARTS REQUIRED.**

FOREWORD

Gardner Denver® pumps are the result of advanced engineering and skilled manufacturing. To be assured of receiving maximum service from this pump the owner must exercise care in its operation and maintenance. This book is written to give the operator and maintenance personnel essential information for day-to-day operation, maintenance and adjustment. Careful adherence to these instructions will result in economical operation and minimal downtime.

DANGER

Danger is used to indicate the presence of a hazard, which will cause severe personal injury, death or substantial property damage if the warning is ignored.

WARNING

Warning is used to indicate the presence of a hazard, which can cause severe personal injury, death or substantial property damage if the warning is ignored.

CAUTION

Caution is used to indicate the presence of a hazard, which will or can cause minor personal injury or property damage if the warning is ignored.

NOTICE

Notice is used to notify people of installation, operation or maintenance information which is important but not hazard related.

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DANGER NOTICES

DANGER

Read and understand the following DANGER NOTICES before moving or operating the pump or any pump package unit equipment.

Reciprocating pumps are machines capable of producing high fluid pressures and flow rates and are designed to be used with proper care and caution by trained, experienced operators. **TO AVOID PERSONAL INJURY, DEATH AND/OR EQUIPMENT DAMAGE, READ AND THOROUGHLY UNDERSTAND THE FOLLOWING DANGER NOTICES PLUS THE ENTIRE OPERATING AND SERVICE MANUAL BEFORE ATTEMPTING TO MOVE OR OPERATE THE PUMP.** Contact a Gardner Denver service representative if you are unable to comply with any of the danger notices or procedures described in these documents.

Closely examine the pump performance data upon pump delivery to become thoroughly familiar with the operating limits for this pump model. **The pump must <u>never</u> be operated at speeds, pressures or horsepower exceeding the maximum values or at speeds below the minimum. Failure to observe the operating limits could result in personal injury, death, and/or equipment damage and will void the warranty.** Alterations to the pump, or application of the pump outside the limits, must not be made without Gardner Denver written approval, together with a new set of performance data, as dangerous operating conditions could result.

Keep in mind that full operator attention and alertness are required when operating high pressure pumping equipment. Operators should not begin or continue operations when tired, distracted or under the influence of alcohol or any type of prescription or nonprescription drugs.

The timely replacement of expendable parts and any other worn or damaged parts can prevent equipment damage and possible injury. The original parts used in Gardner Denver pumps are designed and tested to exacting standards to provide high quality performance and durability. Your best insurance in maintaining these characteristics is to use genuine Gardner Denver replacement parts.

A broad range of danger notices are covered on these pages, however, they cannot substitute for training, experience and common sense in the safe operation of high pressure pumping equipment.

<u>HAMMER LUG FASTENERS</u>

DANGER

On pumps equipped with hammer lug unions and/or hammer lug valve covers the following precautions must be observed to avoid personal injury, death and/or equipment damage due to contact with the hammer, broken parts from the hammer, lugs or other objects propelled by hammer blows. When tightening or loosening hammer lug unions and valve covers, operators or maintenance personnel should:

- Inspect the hammer and hammer lugs to insure they are all in good condition. Replace any of these parts which are cracked, damaged or badly worn.
- Wear safety shoes and safety glasses.
- Alert other personnel to move away from the area.
- Check to insure they have safe footing.
- Fully engage the hammer bar, if one is used, to prevent it from disengaging violently from the cover as a blow is struck.

- Wipe their hands and the hammer handle and maintain a firm grip on the handle to avoid losing control of the hammer while swinging and striking.

- Carefully swing the hammer to avoid striking themselves, another person and objects other than the targeted lugs or hammer bar.

- Avoid swinging the hammer above shoulder height.

VALVE SEAT PULLING

DANGER

The following precautions must be observed by operators and maintenance personnel to avoid personal injury, death and/or equipment damage from contact with the puller, hammer, wedge or broken parts from these components when using either a hydraulic or wedge valve seat puller. Operators or maintenance personnel should:

Hydraulic Seat Puller

- Wear safety shoes and glasses.

- Chain or tie the jack down as it will jump violently when the valve seat disengages from the valve deck.

- Check to insure the pressure applied by the hydraulic pump does not exceed the hydraulic ram maximum pressure rating.

Wedge Puller

- Grind off any mushroomed material from the wedge before use.

- Inspect the hammer and wedge to insure they are in good condition. Replace any of those parts which are cracked, damaged or badly worn.

- Wear safety shoes and goggles.

- Check to insure they have safe footing.

- Fully engage the wedge to prevent it from disengaging violently from the cover as a blow is struck.

- Wipe their hands and the hammer handle and maintain a firm grip on the handle to avoid losing control of the hammer while swinging and striking.

- Carefully swing the hammer to avoid striking themselves, another person and objects other than the targeted wedge.

- Avoid swinging the hammer above shoulder height.

DANGER

Personal injury, death and /or equipment damage can result from contact with moving parts. All moving parts must be equipped with covers and guards. All covers and guards must be securely positioned at all times when the unit is in operation.

COVER AND GUARDS

Covers and guards are intended to not only protect against personal injury or death, but to also protect the equipment from foreign object damage

EQUIPMENT MOVING AND LIFTING

DANGER

Heavy equipment including pumps, pump packages and components should only be moved or lifted by trained, experienced operators, who are physically and mentally prepared to devote full attention and alertness to the moving and lifting operations. An operator should be fully aware of the use, capability, and condition of

both the equipment being moved and the equipment being used to move it.

DANGER

Failure to follow safe and proper pump, pump package or component lifting or moving procedures can lead to personal injury, death and /or equipment damage from shifting, falling or other unexpected or uncontrolled equipment movements.

Make sure the hoist, lift truck, ropes, slings, spreader bar or other lifting equipment you are using is in good condition and has a rated lifting capacity equal to or greater than the weight being lifted. Lifting devices must be checked frequently for condition and continued conformance to rated load capacity. They should then be tagged with the rated capacity together with the date of inspection.

Fully assembled pumps and pump packages are heavy and should only be moved using the specified lifting lugs or attachments.

Many individual components have lifting eyes or lugs which must not be used to lift assemblies, as they are designed to bear the weight of the component only.

Before lifting the individual component check to insure the lifting attachment is firmly secured to the component with undamaged, properly torqued fasteners, sound welds, or other secure attachments. Examine the lifting eyes, lugs, slots, holes or other projections to insure they are not cracked, otherwise damaged or badly worn. The repair of existing or addition of new welded lifting eyes, lugs or other projections should only be performed by experienced, qualified welders.

Package units should be lifted with spreaders connected to the lifting attachments normally built into the package unit support skid. Packages too large to lift as fully assembled should be separated into smaller loads.

For these smaller loads the lifting devices should be fastened to the lifting attachments normally built into the individual motor, engine, pump or transmission / torque converter, or their separate support skids.

When lifting subassembled components, for example a suction stabilizer attached to suction piping or a discharge pulsation damper attached to a strainer cross and piping, use special lifting slings designed to safely support the combined weight of the components.

If a crane or hoist is being used to lift large components or assemblies, one or more persons should assist the operator from the ground with guide lines attached to the equipment being moved to properly position it and prevent uncontrolled movement.

When you start to lift a pump, package unit, subassemblies or individual components and you observe the equipment is tilting, or appears unbalanced, lower the equipment and adjust the lifting device to eliminate these improper lifting conditions before proceeding to move the equipment.

It is poor practice and dangerous to allow the equipment to pass over or close to your body or limbs. Be prepared to move quickly out of danger if equipment starts to fall, slip or move unexpectedly toward you.

PRESSURIZED PUMP SYSTEMS

DANGER

Fluids under high pressure can possess sufficient energy to cause personal injury, death and/or equipment damage either through direct contact with escaping fluid streams or by contact with loose objects the pressurized fluid propels.

Operating a pump against a blocked or restricted discharge line can produce

excessive pressures in the entire discharge system, which can damage or burst discharge system components.

DANGER

Never operate a pump without a properly sized pressure relief valve or working overpressure shutdown in the discharge line immediately adjacent to the pump discharge.

The relief valve should be placed in the flowing discharge line and not at the opposite end of the discharge manifold in a dead end connection. The dead end may become clogged with solid material carried in the fluid, which could prevent proper relief valve operation.

DANGER

Never place a shut-off valve or any other component between the pump discharge connection and the pressure relief valve.

Make sure the pressure relief valve is installed so any pressurized relief discharge from the valve is directed away from possible contact with people or equipment. The relief valve must be set to relieve at a pressure equal to or below the maximum pressure values shown on the pump data plate. However, if a component is used in the discharge system with a lower rated pressure capability than that listed on the pump data plate, the pressure relief valve must be set to relieve at a pressure equal to or below the rated capability of the lowest rated component.

Before starting the pump every time, check to insure:

- The pressure relief valve is in good operating condition and has been set to the proper relief pressure.
- Any pipe line used to direct pressurized relief flow to another location, such as a collecting tank, is not blocked.
- The discharge system is not blocked and all the discharge line valves are open.

Check all fluid end discharge system components including pipes, elbows connections, threads, fasteners, hoses, etc., at least once every six months to confirm their structural adequacy. With time, wear, corrosion and fatigue can reduce the strength of all components. Magnetic iron and steel components should be checked with magnetic particle or dye penetrant crack detection equipment. Nonmagnetic materials should be checked for cracks with dye penetrants. All metallic components should also be visually checked during these inspections for signs of corrosion. If a component shows evidence of cracking or loss of material due to corrosion it must be replaced with a new part.

Continually monitor suction and discharge hose assemblies when the pump is operating for leakage, kinking, abrasion, corrosion or any other signs of wear or damage.

Worn or damaged hose assemblies should be replaced immediately. At least every six months examine hose assemblies internally for cut or bulged tube, obstructions and cleanliness. For segment style fittings, be sure that the hose butts up against the nipple shoulder, the band and retaining ring are properly set and tight and the segments are properly spaced. Check for proper gap between nut and socket or hex and socket. Nuts should swivel freely. Check the layline of the hose to be sure that the assembly is not twisted. Cap the ends of the hose with plastic covers to keep them clean until they are tested or reinstalled on the pump unit. Following this visual examination, the hose assembly should be hydrostatically tested, on test stands having adequate guards to protect the operator, per the hose manufacturer's proof test procedure.

Fluid end component inspections should be performed more frequently than every six months if pressures above 2500 psi are used in the discharge system or if corrosive, abrasive, flammable or hot (over 110º F) fluids are being pumped.

Proper stuffing box packing selection is important for safe pump operation. Contact a Gardner Denver service representative for assistance in selecting the proper packing before beginning operation.

Before starting the pump the first time, and periodically thereafter check the pump, suction and discharge system fastener torques versus the values listed on page 12 to insure proper tightness. Over and under torquing can damage threaded pipes, connections and fasteners, which may lead to component damage and/or failure. Replace all components found to be damaged or defective. On pumps equipped with stuffing boxes, the gland must be engaged by at least three (3) threads to hold the discharge pressure of the pump.

DANGER

Do not attempt to service, repair or adjust the plunger packing or otherwise work on the pump while the unit is operating. Shut off the pump drive engine and relieve the fluid pressure in the suction and discharge systems before any work or investigation is performed on the pump or pump systems.

Block the crankshaft from turning and make certain that all pump drive motor or engine start switches or starter controls are clearly tagged with warnings not to start the pump while repair work is in process.

Whenever the pump is operating, continually monitor the entire suction, discharge and pump lubricating systems for leaks. Thoroughly investigate the cause for leakage and do not operate the pump until the cause of the leak has been corrected. Replace any parts which are found to be damaged or defective. When a gasketed joint is disassembled for any reason, discard the used gasket and replace it with a new, genuine Gardner Denver gasket before reassembling the joint.

Due to the high working pressures contained by the fluid end, discharge manifold and discharge piping, welding on these components is not recommended. If welding on the discharge system cannot be avoided, only experienced, qualified welders should be used. In addition, the welded part should be hydrostatically proof tested in the shop with water or hydraulic fluid to one and one half times maximum discharge system working pressure, with no observable fluid leakage, before the part is reinstalled in the pump system.

In summary, high pressure fluid streams can possess sufficient energy to cause personal injury, death and/or equipment damage. These results can occur either through direct contact with the fluid stream or by contact with loose objects the fluid stream has propelled, if the pump system is improperly used, or if the fluid is misdirected, or allowed to escape from defective or improperly maintained equipment.

FLAMMABLE, HOT, COLD OR CORROSIVE FLUID PUMPING

DANGER

Extreme caution must be exercised by trained and experienced operators when flammable, hot, cold or corrosive fluids are being pumped to avoid personal injury, death an/or equipment damage due to explosion, fire, extreme cold or chemical attack.

Never operate a pump which is pumping hydrocarbons or other flammable, hot, cold,

or corrosive fluids when any part of the pump, suction system or discharge system is leaking. Stop the pump immediately if any leakage, other than a few drops per minute of packing weepage, is observed. Keep all flame, sparks, or hot objects away from any part of the pump, suction system, or discharge system. Shield the pump, suction system and discharge system to prevent any flammable, hot, cold or corrosive fluid leakage from dripping or spraying on any components, flame, sparks, hot objects or people. Inspect the plungers, packing, gaskets and seals for fluid leakage frequently and replace all worn or leaking parts.

Selection of the proper gaskets, seals and stuffing box packing is even more critical when flammable, hot, cold or corrosive fluids are being pumped than when other, inherently less dangerous fluids are used. Contact a Gardner Denver service representative for assistance in selecting the proper gaskets, seals and packing before beginning operation.

Since some packing weepage into the cradle area is inevitable, a drain located below the bottom of the cradle must be connected to a drain line which conducts the fluid leakage to a collection container located in a protected area. The entire drain system and container must be constructed of materials resistant to attack from the pumped fluid or from explosion or fire of the pumped fluid. **Heavy duty cradle covers must be securely fastened in the proper position on the pump at all times when the pump is operating. If the pumped fluid releases harmful, explosive or flammable vapors the covers must be vented to conduct the fumes away from the pump unit to a non-hazardous area.**

Before beginning pumping operations or starting the pump power source (whether an engine or electric motor) check the atmosphere all around the pumping site for the presence of flammable or explosive vapors. Do not begin operation and stop ongoing operation if flammable or explosive vapors are detected. Hot surfaces, sparks, electric current or engine exhaust could ignite flammable or explosive vapors. Each engine used as a power source on pumping units where flammable or explosive vapors could form should be equipped with an air inlet shut-off. If flammable or explosive vapors are present in the pumping site atmosphere, an engine could continue to run on these vapors even after the engine fuel line is shut-off if an air inlet shut-off is not used.

In addition, on pumping units used where flammable or explosive vapors could form, all electric motors used as power sources must be of explosion proof construction and all electrical components and wiring must meet the current National Electrical Code for explosive atmospheres.

These precautions must be taken to avoid possible personal injury, death and/or equipment damage from explosion, fire or burns.

HIGH PRESSURE LIQUID JETTING, BLASTING AND CLEANING

DANGER

Extreme caution must be exercised if any type of wand, gun, nozzle or any other pressure and flow directing device is attached to the pump discharge system for use in jetting, blasting, cleaning, etc. This type of equipment must be used by trained, experienced operators with the utmost care. High pressure fluid streams can either by direct contact or by propelling loose objects, cause serious personal injury or death to operators and/or other persons.

Pressure or flow directing devices often receive pressurized flow through flexible hoses, which can burst if they are kinked, cut, abraded or are otherwise worn, damaged or pressured above their rated capacity. Protect the hose and connections from damage by people, objects and vehicles. A broken, cut or otherwise burst

hose can release pressurized fluid which may cause personal injury, death and/or equipment damage.

High pressure fluid from hand held or hand directed pressure and flow directing devices may overpower an operator's ability to control or direct the device, which could lead to personal injury, death and/or equipment damage. The operator must brace against the backward thrust of a hand held device. In addition, a safety harness or safety net must be used when working in an area where the operator could be injured in a fall. Stand to the side of any tubing or container being sprayed to avoid back spray and never operate a hand held device above shoulder level.

Never direct the pressurized fluid stream at yourself or any other person, control valves, the pump, pump drive, suction or discharge systems. The pressurized stream can cause serious personal injury or death and can also change valve or control settings which could dangerously increase the delivery pressure to the pressure and flow directing device.

When operating a pressure and flow directing device, use only equipment which automatically shuts off flow when an operator releases hand or foot pressure on the pressurized flow trigger control to prevent injury if the operator is overpowered or becomes disabled.

Check to insure this automatic shut-off equipment is operating properly before every use and never circumvent the automatic shut-off for any reason or by any means when operating the equipment.

When operating any type of high pressure liquid jetting, blasting or cleaning devices, the operators must always wear protective clothing including, but not limited to, a hard hat with full face visor, heavy duty rain coat and pants, boots with nonskid sole and safety toe, rubber gloves with rough grip surface and ear noise protection.

Full operator attention and alertness are required when operating this equipment to avoid personal injury, death and/or equipment damage. The operators should take frequent rest breaks and cease operations when they become tired or distracted.

Before the equipment is started, the work area must be inspected and properly prepared to avoid personal injury, death, and/or damage to equipment. Make sure the work area is checked for hazardous fumes, has adequate ventilation for engine exhaust and sufficient drainage for released fluid. Check the work area for electrical equipment, connections, outlets, fixtures, or lines. If any are present they must be made water tight and the electrical power to these devices must be shut off to avoid electrical shocks from fluid contact. The work area should be clearly marked and roped off to keep unauthorized people and vehicles from entering. Remove all loose parts, tools and equipment from the work area before beginning operation.

All pressure containing devices including wands, nozzles, guns, hoses, connections, etc., should be regularly checked for condition. These components should all be tagged with their tested pressure capabilities together with the date testing was performed. **Always be aware of the pressure level in the system and never connect any equipment to the system which has a rated or tested pressure capability below the system operating pressure.** The equipment must be shut down and the system pressure released before changing or disconnecting wands, nozzles, guns, hoses, connections or any other pressurized system components.

All pressure containing devices including wands, nozzles, guns, connections, etc., plus all automatic shut-off, pressure and control equipment should be treated with care. Protect them from damage by people, objects and vehicles. **Never** lay them in dirt, mud, ice or other loose material which could plug the fluid opening or interfere with their operation. **Never** use the wand, nozzle, gun, etc. to pry loose material off items being cleaned.

Before starting operation in a cold environment, check to make sure there is no ice in the fluid system and repeat this inspection each time before operation is restarted.

Before purchasing wands, nozzles, guns, connections, hoses, etc., manufacturers of these components should be contacted for detailed information on the design and safety features incorporated in their products. After careful study of various manufacturers products, we recommend that **only** those wands, nozzles, guns, connections and hose, etc., be considered for purchase that you judge to offer the highest quality of design, construction and safety, since these components are among the most critical to the safe operation of high pressure liquid jetting, blasting and cleaning equipment.

After you have selected and purchased these components, follow the manufacturer's instructions completely in their use.

In summary, high pressure jetting, blasting and cleaning are inherently dangerous, as the pressures and flow rates needed to remove scale, clean, etc. are sufficient to cause personal injury, death, and/or equipment damage resulting from, but not limited to, any of the conditions described in the above Danger Notices.

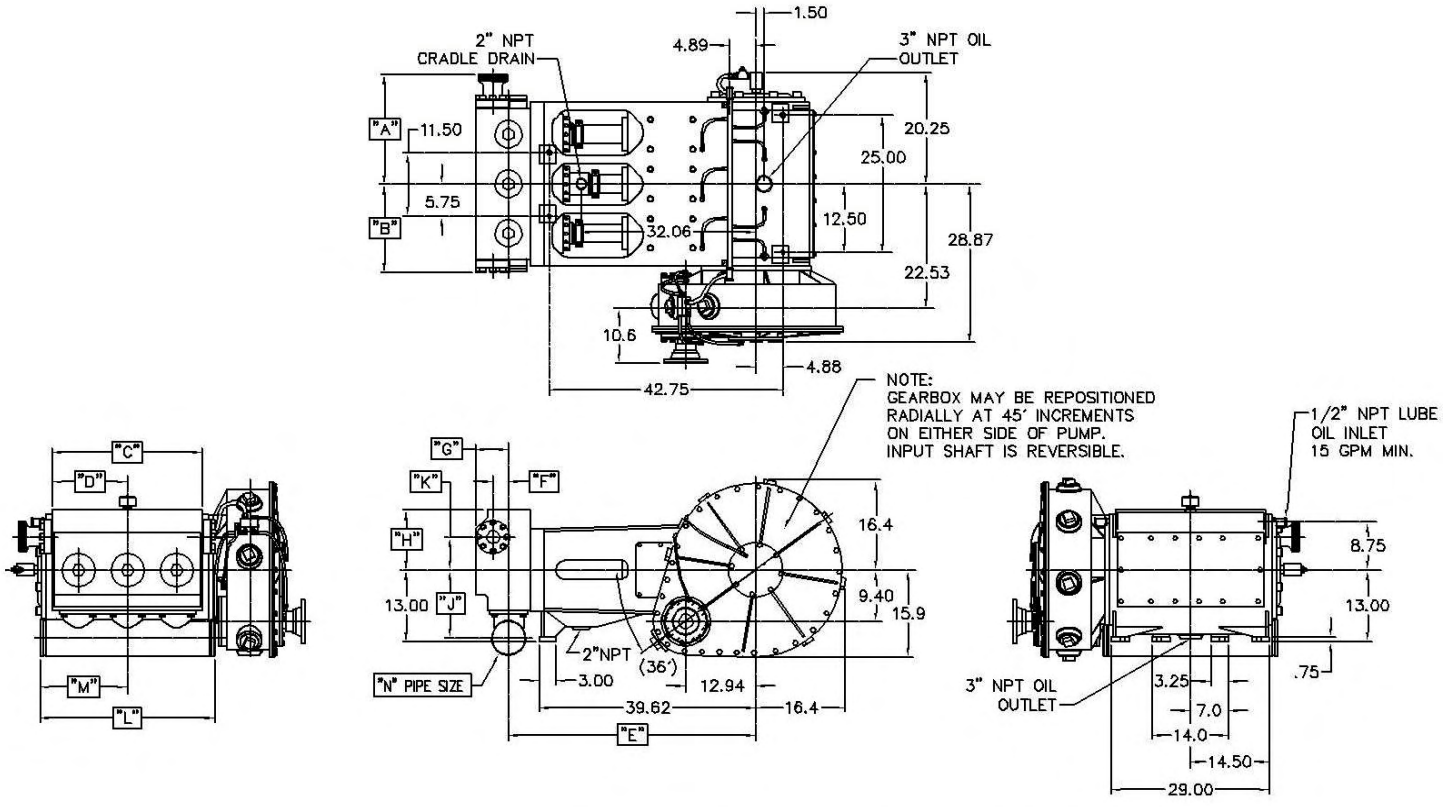
SECTION 2
DESIGN, DESCRIPTION AND SPECIFICATIONS

INTRODUCTION

The Gardner Denver OPI-600 is a multi-purpose pump for various applications such as oil well servicing, water blasting, industrial use, etc. The pump was designed using modern analytical engineering methods and techniques for stress analysis of structural components, gears, and journal bearings. The gear drive was calculated in accordance with the most recent standards, procedures and computer software developed by American Gear Manufactures Association. The OPI-600 has a proven track record as a reliable, trouble-free pump.

The Issue of personnel safety is the most important topic covered in this manual. Therefore, in the beginning of this manual the user is introduced to dangers inherent in the operation of a high pressure pump. To avoid accidents and injuries, all safety rules listed in this section and also all other applicable safety rules and regulations must be carefully observed.

The sections on Pump Design, Description, and Specifications, describe the pump design, list the pump specifications, and present drawings depicting the pump external views and all essential cross-sectional drawings.



NOTE:
THE "A" DIMENSION IS WITH 2"–1502 HAMMER LUG DISCHARGE FLANGE AND THE "B" DIMENSION IS WITH A BLIND FLANGE. OTHER FLANGES MAY VARY.

PLUNGER SIZE	A	B	C	D	E	F	G	H	J	K	L	M	N
2.75 DIA 3.00 DIA	19.3	15.8	27.0	13.5	45.9	2.4	5.5	9.8	10.0	5.4	30.0	15.0	4"
3.50 DIA 4.00 DIA	19.7	16.1	27.5	13.8	45.3	2.9	6.1	10.9	12.4	6.0	32.0	16.0	6"
4.50 DIA 5.00 DIA	19.3	17.0	29.0	14.5	45.6	3.0	5.8	11.3	13.3	7.0	32.0	16.0	6"

FIGURE 2-1 OPI-600 PUMP

Section 3, "Pump Preparation, Operation, and Maintenance," addresses the issues of preparing the pump for operation after shipping or storage, the lubrication system design and specifications, the new pump run-in procedures, and the periodic routine maintenance schedule. The recommended oils, viscosity data, and crankcase oil temperature requirements are also presented in this section.

PUMP DESIGN

The OPI-600 is a horizontal single acting 600 horsepower triplex pump. It has a 6" stroke and various plunger sizes from 2.75" diameter through 5" diameter. The weight of this pump will vary slightly due to the various accessories, but will not exceed 5,000 pounds. Materials used in the power end have been selected to provide long life, and meet the rigorous demands required for well servicing applications. All sizes of plunger fluid ends are interchangeable on the power end.

POWER END

The power end is available with 4.68:1 ratio gearbox only. This is a "dry sump" pump designed for pressure lubrication fed through various hoses and drilled passageways to the main bearings, rod bearings, crossheads, etc. Because of the various drive arrangements for powering these pumps, the lubrication pump itself is not built-in. It must be sized and mounted to suit each particular application.

NOTICE

The direction of rotation must be such that the top side of the crankshaft is moving toward the fluid end (clockwise in the figure below).

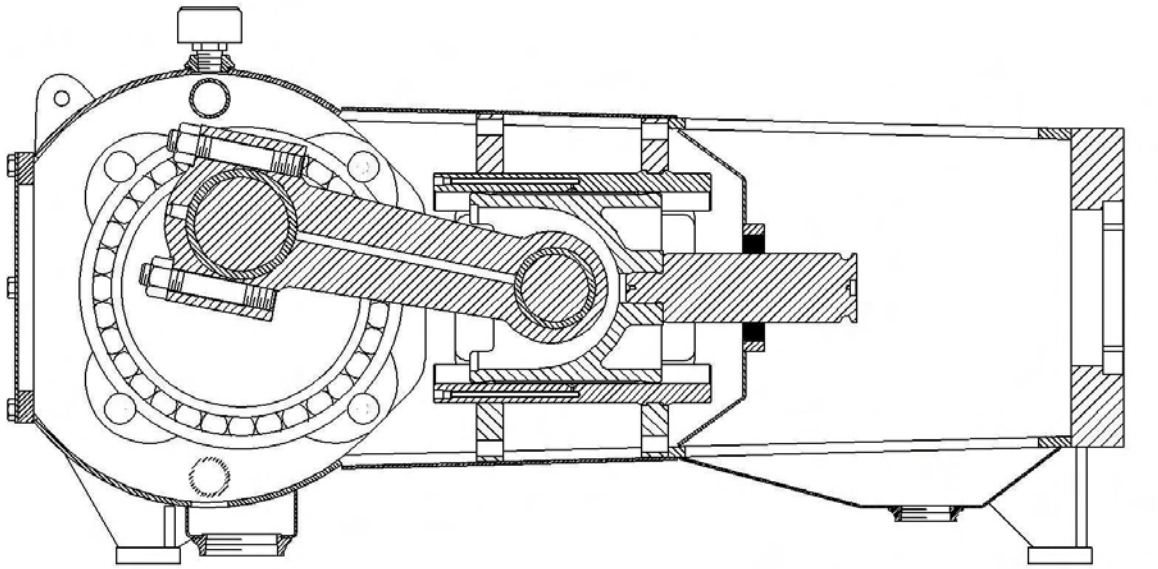


FIGURE 2-2 OPI-600 POWER END CROSS SECTION

CROSSHEAD ASSEMBLY

The crosshead assembly features a wrist pin which is made of heat treated, high strength alloy steel, then nitrided and ground for an optimum bearing surface. The wrist pin bushing has chevron style oil grooves to maintain lubrication pressure throughout the connecting rod oscillation. Oil is fed under pressure to the wrist pin bushing through a drilled passageway in the connecting rod to further extend the durability of this assembly.

GEARBOX

The gearbox is a parallel shaft style unit consisting of a bull gear and pinion. The gears are constructed from alloy steel then heat treated and ground for extended service life. The gearbox may be repositioned radially at 45 degree increments for flexible installation. In addition, the pinion shaft is reversible for under drive mounting configurations.

CRANKSHAFT

The crankshaft is made of high strength alloy steel that has been precision machined and heat treated for fatigue resistance and long wear. It has been drilled with lubrication passageways to provide oil for all the connecting rod journal bearings as well as the crosshead assembly.

POWER END INTERNAL LUBE SYSTEM

There is a single inlet for the lube oil, coming from the lube oil pump. After entering the inlet, the lube oil flow is divided into two lines:

1. Through external hoses and rotating unions the lubrication oil enters the crankshaft where it is distributed to the connecting rod journal bearings and the and wrist pin bushings.

2. Through the lubrication manifold, oil is distributed to the gearbox, main bearings, and the outside of the crosshead.

There are two drain holes on the bottom of the power frame. A 3" NPT drain below the crankcase drains the power end lube, while a 2" NPT drain in the cradle drains any excess packing lube. User plumbing will direct drain oil flow back into the lube sump.

FLUID END

The conventional valve over valve configuration offers field proven valve and spring performance. Improvements in the fluid end life come from:

1. New sophisticated methods of metallurgical control which enable us to obtain steel with very consistent chemical components and mechanical properties. This results in extended fluid end life.

2. Internal edges and corners are hand radiused, blended and polished for improved resistance to fatigue cracking.

3. Extreme pressure autofrettage is available for longer fluid end life and resistance to cracking at the bore intersection areas.

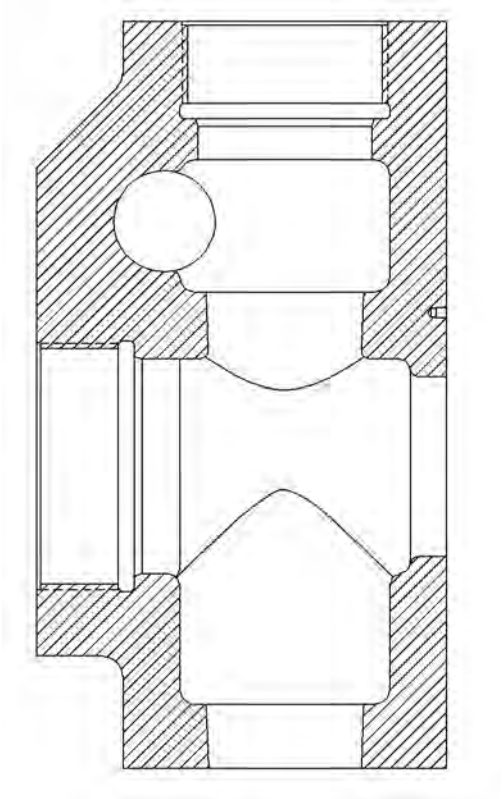


FIGURE 2-3 FLUID END

GENERAL SPECIFICATIONS

This section presents the pump basic specifications (U.S. & Metric). The first set of specifications deals with the pump's power, rod load, plunger stroke, and overall dimensions. Two other tables present allowable pressures and flows for various plunger sizes and pump RPM's along with data on power requirements.

OPI-600 PUMP SPECIFICATIONS (U.S. SYSTEMS)	
Rated Hydraulic Horsepower	600 hp
Stroke Length	6.0 Inches
Maximum Rod Load	100,000 Pounds
Gear Ratio	4.68:1
Weight (system dry)	5,000 Pounds

OPI-600 PERFORMANCE RATING – U.S.

Plunger Size (Inches)	Gallons Per Rev.	100 RPM		200 RPM		300 RPM		450 RPM	
		GPM	PSI	GPM	PSI	GPM	PSI	GPM	PSI
2.75	0.463	46	16845	93	10004	139	6669	208	4446
3.0	0.551	55	14154	110	8406	165	5604	248	3736
3.5	0.749	75	10399	150	6176	225	4117	337	2745
4.0	0.979	98	7962	196	4729	294	3152	440	2102
4.5	1.239	124	6291	248	3736	372	2491	557	1660
5.0	1.529	153	5096	306	3026	459	2071	688	1345
Brake Horsepower*		500		600		600		600	

* Based on 90% Mechanical Efficiency and 100% Volumetric Efficiency.

SECTION 3
PREPARATION, OPERATION AND MAINTENANCE

DANGER

Read and understand clearly all safety rules and precautions before attempting to operate the pump.

This section deals with pump preparation after shipping and storage of the pump, user built lubrication system and its specifications, pump break in procedures, recommended oils, allowable crankcase operating temperatures, viscosity conversion tables, and routine maintenance schedule.

PREPARATION AFTER SHIPPING AND STORAGE

All pumps are shipped dry and therefore must be flushed with light weight oil before operating. The flushing must be performed regardless of method or duration of the shipment or type of container the pump was shipped in.

Pumps are not prepared for storage and should be put in service as soon as possible.

If for any reason the pump has to be put into storage after prior use, the following procedure should be followed:

1. Clean and flush the fluid end with a rust preventative.
2. Plug all discharge and suction openings.
3. Drain oil from the power end and the gear reduction unit.
4. Flush the power end with a rust preventative (before flushing make sure that the rust preventative will not clog the oil passages).
5. Remove the breather and either plug or tape the opening.
6. Coat the gear reducer input shaft and all exposed bare metal with a heavy rust preventive.
7. Plug drain holes at the bottom of the pump frame, at the rear of the pump, and the gear reducer drain.
8. Plug the lube inlet in the lube manifold.
9. Store the pump inside in a warm dry place.
10. If the pump is shipped ocean cargo, it must be crated in a water-tight container placed below the deck to prevent rusting and salt water contamination.

PUMP MOUNTING INSTRUCTIONS

Because of the lightweight, low stiffness nature of these pumps, it is easy to twist or distort the frame during installations. Therefore, it is necessary to follow this procedure to shim the feet of these pumps.

This requires (4) grade 8, 13/16” diameter cap screws of the appropriate length, lockwashers, nuts, if required, and shims if required.

1. Set the pump in its location.
2. Using a feeler gauge, check under the feet at all four boltdown locations.
3. Select the proper number and thickness of shims to fill the gap under the high foot. Note it is better to use shims up to .005” too thick than to leave any gap under the foot.
4. With shims in place, install bolts in all four locations.

CHARGING PUMP REQUIREMENT

A centrifugal pump will be required to prime the fluid end suction. The centrifugal pump should be sized to generate a minimum of 50 PSI at maximum flow. Increased pressure is required for pumping higher volumes, heavy sand concentrations, and

other special fluids and propping agents. To reduce shock and cavitation, which can cause severe damage, a suction dampener should be used.

POWER END LUBRICATION SYSTEM

Due to variety of applications and drive arrangements, the power end lubrication pump and applicable auxiliary hydraulic equipment are not furnished with the triplex pump. Therefore, the pump lubrication system is designed and built by individual customers for each particular application.

The lubrication system is very critical to the triplex pump performance and therefore should be professionally designed in accordance with sound engineering practices developed for similar systems, known otherwise as hydraulic power units or HPU. The following discussion will re-emphasize some of the good practices used in designing similar systems in the past and comment on the system's critical components.

Lube System Pump

A positive displacement pump must be used. Gear type pumps have demonstrated reliable performance for similar applications in the past. The pump should have the largest suction port available for the selected pump size to minimize losses in the suction piping.

Lube Pump Suction Piping Sizing and Requirements

In the past, failure to meet these requirements has lead to pump damage because of restricted oil flow in the lube pump inlet. Therefore, the following guidelines, developed as a result of long experience, should be adhered to closely.

1. The oil flow velocity through the suction piping should not exceed 2 ft/sec or 0.6 m/sec.

2. At maximum operating speed the vacuum reading at the lube pump inlet must be no more than 8" hg or 4 psi or 0.28 bar.

3. The suction strainer should be sized for oil flow three (3) times larger than the actual flow passing through the strainer.

4. The suction pipe should be kept as short as possible and free of bends.

5. Warning devices to monitor lube oil pressure and temperatures are highly recommended. The triplex pump operates at very high rod loads and pressures, and malfunction of the lube system may result in serious damage occurring in a very short time. Therefore, early warning devices are essential to successful operation and should be set according to the following operating limits:

NOTICE

Maximum lube system pressure should be set at 125 psi max. (relief valve setting.)

<u>Minimum</u> lube oil operating pressure is 40 psi (with hot oil).

<u>Minimum</u> lube pump flow is 15 gpm.

Lube system filter should have a 25 micron absolute rating with a by-pass indicator.

Maximum lube system vacuum at lube pump inlet 8 Hg or 4 psi or 0.28 bar.

FIGURE 3-1 provides a typical lubrication schematic for the pump.

FIGURE 3-2 Indicates API-GL5 oil grades recommended for use in the pump power end and the speed reducer lube system, crankcase operating temperature ranges, and minimum startup temperatures for each listed grade of oil for various ambient temperature ranges.

TYPICAL LUBRICATION SCHEMATIC
OPI-600 PUMP

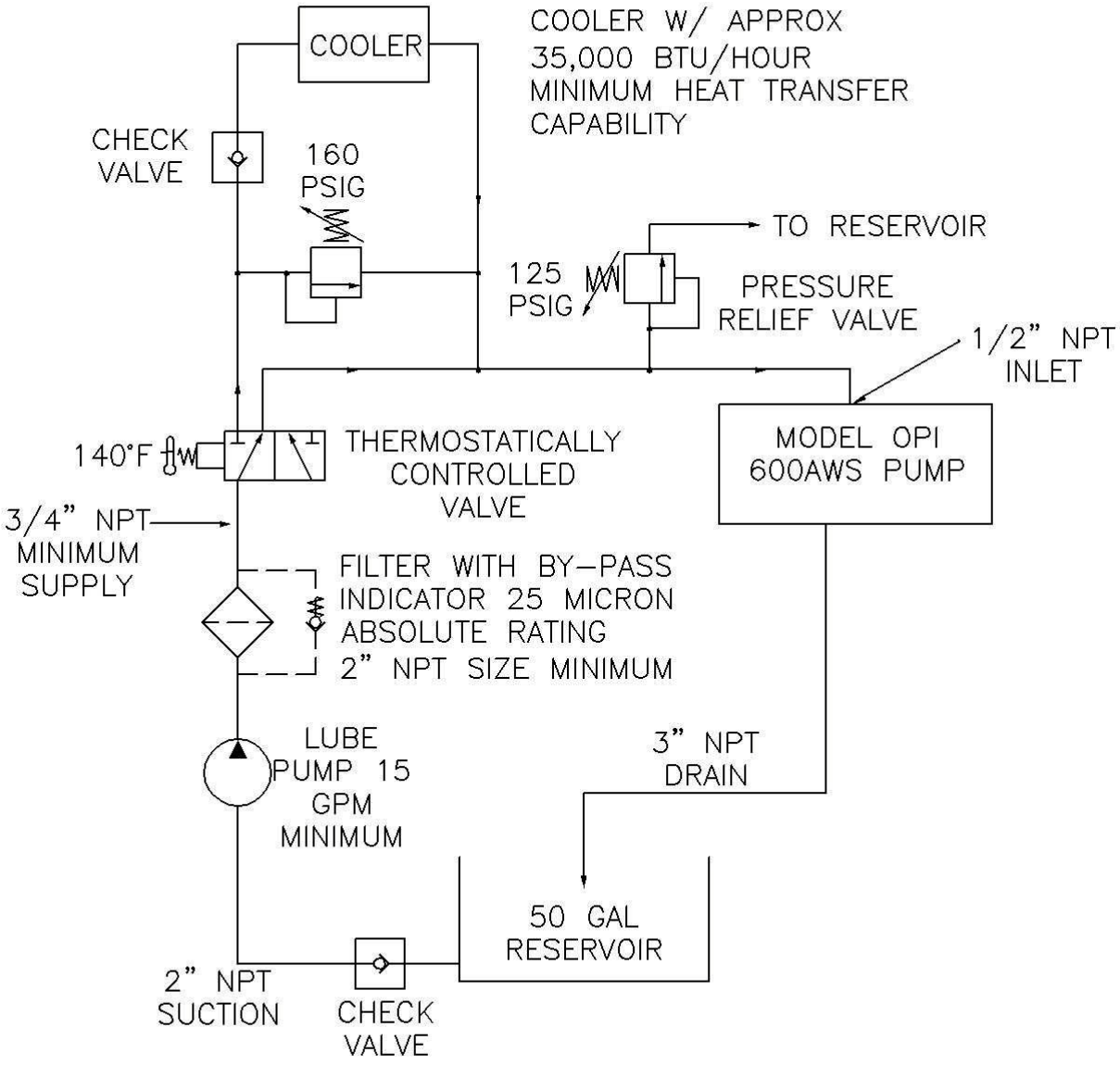


FIGURE 3-1 LUBRICATION SCHEMATIC

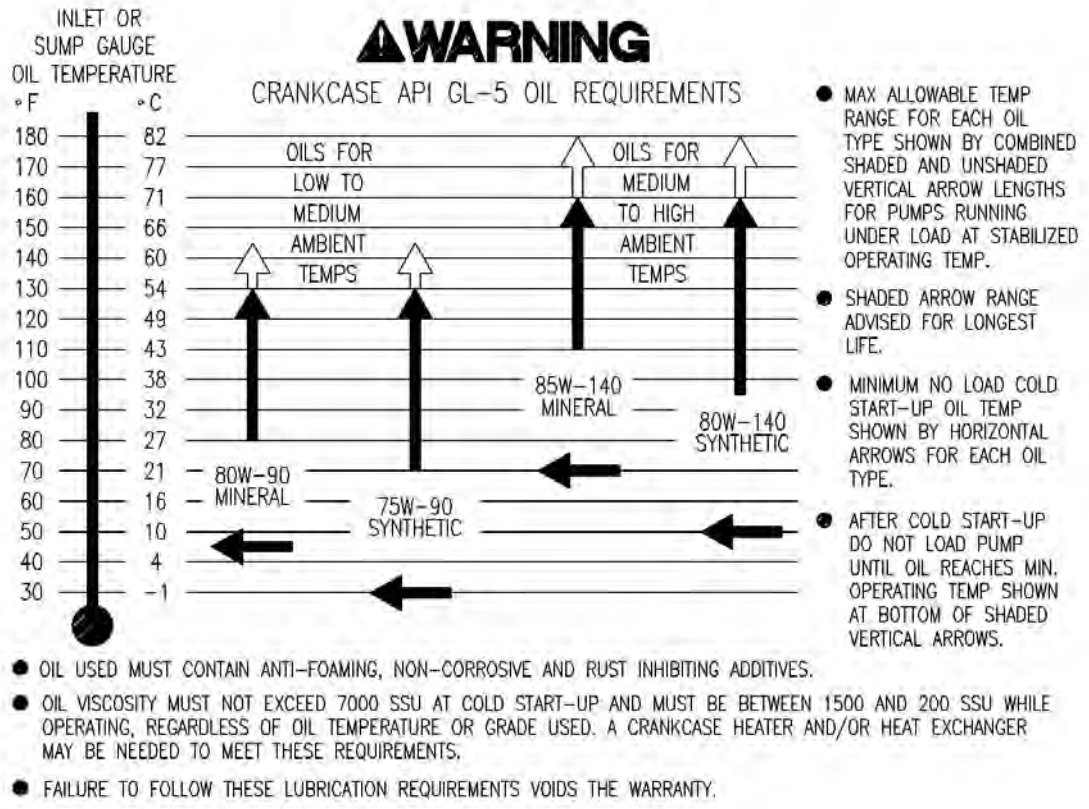


FIGURE 3-2 LUBRICANT RECOMMENDATIONS

PLUNGER / PACKING LUBRICATION

The fluid end plungers are lubricated from a separate lubrication pump through the stuffing box. The lubrication pump, hosing, and check valve to the stuffing box are not provided with the unit.

See "Plunger Packing Lubrication Recommendation Chart," page 19, for a list of lubricants recommended for plunger /packing lubrication.

STARTUP AND NEW PUMP RUN-IN PROCEDURES

A centrifugal charge pump will be required to charge the fluid end suction manifold. The charge pump should be sized according to the volume to be pumped by the triplex pump so that there is no less than 50 psi charge when the triplex pump operates at its maximum flow.

The first startup is performed at the factory during the acceptance tests as a part of quality assurance procedure. However, the new pump break-in period process may continue for the first 80-100 hours of our operation, and therefore it will be each user's responsibility to perform all the tasks related to this critical period. As all moving parts of the pump go through a wearing-in process, steel and bronze wear particles are carried by the oil flow in the lubrication system. The resulting contamination of the lubrication system with the wear particles and especially clogging of the strainer and the oil filter can cause serious problems. To assist the user, the following guidelines are presented for the maintenance personnel to follow during the critical startup and break-in period:

1. Fill the lube oil reservoir with the recommended grade of oil. See FIGURE 3-2 above for Lubricant Recommendations.

2. Fill the plunger reservoir with proper oil. See "Plunger/Packing Lubrication Recommendations" on Page 19.

3. Remove all inspection covers on the back of the pump frame.

4. Start the engine at the lowest possible RPM and triplex pump at zero (0) pressure. Make sure that all roller bearings, crossheads, wrist pin joints, and crankshaft bearings have proper lubrication.

5. Increase the engine RPM to maximum operating speed and check whether the vacuum reading at the lube pump suction inlet is less the 8" Hg or 4 psi or 0.28 bar.

6. Check whether the lube system pressure reading is at least 100 psi or 7.0 bar. Temporary pressure gages should be also checked at this time to make sure that all components of the lube system are working properly.

7. Check to see that oil flow back to the reservoir is normal. (There should be no accumulation in the power end.)

8. Start the plunger lube system and check whether it is adjusted properly.

9. Replace the rear covers and run at low speed to "work out" any trapped air in the fluid end with the charge pump operating.

10. Run the pump at 80-90 strokes per minute and 20% of its maximum pressure rating for 30 minutes.

11. During this time observe the suction vacuum gage reading, oil pressure and temperature and check for leaks.

12. Run the pump at 80-90 strokes per minute at the following loads:

40% of full rated load	30 min
60% of full rated load	30 min
80% of full rated load	30 min
100% of full rated load	30 min

13. During the operation, observe the oil pressure and temperature, and inlet suction vacuum gage reading, and entire system for proper operation.

14. If the triplex pump is equipped with a transmission, run the pump for 30 minutes in each gear in the higher gear ranges pulling full horsepower in each gear. Observe the oil pressures, temperatures, and lube oil suction vacuum closely.

15. Shut the pump down and let it cool thoroughly before starting normal operation of the pump.

16. During the shutdown, change the oil filter elements and clean the suction strainer.

17. Change the lube oil and clean the reservoir to get rid of metal particles and any other wear products now present in lube oil system.

18. Change filter elements and clean the strainer every 10-15 hours until it becomes apparent that the wear-in process is finished.

19. Change the lube oil again, replace the filter elements, and clean the strainer after 80-100 hours of pump operation.

20. Follow the routine maintenance schedule described in the next chapter after completion of the wear-in period.

PERIODIC MAINTENACE SCHEDULE

Performance of the periodic routine maintenance tasks, described in this section, will ensure long, economical, and trouble free operation of this pump. It is highly recommended that the customer set up a maintenance program during the run-in period. The periodic maintenance data should be recorded and kept with other pump documents. The following recommendations should serve as a guideline for establishing a good maintenance program. The periodic maintenance schedule is divided into daily, monthly, and quarterly tasks to be performed by the user after the pump has gone through 100 hours of wear-in. For the tasks performed during the wear-in period, see "Startup and New Pump Run-In Procedure," page 16.

Daily Maintenance Tasks

1. Check the oil level in the lube oil reservoir.

2. Periodically monitor lube oil operating pressure and temperature. The maximum oil operating temperature depends on a particular grade of oil used in the pump lube system.

3. Check the lube pump suction inlet vacuum. A vacuum gage reading higher than 8" Hg or 4 psi or 0.28 bar indicates that the suction strainer and/or oil filter element are clogged. The strainer must be cleaned, and the oil filter element replaced as necessary as soon as the pump can be shut down for a short period of time to perform these tasks.

4. Listen for any abnormal noise or rough operation, which may indicate the need for fluid end maintenance such as changing valves or valve seats. Due to very high pressures in the triplex pump fluid end, worn valves and seats should be changed as soon as possible to prevent washing them out with the pumped fluid.

5. Check the plunger/packing lubrication pump for proper operation. Ensure packing nut is tightened sufficiently into fluid end. Recheck tightness after extended continuous operation.

Monthly (100 hour) Maintenance Tasks

1. Clean the strainer and replace the oil filter element.

2. Check the entire lube system for leaks and eliminate them.

3. Check all fluid end expendables such as valves, packings, and valve seats and replace them as necessary.

4. Check the power end extension rod seals and replace them as necessary.

Quarterly (300 hour) Maintenance Tasks

1. Change the lube oil and clean the oil reservoir thoroughly.

2. Clean the lube system strainer and replace the oil filter elements.

3. Re-tighten the critical bolt joints following torque specifications given in Section 6.

4. Add grease to any exposed bare metal to prevent corrosion.

5. Clean or replace the breather cap filter element.

6. Check all pressure, temperature, and vacuum gages for proper operation and replace as necessary.

7. Check all lube system warning and alarm devices for proper operation and replace if found defective.

8. Check supply of on hand expendables such as packings, valves and seats, maintenance items such as seals. Order to replenish supplies as necessary.

9. Check bearings and wear surfaces for failure until operating experience justifies longer inspection intervals.

PLUNGER PACKING
LUBRICATION RECOMMENDATION CHART

ROCK DRILL LUBRICANTS - NORMAL CONDITIONS

Source	Type	Pour Point Maximum
Amoco	Amoco Rock Drill Oil - Light	-20°F
	Amoco Rock Drill Oil - Medium	0°F
Arco	Air Drill #147	0°F
	Arco Trueslide #150	15°F
Chevron Oil U.S.A.	Vistac #68X	10°F
	Vistac #100X	5°F
	Vistac #150X	0°F
Conoco	EP Rockdrill #49, #17, #78	5°F
Gulf Oil (Chevron)	Rockdrill #100	-30°F
	Rockdrill #32	-35°F
Exxon	Arox EP #46	-20°F
	Arox #150	-35°F
Mobil Oil Co.	Almo #525	-20°F
	Almo #527	-20°F
	Almo #529	-10°F
	Almo #532	0°F
Pacer Oil	Rockdrill #150	-10°F
	Rockdrill #600	0°F
Phillips Petroleum	EP #500 (Summer) or EP #300 (Winter)	-10°F
Shell Oil Co.	Torcula Oil #32	-50°F
	Torcula Oil #100	-20°F
	Torcula Oil #150	-15°F
	Torcula Oil #320	-10°F
Sun Oil Co.	Rockdrill 500 (Light)	5°F
	Rockdrill 1000 (Heavy)	5°F
Texaco Oil Co.	Rockdrill Oil XL	-40°F
	Rockdrill Oil XM	0°F
	Rockdrill Oil XH	-10°F
Union Oil of Ca.	Marok 150	------

OPTIONAL PACKING LUBRICANTS

Category	Specification
Motor Oil	10W30
Motor Oil	5W40

SECTION 4
SERVICE PROCEDURES

This section describes various assembly and disassembly procedures necessary for pump servicing or parts replacement. The General Requirements and Safety Rules section is a reminder for the maintenance personnel of the critical importance of safety rules and precautions while working on the pump. Notes on dangers and notices specifically related to service procedures are repeated and placed in this section also.

The pump consists of three major modules: (1) the fluid end, (2) the power end, and (3) the gear reduction unit. The description of service procedures follows the modular concept. Due to many expendable parts, fluid end servicing is rather common in the field and is therefore presented in the very beginning followed by power end and gear reduction unit servicing procedures.

General Requirements and Safety Rules

DANGER

Before any attempt to work on pumps is made, all safety rules and precautions described in this manual must be read and clearly understood.

DANGER

Only qualified and specially trained personnel should be allowed to work on this pump.

DANGER

Proper capacity hoist and lifting devices should be used while working on pump.

FLUID END SERVICE

This discussion starts with the description of steps necessary for removal and installation of the fluid end assembly and proceeds to the removal and replacement of expendable parts such as valves, valve seats, and packing.

Fluid End Removal

1. Disconnect suction and discharge lines, plunger oiler lines, and also any accessories such as stroke counters, pressure gages, etc. from the fluid end.

2. Open the hinged cradle cover on the top of the crosshead housing, if equipped, and disconnect the plungers from the extension rods by removing the extension rod clamps.

3. Slide the plungers into the fluid end as far as possible.

4. Connect a hoist to the fluid end and tighten the lines until they are snug only. Make sure that hoisting slings are not too tight, because that may cause a strain on the fluid end and cause injury or damage when removing from the pump frame.

5. Remove the twelve (12) 1-1/2” socket head capscrews from the fluid end using a hydraulic torque wrench with a modified 1-1/2” 12 point socket (OD ground to 2.19” max) for a 1” drive or a hand tool combination of a 4X1 torque multiplier, a 3/4” drive torque wrench, a 1” drive extension, and a modified 1-1/2” 12 point socket (OD ground to 2.19” max) for a 1” drive.

6. Pull the fluid end assembly horizontally forward, straight away from the power end until it is completely clear of the 1/4” dowel pins.

7. Move the fluid end to the service area for changing valves or other service.

NOTICE

The procedure for fluid end installation is presented separately due to the special and critical nature of the connection between the power end and the fluid end.

Fluid End Installation

1. Clean the surfaces between the mating faces of the power end counter bores, stuffing boxes, and fluid end, removing any debris or surface imperfections such as corrosion or raised metal. Make sure the o-rings and gaskets are in place.

2. Orient the stuffing boxes so that the 1/4" dowel pin holes are on top.

3. Lift the fluid end until the dowel pins match the dowel pin holes in the stuffing boxes and push the fluid end toward the stuffing boxes.

4. As seen in Figure 4-1, label the top row of bolt holes on the frame starting from the left corner to the right corner with the following sequence of numbers: 9, 5, 1, 3, 7, 11.

5. As seen in Figure 4-1, label the bottom row of bolt holes on the frame starting from the left corner to the right corner with the following sequence of numbers: 12, 8, 4, 2, 6, 10.

6. Install the bolts hand tight using the following sequence: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12.

7. Check the clearance between the face of the fluid end and the power frame. The clearance range is between .003" and .030". This clearance should be approximately the same at all four corners before proceeding. If the clearance is not the same at all four corners, remove the fluid end and clean the surfaces between the mating faces of the power end counter bores, stuffing boxes, and fluid end, removing any debris or surface imperfections such as corrosion or raised metal. Reassemble the unit and recheck the clearance.

8. Tighten the fasteners to 80-100 ft-lbs. using a hydraulic torque wrench with a modified 1-1/2" 12 point socket (OD ground to 2.19" max) for a 1" drive or a hand tool combination of a 4X1 torque multiplier, a 3/4" drive torque wrench, a 1" drive extension, and a modified 1-1/2" 12 point socket (OD ground to 2.19" max) for a 1" drive. Use the same tightening sequence as step 6.

9. Check the clearance between the face of fluid end and power frame. The clearance of .003" - .030" should be approximately the same at each of the four corners.

10. Tighten the fasteners to 1250 ft-lbs. using the same sequence as step 6.

11. Recheck the clearance between the face of fluid end and power frame. The clearance of .003" - .030" should be approximately the same at each of the four corners.

12. Repeat step 10, verifying that each fastener is properly torqued to 1250 ft-lbs.

13. Conduct a final check of the clearance between the face of the fluid end and power frame. The clearance of .003" - .030" should be approximately the same at each of the four corners.

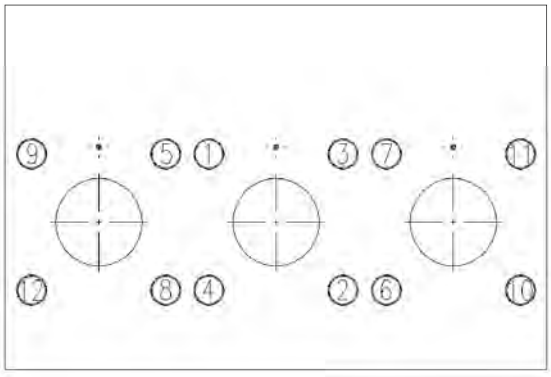


FIGURE 4-1 FLUID END TIGHTENING SEQUENCE

Plunger and Packing Replacement

This service procedure can be performed with the fluid end in place on the pump, and consists of the following steps:

1. Remove the suction cover retainer nut with the appropriate male hex wrench.

2. Remove the suction cover with a threaded “slide hammer type” puller.

3. If equipped, open the hinged cover on the top of the crosshead housing to get access to the plunger/extension rod area.

4. Remove both capscrews holding the plunger clamp, then remove the clamp.

5. Loosen the packing nut to free the plunger from packing pressure.

6. Remove the plunger through the suction cover opening.

7. Remove the packing nut, packing, and spacers.

8. Inspect the plunger, the packing, the rod wiper, the stuffing box bore, and the packing nut for excessive wear, nicks, burrs, or any other defects. Replace expendable parts as necessary.

9. Coat packing and stuffing box bore with a light grease or oil.

10. Install the packing in the packing bore with the packing lips toward the front of the fluid end. See FIGURE 4-2.

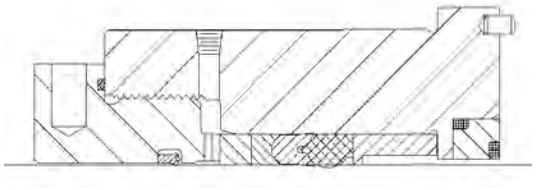


FIGURE 4-2 TYPICAL PACKING ASSEMBLY

11. Install and hand tighten the packing nut to align the packing in the bore.

12. Loosen the packing nut to allow for installation of the plunger.

13. Apply a light coat of grease or oil to the clamp end of the plunger (approx. 2 in.). Insert the plunger through the suction cover hole into the packing. It may be necessary to bump the plunger through the packing with a slide hammer. Be sure to keep the plunger level through installation.

14. Tighten the packing nut.

15. Inspect the clamp surfaces of the plunger, and the extension rod for cleanliness.

16. Install the plunger clamp and tighten the clamp screws to the specified torque.

17. Tighten the packing nut again.

18. Replace the o-ring and back-up rings on the suction cover and apply grease or o-ring lube.

19. Install the suction cover and tighten the suction cover retainer nut.

20. Make sure that the plunger lube line is in place before restarting the pump.

Valve and Seat Replacement

This procedure can be performed with the fluid end on the pump. Before starting, make sure that special tools required for this procedure are available. For part number of the tools see Parts Manual.

WARNING

Never try to remove or cut a valve seat with a torch. Severe damage to the fluid end may occur.

1. Remove the discharge cover retainer nut with the proper hex wrench.

2. Remove the discharge cover with a “slide hammer type” puller.

3. Remove the suction cover retainer nut with the proper hex wrench.

4. Remove the suction cover with a “slide hammer type” puller.

5. Remove the suction valve spring retainer. The suction valve spring and valve can now be removed by hand.

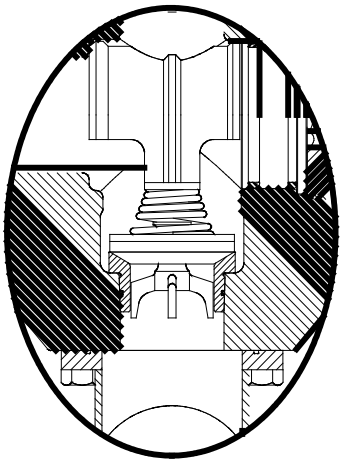


FIGURE 4-3 VALVE CAGE SPRING RETAINER

6. Remove the suction valve seat or discharge valve seat with a seat puller and a seat puller jack. These tools are available from Gardner Denver.

7. Clean the valve seat deck thoroughly using a non-petroleum based cleaner.

8. Clean the replacement valve seat using a non-petroleum based cleaner. Do not apply any type of lubricant to the seat or o-ring on the seat prior to installation.

9. Snap the replacement valve seat into the taper by hand to fit tightly.

10. Place the winged valve on the top of the valve seat.

11. Bump the seat into the taper 2-3 times with a heavy bar to make the fit tight.

12. Reinstall the valve spring and suction valve spring retainer cage.

13. Reinstall the suction valve cover and retainer nut.

14. Reinstall the discharge valve, spring, cover, and retainer nut.

15. Run the pump at 80% to 100% of the maximum discharge pressure until the seats “pop” into the fluid end tapered holes. (Listen for 6 distinct loud “pops”)

POWER END SERVICE

DANGER

Before attempting to service the power end of the pump, the following safety precautions must be observed:

1. **Shift the pump transmission into the neutral gear.**
2. **Shut off the pump engine and remove the key from the ignition to prevent starting the engine inadvertently.**

Extension Rod

1. Remove any plunger / cradle-chamber covers or guards.

2. Remove the plunger and push it into the fluid end.

3. Unscrew the extension rod with a pipe wrench on the knurled portion of the rod (be careful not to damage the seal surface). Remove the extension rod through the top of the cradle section.

4. Check the extension rod seal for wear. Replace if necessary.

5. Before replacing the extension rod, inspect the threads in the crosshead and check for cracks on the extension rod. Apply a light coat of anti-seize to the extension rod threads.

6. Install extension rod in crosshead. Apply approximately 150 ft-lbs to extension rod.

7. Check to see that mating faces of extension rod and plunger are free of nicks or burrs. Any raised metal could cause misalignment, resulting in poor packing life.

8. Replace the plunger as detailed in the previous section.

Connecting Rod Bearing

1. Remove the rear cover from the power end.

2. Remove the two locknuts from each rod cap to be removed.

3. Remove the rod cap, labeling each for correct re-assembly.

4. Using a rubber hammer or wooden hammer handle, tap on one edge of the bearing to work it around in the connecting rod and out. Use a screwdriver to remove the bearing from the crank journal.

5. Check the crankshaft journal surface for wear or damage. Polish if necessary.

6. Clean the new bearings and connecting rod thoroughly before replacing bearings. The grooved bearing half goes in the cap and the non-grooved half goes in the connecting rod.

7. Install the rod caps, making certain the correct cap is assembled with the correct rod.

8. Tighten the locknuts on the rod caps to 450 ft-lbs.

9. Before operating the pump, move the connecting rod from side to side with a large screwdriver to make sure the rod is free on the crankshaft. If new bearings are installed, perform the “Run-In” Procedure prior to field operation.

Connecting Rod and Crosshead

1. Remove the side and rear cover s from the power end.

2. Remove the plunger clamps and push the plungers into the fluid end.

3. Remove the extension rods.

4. Using strong internal snap ring pliers, remove the snap rings from the from the crosshead pin.

5. Using a slide hammer or partially threaded rod, remove the pin from the crosshead.

6. Remove one crosshead and connecting rod at a time. The middle crosshead pin can not be removed until the outer crosshead is removed.

7. Remove the two locknuts from each rod cap of the rod to be removed.

8. Remove the rod cap, labeling each for correct re-assembly.

9. Remove the studs in the connecting rod by locking two nuts onto the stud. Remove the stud by loosening the inner nut against the outer nut.

10. Remove the main bearing retainers (1/2”-13 bolt, nut and washers) opposite the crank throw.

11. Rotate the crankshaft to the back stroke of the rod to be removed and push the rod forward till it clears the throw and lower it to the bottom of the power end.

12. Rotate the crankshaft till the throw is on top (90 degrees from the back position) and remove the connecting rod out the back of the power end, being careful not to damage the crank throw.

13. Rotate the crosshead about the center axis until it is free from the crosshead guides. Remove the crosshead from the power end through the side inspection window.

14. Clean and inspect all bearings and bearing surfaces. Replace any defective or worn parts.

15. Clean the oil port in the center of the connecting rod.

16. When replacing the wrist pin bushing in a connecting rod, make sure the oil grooves are placed toward the rear (crank end of the rod). Use a hydraulic press to replace the wrist pin bushing, as hammering will destroy the bushing. If a hydraulic press is not available, place the bushing in a freezer overnight to allow the bushing to slip easily into the connecting rod.

17. When re-installing the crossheads and connecting rods, start with the center assembly.

18. Re-install the crosshead, with one snap ring in place, through the side inspection window of the power end. Rotate the crosshead about the center axis, with the installed snap ring towards the inside, till the crosshead is in place in the crosshead guide shoes. Push as far forward as possible.

19. Install the non-grooved rod bearing into the connecting rod.

20. With the crank throw at the top position, feed the connecting rod into the power end and place as far forward as possible.

21. Rotate the crank throw to the back stroke position. Lift and pull the connecting rod back until it is in place on the crank throw.

22. Hand tighten the two studs into the connecting rod. Apply Loctite 242® or equivalent to the stud threads engaged in the rod. Make sure the studs are fully seated in the connecting rod.

23. Install the grooved rod bearing into the cap.

24. Install the rod cap with bearing onto the connecting rod.

25. Install and torque the rod cap locknuts to 450 ft-lbs.

26. Lift the front of the connecting rod and slide the crosshead back until the wrist pin bores align.

27. Install the wrist pin.

28. Install the snap ring into the groove in the crosshead.

29. Re-install the main bearing retainers.

30. Repeat steps 16-27 until all connecting rods and crossheads have been re-installed.

31. Check crosshead guide clearances prior to operation.

Crosshead Guides

1. Remove the connecting rod and crosshead of the guides to be serviced.

2. Remove the lube system connections to the crosshead guides.

3. Remove the four (4) 1/2”-13 X 4 in. capscrews from each crosshead guide. Keep track of the crosshead guide shim packs if the same guide and crosshead is to be reused.

4. Thoroughly clean and inspect guide for pits, cracks, or scoring. Replace if necessary.

5. If replacing a crosshead or crosshead guide(s) due to damage, both the upper and lower crosshead guides must be re-shimmed.

6. Place the new guides in the power frame, firmly seating the guides in the frame before bolting.

7. Install the four (4) crosshead guide bolts. Do not use the rubber lined washers until the shimming is complete. Do not allow the bolt to pass above the guide thread.

8. Install the crosshead through the side inspection window. Rotate the crosshead about the center axis (roll upward and push down).

9. Install the extension rod.

10. With the extension rod seals out of the seal bore in the frame, use an inside micrometer to measure the distance from the extension rod to the extension rod seal bore at the top and bottom.

11. Subtract the bottom dimension from the top dimension and divide by two to obtain the shim pack required for the lower guide (TOP-BOTTOM) / 2. For example, if the distance from extension rod to the extension rod seal bore is 0.895 in. on top and 0.855 in. on bottom, the shim pack is calculated as follows: 0.895-0.855 = 0.040, 0.040 / 2 = 0.020. The lower guide shim pack would equal 0.020 in. to center the extension rod in the seal bore.

12. Remove the extension rod and crosshead.

13. Remove the lower crosshead guide.

14. Install the calculated shim pack. Shim packs are placed between crosshead guide and each of the two frame supports.

15. Install the lower crosshead guide.

16. Install the 1/2”-13 X 4 in. capscrews into the lower guide. Do not allow guide bolt to pass above thread.

17. Install the crosshead with both guides in place (lower guide has been shimmed, upper guide has no shims yet).

18. To shim the upper guide, measure the clearance between the top of the crosshead and upper guide. For best results, use long feeler gauges and average the clearance along the width of the crosshead.

19. To obtain the upper guide shim pack, subtract the average operating clearance (0.012 in.) from the measured feeler gauge clearance. For example, if the measured feeler gauge clearance between the crosshead and upper guide was 0.032 in., the shim pack would be calculated as follows: 0.032 - 0.012 = 0.020 in. shim pack.

20. Remove the crosshead.

21. Remove the upper crosshead guide.

22. Install the calculated shim pack. Shim packs are placed between crosshead guide and each of the two frame supports.

23. Install the upper crosshead guide.

24. Install the 1/2”-13 X 4 in. capscrews into the upper guide. Do not allow guide bolt to pass above thread.

25. Install the crosshead.

26. Slide crosshead from front to back, checking for clearance of 0.009 to 0.015 in.

27. Shims make require minor adjustments if areas of tight clearance occur.

28. Once proper clearance is measured, remove guide bolts and re-install with ring of silicone and rubber washers under the bolt heads. Torque guide bolts to 75 ft-lbs.

29. Re-assemble crossheads and connecting rods.

Gearbox

1. Remove the companion flange from the pinion shaft by removing the 1/2”-13 X 1 in. capscrew holding the pinion shaft retainer to the end of the pinion. Pull the companion flange off the pinion.

2. Remove the outer bearing and seal retainers, and pinion shims.

3. Remove housing cover (hold the pinion shaft in place while the cover is removed).

4. Remove the pinion shaft bearings and the pinion shaft. Replace bearings or pinion shaft if severely pitted, scored, or worn (apply low heat to the inner race to remove from the shaft).

5. Remove the crankshaft bearing snap ring and bearing.

6. Remove the gear snap ring.

7. Remove the gear with the puller holes provided. Inspect the gear for pitting, cracks, and scoring and replace if necessary.

8. If case is being repositioned, hammer out the 1-3/4" diameter freeze plugs.

9. Remove the eight (8) 1"-8 X 2 in. socket head capscrews that retain the gearbox housing to the pump frame.

10. Remove the gearbox from the power frame.

11. Thoroughly clean and inspect all parts prior to re-assembly.

12. Using a silicone seal, form a gasket around the outside of the spherical bearing adapter on the power end.

13. Install the gearbox housing onto the power frame in the correct orientation with eight (8) 1"-8 X 2 in. socket head capscrews.

14. If previously removed, hammer in the 1-3/4" diameter freeze plugs with silicone sealer.

15. If new bull gear is being installed, fit key to shaft and gear. Key must fit with 0.000 to 0.001 in. clearance (slip fit). Do not drive key in with excessive force.

16. Coat the crankshaft extension with some light oil and install the gear with the long hub side inward.

17. Install the gear snap ring with snap ring pliers. Be sure snap ring is seated in groove.

18. Install the crankshaft bearing and snap ring. Be sure snap ring is seated in groove.

19. Install the pinion bearings onto the pinion shaft. Heat the bearings to 250 degrees F in an oven or oil bath to install on the pinion shaft.

20. Install the pinion shaft into the pinion bore of the gearbox housing.

21. While holding the pinion shaft in place, install the gearbox housing cover. Use silicone seal as gasket material.

22. Install the pinion bearing races into the gearbox housing.

23. Install the pinion bearing retainer (off drive) and pinion bearing seal retainer (drive) without shims. Tighten the retainers while moving the pinion back and forth. When the pinion begins to tighten and move with resistance, stop tightening the retainers. Use the shims in the shim pack to measure the clearance between the housing and retainer. Remove the retainers, add the measured shim pack between the retainer and the housing and re-install the retainers. Recheck the movement in the pinion. If the pinion does not move, continue adding shims until the pinion moves back and forth without resistance. The bull gear bearing retainer needs no shims but needs silicone seal as a gasket.

24. Install the companion flange.

25. Install the pinion shaft end retainer using the 1/2"-13 X 1 in. capscrew to hold the companion flange in place.

Crankshaft

1. Remove the pump from the trailer and move it to a service area with an overhead lift, where the frame can eventually be turned on its side.

2. Remove the gearbox, connecting rods, and crossheads.

3. Remove the rotary lube union.

4. Remove the crankshaft cover bolts from the off drive side (eight 1"-8 X 2 in. capscrews).

5. Remove the four (4) 1/2”-13 X 3-3/4” bolts from inside the frame, threaded into the crankshaft cover.

6. Remove the crankshaft cover.

7. Place the power end on its side with the crankshaft extension pointing upwards. Lift the crankshaft upwards using a lifting eye adapted to 4”-8 threads in the end of the crankshaft extension. It may necessary to heat the power end around the spherical bearing retainer (less than 250 degrees F oven or oil bath) to break the bearing retainer away from the frame. Be careful when pulling the crankshaft roller bearings through the outer races, as not to scratch the inner surfaces of the races. Rotating the crankshaft while pulling up aids removal.

8. Remove the bearing retainer, adapter, and spherical bearing from the crankshaft. It may be necessary to heat the adapter and bearing to remove.

9. Remove all the roller bearing retainers (1/2”-13 X 3-3/4” capscrews, nuts and washers) from the crankshaft.

10. Remove the bearings from the crankshaft. It may be necessary to apply low heat to remove the bearings from the crankshaft.

11. Remove all the roller bearing retainers in the power end.

12. Remove the outer races of the bearings in the frame by tapping them out with a soft metal (brass) bar.

13. Thoroughly clean and inspect all parts for cracks, pits, or scoring and replace if necessary prior to re-assembly. Frame bores should be clean and smooth, free of nicks and raised metal.

14. Label the three (3) straight roller bearings and outer races as match sets for proper re-assembly.

15. For easiest assembly, place the outer bearing races in the freezer for at least 8 hours to allow the bearing races to shrink.

16. On the inner side of the two inner main bearing rings of the frame (closest to the centerline), install three (3) of 1/2”-13 X 3-3/4” capscrews with main bearing retainer washers between the frame and bolt head. On the opposite side of the frame, install a nut on the capscrew. The washers will act as a stop for the outer bearing races during re-assembly and center the outer bearing race in the bore of the frame.

17. One at a time, remove the outer bearing races from the freezer and install in the two inner bearing bores of the frame by passing the race through the outer frame bores. The outer bearing races should shoulder against the installed washer. Keep the races as level as possible during the assembly process.

18. On the inner side of the off drive outside main bearing ring of the frame, install three (3) 1/2”-13 X 3-3/4” capscrews with main bearing retainer washers between the frame and bolt head. On the opposite side of the frame, install a nut on the capscrew. The washers will again act as a stop for the final main bearing outer race.

19. Remove the final outer bearing race from the freezer and install in the off drive main bearing bore of the frame. Keep the race as level as possible during the assembly process.

20. The outboard bearing bore on the input side of the frame should be left open.

21. Remove the nuts on the main bearing retainer bolts and install retainer washers and locknuts (the off drive outside main bearing retainers in the frame can not be installed until the crankshaft cover is installed).

22. On the inner side of the two inner cheeks of the crankshaft (closest to the centerline), install three (3) of 1/2”-13 X 3-3/4” capscrews with main bearing retainer washers between the

crankshaft cheek and bolt head. On the opposite side of the crankshaft, install a nut on the capscrew. The washers will act as a stop for the main bearings during re-assembly and center the bearing on the crankshaft.

23. One at a time, heat the straight roller bearings (less than 250 degrees F oven or oil bath) and install on the two inner cheeks of the crankshaft by passing the bearing over the outer crankshaft cheeks. The roller bearings should shoulder against the installed washer. Keep the bearings as level as possible during the assembly process.

24. On the inner side of the off drive outside crankshaft cheek, install three (3) 1/2”-13 X 3-3/4” capscrews with main bearing retainer washers between the crankshaft and bolt head. On the opposite side of the crankshaft cheek, install a nut on the capscrew. The washers will again act as a stop for the final main roller bearing.

25. Heat the final main roller bearing and install on the off drive main bearing cheek of the crankshaft. Keep the race as level as possible during the assembly process.

26. The outboard bearing cheek on the input side of the crankshaft should be left open.

27. Heat and install the spherical bearing onto the drive side crankshaft cheek.

28. Install the spherical bearing retainer onto the crankshaft.

29. Heat and install spherical bearing adapter onto the spherical bearing.

30. Lift the crankshaft with a lifting eye screwed into the end of the crankshaft and lower into the power frame (the power frame should still be on its side with the input end up). Rotating the crankshaft while lowering will aid the installation. Tap the spherical bearing adapter to complete the installation.

31. Re-install the crankshaft cover using silicone seal as a gasket.

32. Install the eight (8) 1”-8 x 2 in. socket head capscrews holding the crankshaft cover to the outside of the frame.

33. Install the four (4) 1/2”-13 X 3-3/4” capscrews and main bearing retainer washers on the inside of the frame through to the crankshaft cover.

34. Re-install the rotary union, crossheads, connecting rods, and gearbox.

35. Remount pump on skid or trailer.

36. If new bearings were installed, repeat the new pump run-in procedure.

WARNING

Do not drive against rollers or bearing cage. Drive only against the bearing race, as severe damage to the bearings could occur.

WARNING

When reassembling the crankshaft assembly, make sure to follow these steps:

1. **Freeze the outer bearing races or pack in dry ice before assembling in the frame.**
2. **Heat the roller bearings (straight and spherical) before installing on crankshaft. (250°F max. oven or oil bath).**

Failure to follow these directions may result in serious damage to the pump.

SECTION 5
TROUBLE-SHOOTING

PROBLEM	POSSIBLE CAUSE	SUGGESTED ACTION
Pump Overloads Driver.	1. Excessive pump speed and/or discharge pressure.	1. Reduce pump speed and/or pressure.
	2. Blockage or closed valve in discharge line.	2. Clean or open valve.
	3. Incorrect plunger size.	3. Install the correct plunger.
	4. Improper bypass conditions.	4. See recommended system layout, and correct error.
Fluid Not Delivered.	1. Pump not primed.	1. Prime pump.
	2. Air or vapor pocket in suction line.	2. Remove pocket from line.
	3. Clogged suction line.	3. Clean out line.
	4. Suction and/or discharge valves propped open.	4. Remove the obstruction.
Low Discharge Pressure.	1. Worn or fluid cut valve.	1. Replace valve assembly.
	2. Valve propped open.	2. Remove the obstruction.
	3. Pump cavitating.	3. See Cavitation, Fluid Knock or Hammer problem.
	4. Fluid leakage.	4. Replace plungers/packing and/or fluid end seals.
	5. Erroneous gauge reading.	5. Recalibrate or replace gauge(s).
Low Suction Pressure.	1. Low head (NPSH).	1. Raise fluid supply level. Install charging pump.
	2. Insufficient charging pump capacity.	2. Increase charging pump speed or size.
	3. Retarded fluid flow.	3. Remove restrictions from suction line.
	4. Erroneous gauge reading.	4. Recalibrate or replace gauge(s).

PROBLEM	POSSIBLE CAUSE	SUGGESTED ACTION
Cavitation, Fluid Knock or Hammer.	1. Improper suction system layout.	1. See recommended system layout in manual.
	2. Low suction pressure.	2. See Low Suction Pressure problem.
	3. Suction stabilizer and pulsation damper not used.	3. Install suction stabilizer and pulsation damper.
	4. Defective stabilizer or damper.	4. Repair and recharge or replace.
	5. High fluid temperature or viscosity.	5. Reduce pump speed.
	6. High fluid vapor pressure.	6. Increase NPSH.
	7. High acceleration head.	7. Increase supply line size. Decrease supply line length.
	8. Suction valve spring too stiff. with low NPSH.	8. Use weaker spring.
	9. Air/Gas in pumped fluid.	9. Allow more settling time in supply tank. Reduce pump speed.
	10. Air entering suction line.	10. Repair suction line.
	11. Air entering charging pump.	11. Tighten or replace shaft packing or seal.
	12. Air entering or charge gas escaping from suction stabilizer.	12. Repair and recharge stabilizer
	13. Multiple pumps operating in phase.	13. Use a suction stabilizer on each pump. Separate lines may also be needed.
Suction or Discharge Line Vibration.	1. Line(s) not supported.	1. Install supports or hangers.
	2. Pump cavitating.	2. See Cavitation, Fluid Knock or Hammer problem.
High Crankcase Oil Temperature.	1. High ambient temperature.	1. Use an oil heat exchanger with a circulating pump.
	2. Improper type/grade oil used.	2. Use recommended oil.
	3. Pump overloaded.	3. Reduce pump speed and/or pressure.
	4. Improper clearance in main or rod bearings, crossheads or bushings.	4. Check and adjust clearance. Replace parts as required.

PROBLEM	POSSIBLE CAUSE	SUGGESTED ACTION
Knock In Power End.	1. Improper main bearing clearance.	1. Check and adjust clearances.
	2. Incorrect pump rotation.	2. Reverse rotation.
	3. Loose plunger coupling.	3. Check and tighten. Replace if damaged.
	4. Loose bearing housings/ covers.	4. Check and tighten. Replace if damaged.
	5. Worn crosshead pin.	5. Replace.
	6. Worn crosshead pin bushing.	6. Replace.
	7. Worn connecting rod to journal bearing.	7. Replace.
	8. Worn crankshaft.	8. Replace.
	9. Worn crosshead.	9. Replace.
	10. Worn main bearing.	10. Replace.
	11. Valve noise transmitted to power end.	11. See Excessive Valve Noise problem.
	12. Cavitation noise transmitted to or causing shock loading in power end.	12. See Cavitation, Fluid Knock or Hammer problem.
Excessive Valve Noise.	1. Pump cavitation.	1. See Cavitation, Fluid Knock or Hammer problem.
	2. Seal on inserted valve damaged or missing.	2. Replaced seal or valve.
	3. Broken/weak valve spring(s)	3. Replace spring(s).
Oil Leakage From Stop Head.	1. Worn, damaged or corroded. extension rod.	1. Replace extension rod.
	2. Worn oil stop head seal.	2. Replace seal.
	3. Oil level too high.	3. Reduce oil level.
	4. Excessive crosshead wear.	4. Replace crosshead.
	5. Pressure in crankcase.	5. Clean or replace air breather.
	6. Misalignment in front.	6. Loosen bolts and center. crosshead guide cover.

PROBLEM	POSSIBLE CAUSE	SUGGESTED ACTION
Oil Seal Leakage.	1. Worn sealing lip.	1. Replace seal.
	2. Damaged sealing lip.	2. Replace seal.
	3. Outside diameter not seated.	3. Clean and polish bore of oil seal housing.
	4. Shaft rough at seal lip.	4. Clean and polish shaft or replace wear sleeve.
	5. Pressure in crankcase.	5. Clean or replace air breather.
Stuffing Box Leakage.	1. Short plunger/packing life.	1. See Short Plunger/Packing Life problem.
	2. Worn packing rings/metal.	2. Replace packing rings/metal.
	3. Seal leaking at fluid end.	3. Check seal, stuffing box groove and sealing surface.
	4. Corrosion due to wrong stuffing box material for pumped fluid.	4. Determine and install correct stuffing box.
	5. Stuffing box bore worn.	5. Replace stuffing box.
Pumped Fluid In Crankcase.	1. Worn, damaged or corroded extension rod.	1. Replace extension rod.
	2. Worn oil stop head seal.	2. Replace seal.
	3. Stuffing box leakage.	3. See Stuffing Box Leakage problem.
Short Valve Life.	1. Abrasives in pumped fluid.	1. Filter pumped product. Use severe duty valves with insert.
	2. Valve not sealing.	2. Broken valve spring - replace. Worn valve guide - replace. Worn valve/seat - replace.
	3. Pump cavitating.	3. See Cavitation, Fluid Knock or Hammer problem.
	4. Corrosion.	4. Treat pumped fluid. Use different materials for valves/seats. Install sacrificial anodes in suction manifold.

PROBLEM	POSSIBLE CAUSE	SUGGESTED ACTION
Short Plunger/Packing Life.	1. Abrasives in pumped fluid.	1. Consult Gardner Denver Customer Service for plunger / packing recommendation. Filter pumped fluid.
	2. Excessive plunger/packing friction.	2. Lubricate with rock drill oil. Do not overtighten adjustable packing. Use Gardner Denver plungers.
	3. Metal parts or particles wearing plunger.	3. Check stuffing box alignment. Check gland alignment. Check plunger alignment. Check packing for foreign particles. Replace lantern ring.
	4. Wrong plunger/packing for pumping conditions.	4. Consult Gardner Denver Customer Service.
	5. Wrong size packing.	5. Install correct size packing.
	6. Improper packing installation.	6. Check installation procedure and install correctly.
	7. Excessive crosshead wear.	7. Replace crosshead.
	8. Pump cavitating.	8. See Cavitation, Fluid Knock or Hammer problem.
Catastrophic Failures: Broken Shafts, Bent Rods, etc.	1. Pump overloaded.	1. Reduce pump speed and/or pressure.
	2. Start-up against closed discharge valve.	2. Ensure valve is open before starting.
	3. Main bearing failure.	3. Repair or replace.
	4. Plunger striking valve or valve parts.	4. Check valve condition and installation procedure.
	5. Plunger striking fluid end.	5. Check plunger for proper length.
	6. Frozen liquid in fluid end.	6. Do not start pump when pumped fluid is below freezing temperature.
	7. Lube oil pump failure.	7. Replace oil pump.

PROBLEM	POSSIBLE CAUSE	SUGGESTED ACTION
Catastrophic Failures: Broken Shafts, Bent Rods, etc. (continued).	8. Low oil level in sump.	1. Check oil level frequently, and add oil as required.
	9. Contaminated oil in sump.	9. Check oil condition frequently.
	10. Cavitation shock loading.	10. See Cavitation, Fluid Knock or Hammer problem.
Stud Failures.	1. Catastrophic failures.	1. See Catastrophic Failures problem.
	2. Improper nut torquing.	2. Check torque specifications and torque to correct values.
	3. Stud bending due to uneven nut seating.	3. Check nut seat surface for flatness. Rework or replace as required.
	4. Corrosive attack by pumped fluid.	4. Treat fluid or use corrosion resistant studs.
	5. Studs damaged before installation.	5. Check condition before installation, and replace if necessary.
	6. Low strength studs.	6. Use Gardner Denver studs.

SECTION 6
REBUILDING DATA, RUNNING CLEARANCES AND TORQUES

REBUILDING DATA FOR OPI-600 PUMP (in.)

PUMP STROKE	6 Inches
Crankshaft Throw Diameter	4.499” / 4.500”
Crankshaft Shaft Diameter at Main Bearing	11.254” / 11.253”
Distance Between Main Bearing Centers	9.00”
Bore in Frame for Main Bearings	15.249” / 15.251”
Connecting Rod Centers	9.00”
Connecting Rod Bearing Bore (Bearing Assembled in Bearing Housing)	4.505” / 4.507”
Crosshead Guide Bore (shim to obtain clearance)	9.008” / 9.016”
Crosshead OD	8.999” / 9.001”
Wrist Pin Diameter	3.2475” / 3.2481”
Wrist Pin Bushing Bore…	3.254” / 3.255”

RECOMMENDED RUNNING CLEARANCES – ACTUAL

	New (in.)	Maximum Allowable Wear Limit (in.)
Connecting Rod Bearing to Crankshaft	.005” / .008”	016”
Wrist Pin to Bearing	.004” / .007”	.020”
Main Bearing Installed Clearance*	.005” / .008”	.016”
Main Bearing Bench Clearance*	.011” /. 013”	
Crosshead to Guide*	.009” / 015”	.045”

* Feeler gauge clearances .001 inch less than actual values.

RECOMMENDED TORQUES FOR OPI-600 PUMP MAINTENANCE

DESCRIPTION	FASTENER	FOOT POUNDS LUBRICATED
Crankshaft Cover to Frame.	1”-8	475
Gearbox to Frame	1”-8	475
Main Bearing Retainer Plate Washers	1/2”-13	75
Plunger Clamp	1/2”-13	58
Crosshead Guide to Frame	1/2”-13	75
Connecting Rod (Cap to Rod)	1”-8	450
Suction Manifold to Fluid End	1/2”-13	75
Discharge Flange to Fluid End	3/4”-10	275
Fluid End to Frame	1-1/2”- 12	1250

PRODUCT WARRANTY

GENERAL PROVISIONS AND LIMITATIONS

Gardner Denver (the "Company") warrants to each original retail purchaser ("Purchaser") of its new products, assemblies or parts from the Company or its authorized distributors that such products are, at the time of delivery to the Purchaser, made with good material and workmanship. No warranty is made with respect to:

1. Any product which has been repaired or altered in such a way, in the Company's judgment, as to affect the product adversely.
2. Any product which has, in the Company's judgment, been subject to negligence, accident, or improper storage, improper installation, operation or application. (Examples: over-pressure, sand-outs, cavitation, corrosion, erosion or degradation).
3. Any product which has not been operated or maintained in accordance with the recommendations of the Company.
4. Components or accessories manufactured, warranted and serviced by others.
5. Any reconditioned or prior owned product.

Claims for items described in (4) above should be submitted directly to the manufacturer.

WARRANTY PERIOD

The Company's obligation under this warranty is limited to repairing or, at its option, replacing, during normal business hours at an authorized service facility of the Company, any part or assembly which in the Company's judgment proved to have unsatisfactory material or workmanship within the applicable Warranty Period as follows.

Except for the products or components listed below, and subject to the limitations and restrictions set forth in the "Disclaimer" section set forth below, the Warranty Period for all products is 1,250 hours of operation or three (3) months after start-up, not to exceed 120 days after delivery to Purchaser, whichever occurs first. The exceptions are as follows:

1. Power end is warranted for twelve (12) months from date of start-up or eighteen (18) months from date of delivery to the Purchaser, whichever occurs first.
2. Forged steel fluid ends are warranted for materials and workmanship for 6 months from the date of installation or 18 months from the date of delivery to the purchaser, which ever occurs first.
3. Repairs are warranted for 90 days from the date of delivery, for the workmanship and materials of the new parts installed.
4. Weld repaired fluid ends and weld repaired components are not warranted.
5. Expendable fluid end parts, including, but not limited to, valves, valve parts, packing, liners and pistons, are not covered by this warranty due to variable abrasive nature of material pumped.

PRESERVATION ASSEMBLIES DESTINED FOR STORAGE

In order for warranty acceptance any pump assembly not immediately installed or destined to be in storage or in transit for extended periods of time must be prepared for storage as defined in the Company's Long Term Storage Procedure. This includes but is not limited to:

- Drain and thoroughly clean inside power end crankcase.
- Spray rust inhibiting oil on all bearing, machined and inside surfaces of the power end.
- Induce clean gear oil into any circulating pump, filter, heat exchanger and piping.
- Remove valves, seats and plungers from the fluid end. Thoroughly clean and dry these parts and all internal surfaces. Coat all fluid end bores, valve covers and reusable expendable parts with rust preventative.
- Flush all water, and contaminants from pump, tanks, hoses and spray nozzles. Spray all components with a rust inhibiting oil.

- Rotate pump every 30 days to insure bearings are oiled.
- At the expense of the Purchaser, any product properly preserved must be inspected by an authorized agent of the Company, prior to the Company, granting any extended warranty beyond that stated in this warranty.

LABOR TRANSPORTATION AND INSPECTION

The Company will provide labor, by Company representative or authorized service personnel, for repair or replacement of any product or part thereof which in the Company's judgment is proved not to be as warranted. Labor shall be limited to the amount specified in the Company's labor rate schedule. Labor costs in excess of the Company rate schedules caused by, but not limited to, location or inaccessibility of the equipment, or labor provided by unauthorized service personnel is not provided for by this warranty.

All costs of transportation of product or parts claimed not to be as warranted and, of repaired or replacement parts to or from such service facility shall be borne by the Purchaser. The Company may require the return of any part claimed not to be as warranted to one of its facilities as designated by the Company, transportation prepaid by the Purchaser, to establish a claim under this warranty.

Replacement parts provided under the terms of this warranty are warranted for the remainder of the Warranty Period of the product upon which installed to the same extent as if such parts were original components.

The Company may request a root cause analysis be performed in-order to identify if a request for warranty claim meets the requirements of this warranty.

DISCLAIMER

Except as to title, the foregoing warranty is the sole and exclusive warranty of the Company. The Company hereby extends other manufactures' warranty or guaranties, if any given to Company by such manufacturer, but only to the extent the Company is able to enforce such warranty or guaranties. The Company has not authorized any party to make any representation or warranty other than as expressly set forthherein. SELLER HEREBY DISCLAIMS AND EXCLUDES ANY OTHER EXPRESS, IMPLIED OR STATUTORY WARRANTIES, ARISING BY OPERATION OF LAW OR OTHERWISE, INCLUDING, WITHOUT LIMITATION, ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. COMPANY MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WHATSOEVER (EXPRESS, IMPLIED OR STATUTORY), OF LAW OR OTHERWISE, ON ANY EQUIPMENT, COMPONENT PARTS OR ACCESSORIES SOLD HEREUNDER WHICH, ARE NOT MANUFACTURED BY COMPANY.

NOTWITHSTANDING ANYTHING HEREIN TO THE CONTRARY, THE FOREGOING WARRANTY SHALL BE THE SOLE AND EXCLUSIVE REMEDY AVAILABLE TO THE PURCHASER. UNDER NO CIRCUMSTANCES, WHETHER IN CONTRACT, TORT OR OTHERWISE, SHALL THE COMPANY'S TOTAL LIABILITY ARISING IN CONNECTION WITH ANY PURCHASE ORDER EXCEED THE AMOUNT OF ANY SALES OR OTHER PROCEEDS RECEIVED PURSUANT THERETO. IN ADDITION, UNDER NO CIRCUMSTANCES, WHETHER IN CONTRACT, TORT OR OTHERWISE, SHALL THE COMPANY BE LIABLE FOR LIQUIDATED, SPECIAL, INDIRECT, INCIDENTAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES, EXPENSES OR COSTS, INCLUDING, WITHOUT LIMITATION, LOST PROFITS OR FACILITY DOWNTIME, HOWEVER CAUSED AND EVEN IF THE POTENTIAL OF SUCH DAMAGES WAS DISCLOSED AND/OR KNOWN.

No statement, representation, agreement, or understanding, oral or written, made by any agent, distributor, representative, or employee of the Company which is not contained in this Warranty will be binding upon the Company unless made in writing and executed by an officer of the Company.

This warranty shall not be effective as to any claim which is not presented within 30 days after the date upon which the product is claimed not to have been as warranted. Any action for breach of this warranty must be commenced within one year after the date upon which the cause of action occurred.

Any adjustment made pursuant to this warranty shall not be construed as an admission by the Company that any product was not as warranted.

WARRANTY REQUESTS

Products to be returned for warranty analysis shall be approved for return in writing by the Company prior to shipment. All requests for product return shall be submitted by email. Facsimile or letter to:

Warranty Department c/o
Gardner Denver Petroleum Pumps
4747 South 83rd East Avenue
Tulsa, Oklahoma 74145

Email: CCR.QAR@gardnerdenver.com
Facsimile: (918) 664-6225

For additional information contact your local representative or

Gardner Denver Inc.
4747 South 83rd East Avenue, Tulsa, OK 74145
PH: (918) 664-1151, (800) 637-8099
FAX: (918) 664-6225
www.gardnerdenver.com