GARDNER DENVER®

3-1-616
Version 1
June 2001

TRIPLEX PISTON PUMP

5” STROKE

MODEL
THE

4” to 5.5” PISTON SIZE
HORIZONTAL DIRECTIONAL
DRILLING SERVICE

OPERATING AND SERVICE MANUAL

Gardner Denver

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

Gardner Denver® and OPI® 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 are incorporated in our genuine replacement parts.

Your authorized Gardner Denver and OPI distributor offers all the backup you'll need. A worldwide network of authorized distributors provides the finest product support in the pump industry. Your local authorized distributor maintains a large inventory of genuine parts and he is backed up for emergency parts by direct access to the Gardner Denver Master Distribution Center (MDC) in Memphis, Tennessee.

Your authorized distributor can support your Gardner Denver and OPI pump 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 distributor 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 and OPI distributor, refer to the yellow pages of your phone directory or contact:

Distribution Center:
Gardner Denver
Master Distribution Center
5585 East Shelby Drive
Memphis, TN 38141

Phone: (901) 542-6100
(800) 245-4946

Fax: (901) 542-6159

Factory:
Gardner Denver
1800 Gardner Expressway
Quincy, IL 62301

Phone: (217) 222-5400

Fax: (217) 224-7814

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 cylinder end of the frame (cradle area).

All orders for Parts should be placed with the nearest authorized distributor.

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.**

DO NOT ORDER BY SETS OR GROUPS.

To determine the Right Hand and Left Hand side of a pump, stand at the power end and look toward the fluid end. Right Hand and Left Hand are indicated in parenthesis following the part name, i.e. (RH) and (LH), when appropriate.

FOREWORD

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

TABLE OF CONTENTS

For Parts List Refer to:

Manual 3-1-535

INDEX

LIST OF ILLUSTRATIONS

SECTION 1
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 data plate 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 shown on the data plate or at speeds below the minimum shown. Failure to observe the operating limits shown on the data plate 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 data plate limits, must not be made without Gardner Denver written approval together with a new data plate, as dangerous operating conditions could result.

THE DANGER NOTICE AND DATA PLATES PROVIDED ON THE EQUIPMENT MUST NOT BE REMOVED, PAINTED OVER, HIDDEN OR DEFACED. They must be replaced if they become damaged or unreadable. Provisions should be made to have the following written danger notices plus the pump operating and service manual readily available to operators and maintenance personnel. In addition, copies of all pump system accessory component (e.g. pressure relief valve, pulsation dampener, suction stabilizer, engine, electric motor, etc.) operating and service manuals should be readily available for operator and maintenance personnel use. Read and follow all the precautions and instructions contained in these manuals. If any of these documents are lost or become illegible they must be replaced immediately. The danger notices plus the operating and service manuals should be reread periodically by both operators and maintenance personnel to refresh their memories in safe procedures and practices.

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 or pump package units equipped with hammer lug connectors 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, hammer bar, broken parts from the hammer, hammer bar or lugs or other objects propelled by hammer blows. When tightening or loosening hammer lug connectors and valve covers, operators or maintenance personnel should:

- Inspect the hammer, hammer lugs and hammer bar, if one is used, to insure they are all in good condition. Replace any of these parts which are cracked, damaged or badly worn.
- Wear safety shoes and goggles.
- Alert other personnel to move away from the area.
- Check to insure they have safe footing.
- Fully engage the hammer b ar, 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 Puller

- Wear safety shoes and goggles.
- 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.

COVERS AND GUARDS

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 a all times when the unit is in operation.

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 package units 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, capabilities, 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, 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 inspected capacity together with the date of inspection.

Fully assembled pumps and pump package units 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 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 dampener 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 located in the flowing discharge line immediately adjacent to the pump discharge connection.

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 pipe, connections, elbows, 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 penetrate 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 2,500 PSI are used in the discharge system or if corrosive, flammable or hot (over 110º F) fluids are being pumped.

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 26 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.

DANGER

Do not attempt to service, repair, adjust or otherwise work on the pump while the unit is operating. Shut off the pump drive motor or engine and relieve the fluid pressure in the pump 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 cylinder, 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 in order to avoid personal injury, death and/or equipment damage due to explosion, fire, burn, 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 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 gaskets and seals for fluid leakage frequently and replace all worn or leaking parts.

Selection of the proper gaskets and seals 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 and seals before beginning operation.

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 with utmost care by trained, experienced operators. High pressure fluid streams can either by direct contact or by propelling loose objects, cause serious personal injury or death to the 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, and hose, 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.

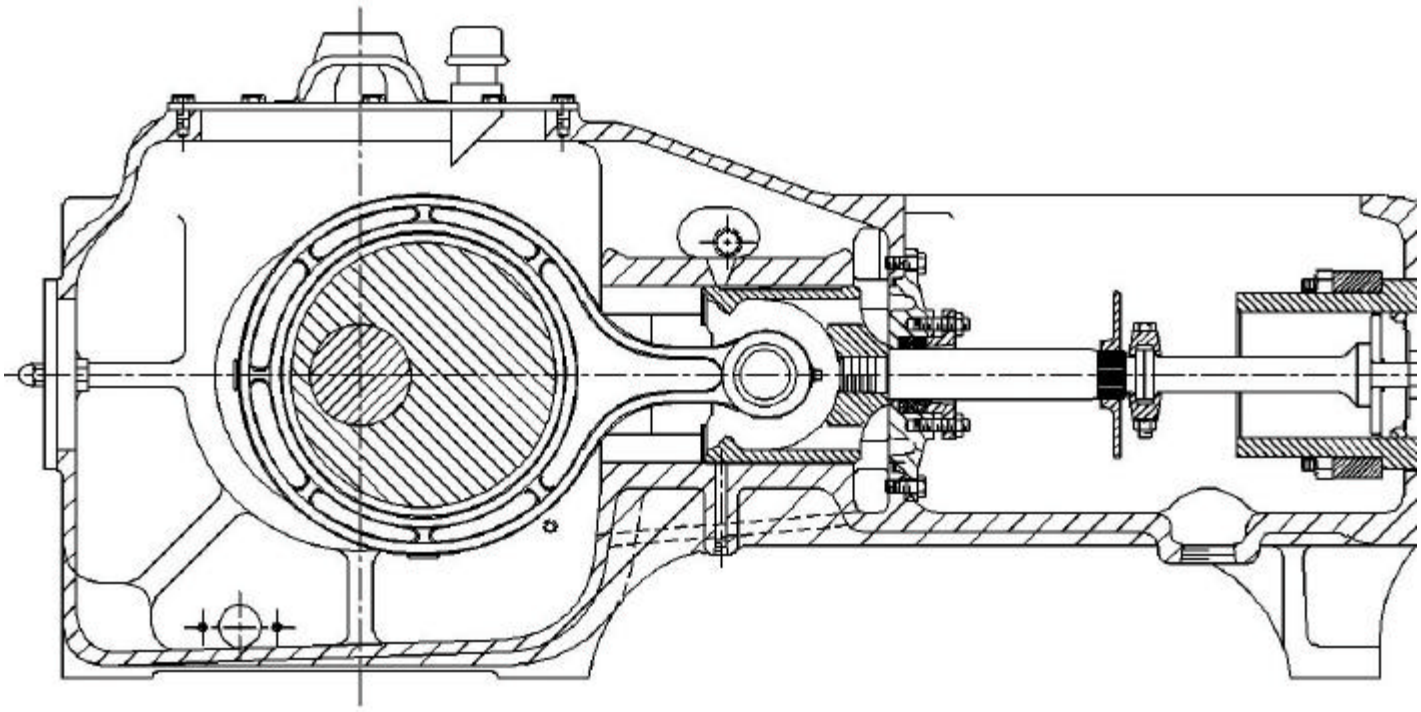


FIGURE 1 – SECTIONAL VIEW OF MODEL 'THE' TRIPLEX PISTON PUMP

SECTION 2
OPERATING AND MAINTENANCE INSTRUCTIONS

DANGER

Always wear safety shoes and goggles when operating and performing maintenance or repair on a pump or pump package unit to help prevent personal injury to eyes and toes from pressurized fluids and falling or flying objects.

WARNING

The suction line strainer must be serviced at regular intervals. A clogged or partially clogged strainer can cause severe pump cavitation, poor expendable part life and potentially serious pump damage.

INSTALLATION

LOCATION - Pump should be located as close to the fluid supply as possible. A short and direct suction line will improve pump performance and reduces the possibilities of cavitation. Whenever possible, adequate space should be provided around the pump to permit easy inspection and adjustment. Particular attention should be given to the space required for removal and installation of the gear reducer, eccentric, etc.

The drive must be accurately aligned. Pump must be properly leveled and securely fastened to a foundation or base. The pump must have a positive suction head. Refer to page 19 for NPSH requirements. Maximum allowable temperature of the fluid being pumped is 200 ? F (93? C). The maximum allowable suction pressure is 150 PSI. Any application with suction pressures over 150 PSI must be approved in writing by Gardner Denver Inc. Engineering Department.

SUCTION PIPING - Suction pipe (or hose if used) should be the full size of suction opening. If, for any reason, the suction line is of greater length than usual, the next larger size should be used. Suction line should slope up towards the pump at a uniform grade so that air pockets are eliminated. Suction line must be air tight as any air leaking into the line will reduce the volumetric efficiency of the pump. If it is necessary to have bends in the suction line, they should have long radius sweeps.

Refer to page 18 for recommended suction piping system. All piping must be supported independently of the pump to insure that no strain is imposed in the pump by misalignment or improperly fitted pipe.

PRESSURE RELIEF VALVE – The pump must be protected from excessive discharge pressure by a pressure relief valve. This valve must be installed as near to the pump discharge as possible.

DANGER

Never install a shutoff valve in the line between the pressure relief valve and the pump cylinder, as pumping against a closed valve could produce pressures sufficient to cause property damage and/or serious personal injury or death.

DANGER

Improper use or maintenance of pressure relief valves can cause excessive pressure which may result in property damage and/or serious personal injury or death.

The pressure relief valve should be set to operate at approximately 1.1 to 1.25 times the discharge pressure, depending on the relief valve manufacturer's recommendations, but this setting MUST NOT exceed adjoining system equipment rated pressure capabilities. The relief valve must be sized to accept the full pump flow per the valve manufacturer's instructions. When the pump is equipped with a shear pin type pressure relief valve,

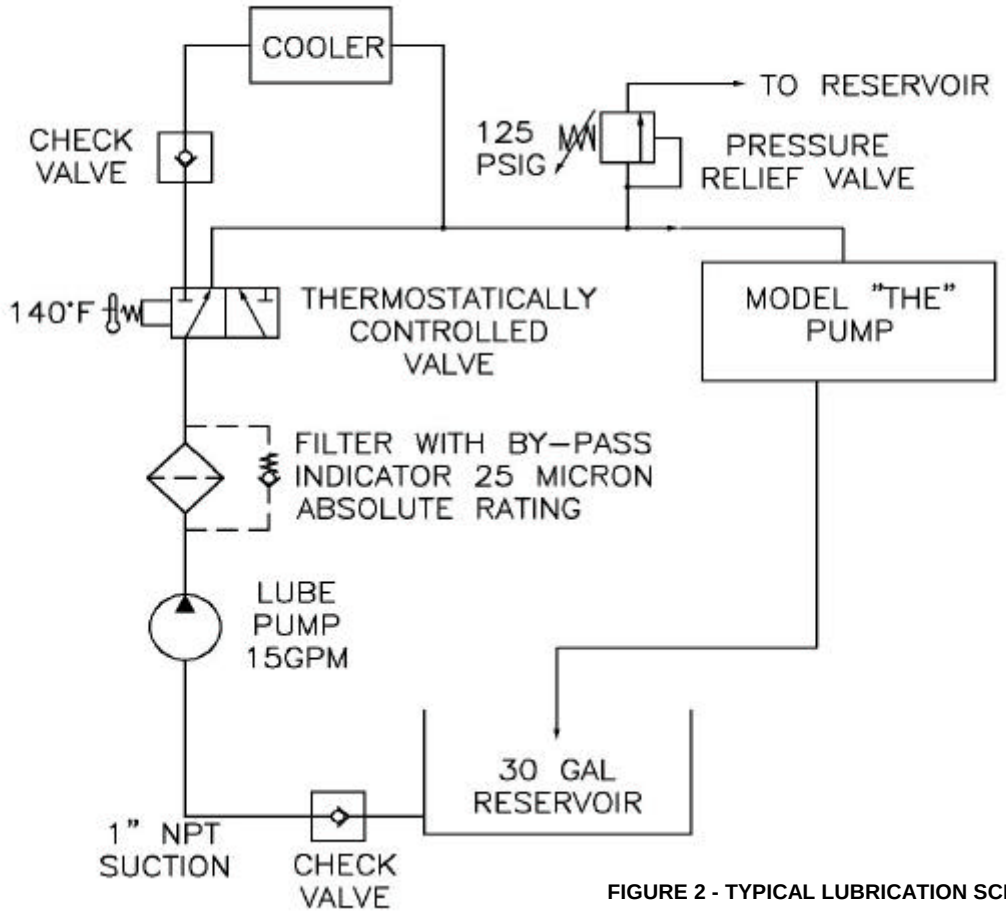


FIGURE 2 - TYPICAL LUBRICATION SCHEMATIC

use only the shear pin specified in the relief valve manufacturer's instructions. Do not use allen wrenches for shear pins, or hammer on the shear bar stem, or shear bar slot. For complete installation and maintenance instructions refer to the relief valve manufacturer's catalog and/or instruction manual.

LUBRICATION - POWER END - Use only extreme pressure GL-5 gear oil in the crankcase. The crankcase oil capacity is 12 gallons (45.5 liters). Add oil as required to keep oil level with top of pipe elbow located on the side of the pump frame. Never use motor oils in the crankcase as they do not provide acceptable lubrication.

⚠ WARNING

Use only extreme pressure API GL-5 gear oil in the crankcase, which has the required additives and viscosity. The use of motor oils in the crankcase does not provide acceptable lubrication and voids the warranty.

The selected API GL-5 oil must have antiwear, antifoaming, noncorrosive and rust inhibiting additives. A list of recommended grades vs. temperatures is located at the back of this manual and on the pump lubrication data plate. The list is based on premium quality oils having viscosity values that do not exceed 7,000 SSU at the minimum start-up oil temperatures listed and viscosity values between 1,500 SSU and 200 SSU for crankcase oil temperatures listed. Oils with viscosity values significantly different from these values, at the temperatures listed. Oils with viscosity values significantly different from these values, at the temperatures listed, may be too thick at low temperatures to flow into close bearing clearances, or may be too thin at high temperatures to carry the required loads. In either case pump damage could occur.

If a 7,000 SSU maximum viscosity at start-up cannot be assured, a crankcase heater is required. Also if crankcase oil temperatures exceed 200 ? F (93? C), an oil heat exchanger with a circulating pump is required to prevent seal damage and oil break down.

For outdoor operation, the multiviscosity oils are

preferred to provide acceptable lubrication over wide temperature ranges. However, when multiviscosity oils are not available, straight weight oils should be acceptable, if care is taken to stay within the listed temperature ranges. Straight weight oils are also ideal in pumps used indoors, when ambient temperatures are controlled.

The oil level in the pump should be checked frequently. Add oil through the breather opening. The breather can be removed by rotating and lifting. Keep the breather tightly in place while the pump is operating to prevent moisture and dirt from entering the crankcase. On pumps equipped with a replaceable filter element type breather, clean the element frequently and replace the element every six months. When operating in very dusty or dirty conditions, more frequent replacement may be necessary.

If the pump has been stored or shut down for an extended period, the crankcase should be drained and filled with new oil before start-up.

Pump lubrication is provided by a force-feed system. The oil pump is rotary type, driven independently, which delivers filtered oil to the connecting rod liners and crosshead pin bushings.

⚠ WARNING

Do not operate the THE drilling pump below 50 RPM.

The oil pump must have a capacity of 12 gallons per minute.

⚠ WARNING

A minimum oil pressure of 50 PSIG (3.45 bar) and oil viscosity of 200 SSU must be maintained at all times. Failure to observe this warning could result in severe pump damage from lack of adequate lubrication and voids the warranty.

The direction of rotation of the input shaft is indicated by an arrow located on the frame.

The indicated direction is recommended because crosshead load will be carried on the bottom guide, resulting in a more quiet operation, better lubrication, and longer life.

⚠ WARNING

Pump must be driven only in the direction indicated on the frame to provide adequate lubrication and prevent excessive pump wear.

OIL FILTER - A replaceable element oil filter is recommended. The filter element should be replaced each time the crankcase oil is changed or every 500 hours.

The oil filter and all other oil pump system components are protected from excessive internal oil pressure by a pressure relief valve between it and the oil pump. The pressure relief valve setting is 100 PSIG (6.9 bar).

Time between oil changes depends upon local or operating conditions. Ordinarily, if the crankcase is kept closed, it should not be necessary to change oil more often than once in 500 working hours. However, the oil must be changed anytime water or other contamination is found. The oil pressure and oil level must be monitored and if the pressure is less than 50 PSIG, the system must be checked to determine what problems might exist.

⚠ WARNING

The oil should be checked for contamination whenever pumped fluid sprays or splashes against an oil stop head. This is especially critical when the fluid contains salts or solids, as these contaminants can plug lubricating passages and cause rapid power end failure.

The screen on the suction pipe might be obstructed so that the pump cannot get sufficient oil to maintain pressure. This screen should be examined when the oil is changed and cleaned thoroughly. The oil should be changed if found to be dirty or if it contains any contamination or water.

⚠ WARNING

Pumps are shipped from the factory without oil in the crankcase.

HEAT EXCHANGER (Optional Equipment) – A bronze shell and tube heat exchanger can be provided to keep crankcase oil temperature at 160 ? F (71? C) by using an automatic water control valve. This valve has a heat sensing probe in the crankcase oil which controls water to the heat exchanger to maintain oil temperature within limits.

DANGER

The frame cradle safety cover, all guards and all inspection plates must be securely fastened in proper position before the pump is started and not removed while in operation to avoid personal injury and/or death from moving parts.

STARTING A NEW PUMP - The hood should be removed, power end examined and cleaned if necessary. Pump may have been in storage or in the yard for some time and as a consequence, dirt or rust from condensation may have formed in the crankcase. Drain all water accumulation from the bottom of crankcase. Check all nuts and screws and tighten if necessary. Fill crankcase with oil of proper grade to proper level. Quantity on the data plate indicates the approximate oil requirement.

CAUTION

Priming is important! It lubricates the piston and liners. If these parts are not lubricated they could be severely damaged in operation.

To prevent excessive wear on fluid pistons when starting, remove the discharge valve cover plates and discharge valves and prime the pump. The pump should be started slowly and operated for several hours with little or no discharge pressure.

Check the oil level as it may be necessary to add a small amount of oil to compensate for that adhering to walls of the crankcase and moving parts.

The pump may then gradually be brought up to full speed and full working pressure. Watch for undue heating or abnormal noise in the working parts. Check all joints in the suction line to be sure there are no air or fluid leaks. Check for abnormal vibration caused by improper suction conditions.

Before starting a pump which has been idle for a long period of time, drain any water accumulation from crankcase by removing the drain plug and replacing when clean oil begins to flow from the drain. Add oil to proper level. It is recommended that the fluid end of pump be primed to prevent excessive wear on the pistons and liners when starting.

OPERATION – The pump should always be started slowly, with little discharge pressure; this gives oil a chance to warm up and flow through all oil lines and bearings. This warm-up is especially important during cold weather operation.

The pump must not be operated at speeds exceeding the rated speed on the nameplate. Horsepower given in the bulletin must not be exceeded. Application approval must be obtained from Gardner Denver Marketing Department for any application in which pump speed is below 50 RPM.

WARNING

Pump must never be operated at speeds or pressures exceeding the values shown on the nameplate. Never operate pump below 50 RPM on intermittent service or 100 RPM on continuous service without written approval from Gardner Denver Inc. Failure to observe this warning could result in severe pump damage due to overloading and/or lack of adequate lubrication.

SERVICE INSTRUCTIONS – FLUID END

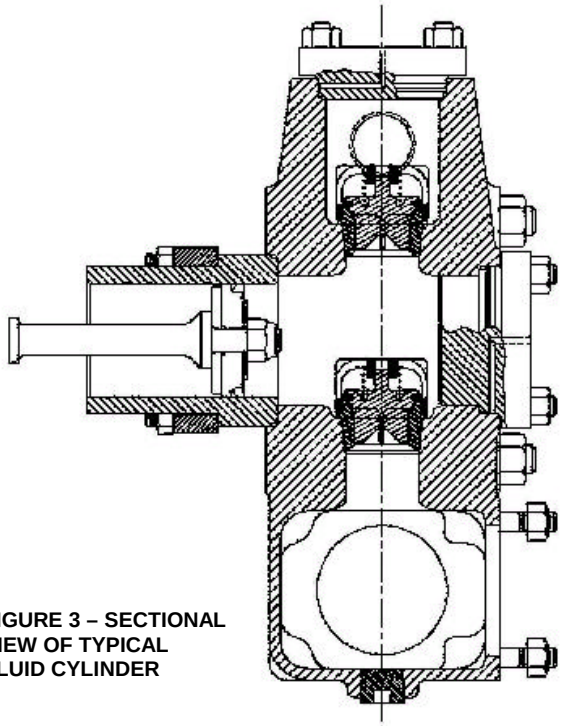


FIGURE 3 – SECTIONAL VIEW OF TYPICAL FLUID CYLINDER

Fluid cylinders are secured to the frame by high tensile strength connecting studs. It is important that nuts on these studs be checked occasionally for tightness. A loose or improperly torqued nut will cause a stud to break under a pulsating load. For proper tightening torques refer to page 26.

TAPERED SEAT VALVES - This type of valve is retained in the cylinder by the locking action of the matching valve seat and deck tapers.

DANGER

Wear eye protection when removing the valve seat as metal chips could be dislodged from the valve seat or valve puller and fly up into your face.

The valves should be examined regularly for excessive wear and for coating or particle adhesion that may prevent proper valve opening and closing. A valve that is not sealing, opening and closing properly, or a seat that is improperly seated in the deck, can fail quickly by erosion of the valve, seat or deck.

WARNING

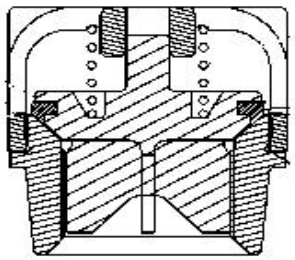
Never attempt to install the valves as an assembly. The valve could be damaged when a block and hammer are used to strike the retainer to set the seat.

Access to the discharge valves is gained by removing the valve covers on top of the cylinder. The valve covers are held in place by studs and nuts. The retainers or cages, springs and discs or valves must be removed before the seats can be inspected or pulled. The suction valves can be examined by removing the cover on the front of the fluid cylinder. The suction valve seats are also removed with a valve seat puller.

Several different valve options are offered for the pump models covered by this manual. Consult Gardner Denver Marketing Department or your nearest salesman if you need help deciding which valves to use.

Wipe the taper surface of the seat and pump port taper with a clean cloth. Lower the seat into the port taper and then lift slightly and drop. If the seat drops straight, it will seize on the taper sufficiently that it cannot be pulled up by hand.

It is necessary to strike the seat once to assure a perfect seat. This may be done with a short section of hard wood and a four-pound (1.8 kilogram) hammer. The end of the wood block placed against the valve seat should be large enough to cover the outer sealing ring. One sharp blow should be sufficient for proper seating. Additional hits may jar the seat loose and could damage the seat. Check the seat top surface to see that it has not been damaged after the seat has been installed.



Fluid Valve Assembly – Ref. Drawing No. 309TEE810

These valves are retained by a cage that screws onto the seat. A valve cage removal tool can be purchased from Gardner Denver Inc. Refer to the Parts List for the part number.

The wing guided valves can be removed with a puller that uses a cam arrangement to pass through the seat opening and engage one side of the seat bottom. This type head is preferred since it is less likely to damage the seat during the pulling procedure.

DANGER

If a seat puller powered by a hydraulic jack is used, be certain to chain or tie the jack down as it will jump violently when the valve seat lets go.

The severe duty, tapered seat valves can be removed with a threaded puller head. This type puller head has threads on the outside diameter that match the threads cut into the inside diameter of the seat. A hydraulic jack type puller can be used with this type head.

Before installing a valve, make sure the seats and deck tapers to insure they re not scratched, nicked or otherwise damaged. Replace any seat found damaged and have any damaged deck tapers remachined. Do not coat the tapers with any kind of lubricant or coating before assembly.

Drive the seat into the taper using a four-pound (1.8 kilogram) hammer striking either a wood block (covering the full upper surface of the seat) or one of the factory option valve seat drivers that thread onto the various style valve seats. One sharp blow on the block or the rod end of the driver should be sufficient for seating. If the seat jumps up when it is struck, take it out and inspect both the seat and the deck tapers. They must be clean, dry and undamaged before a second attempt is made to install the seat. Again use only one sharp blow on the block or driver after dropping the seat into the taper. Excessive pounding could loosen or damage the seat.

Use caution when installing the valve cover to prevent "pinching" of gaskets. The gasket must be installed with the chamfer facing up. Tighten the valve cover nuts to proper torque as shown in "Rebuilding Data", page 26.

PISTON LINERS AND LINER CLAMPS - When liners are reinstalled or replaced, check cylinder to frame stud nuts and tighten if necessary. Refer to page 26 for proper tightening torques.

Nuts holding liner clamps in place should not be overtightened as distortion of liner clamp and liner bore may result. Recommended tightening torque is shown on page 26.

Change sizes of pistons and liners as volume and/or pressure requirements change.

Liners are replaced by removing the liner clamps. Liners should be cleaned and oiled after removal to protect against rusting during storage, as they can be used again if bore is in usable condition.

Pump liners are to be clean both inside and out prior to installation. Also clean the liner clamp bore and lightly oil all surfaces.

Always use new gaskets when installing liners and be sure to clean all surfaces against which the gaskets fit. Liners and/or fluid cylinders may be cut by leaking gaskets. If the pistons are properly maintained, there will be little or no cutting of the liners.

PISTONS - Single-acting pistons consist of a composite piston body with molded insert retained by a nut and washer. Pistons and piston rods can be removed or installed through the suction valve opening. The valve spring and cage must also be removed. It is recommended that a piston and rod assembly be kept ready for replacement. This is a practical time saver.

PISTON ROD - The piston rods are manufactured of high carbon steel. It is important that the piston rod nut be tightened to the recommended torque as shown on page 26.

The piston rod to piston fit is straight. The piston hub fits against the rod flange with an "O" ring gasket to prevent leakage. Removal of the piston is a simple operation since it is not driven on a taper.

⚠ WARNING

After removing the piston rod nut and the rod to the crosshead extension coupling, do not use a screwdriver or cold chisel to separate the piston rod flanges from either the extension rod flange or the piston hub, as burrs may be formed which could cause misalignment on reassembly. Instead, rotate the eccentric slightly.

If the parts do not separate, tap the flanges with a plastic, wood or rawhide head hammer while rotating the eccentric.

If the piston and piston rod are removed from the pump as a unit, they can be separated by holding the rod and tapping the piston with the same type of hammer.

PISTON WASHING SYSTEM – The piston washing system is vital to satisfactory performance and the life of the pistons and liners. The complete system must be kept in good operating condition. Washing fluid should be maintained in good condition and should be replaced when contaminated to the point where free circulation is impaired. This is of utmost importance and should be impressed upon all operators of the pump.

The piston washing fluid may vary according to conditions and operator's preference. Good results can be obtained using one part water with one part soluble oil within the closed system. Under severe freezing conditions a light undiluted oil gives good results.

The more washing fluid circulated the better. However, it should be regulated by a valve in the discharge line of the centrifugal pump to prevent splashing and being blown about by the wind. This could result in dangerous conditions around the pump when using any oil based solutions.

FLUID END CORROSIVE ATTACK - Some aluminum bronze fluid cylinders and components (especially valve decks and seats) experience corrosive attack from chemicals in the water being pumped. To avoid damage to pump components, water containing corrosive chemicals should be treated to neutralize corrosive properties before it is pumped. To determine if corrosive chemicals are present in pumped water, a sample should be chemically analyzed and/or one or more sacrificial anodes should be placed in the suction fluid stream. If the water analysis shows corrosive chemicals are present, or on frequent inspection the anode is observed to be eaten away, the fluid should be treated.

Anodes, mounted on threaded plugs, are available from Gardner Denver Inc. to replace one or more of the drain plugs located in the bottom of aluminum bronze suction manifolds.

SERVICE INSTRUCTIONS - POWER END

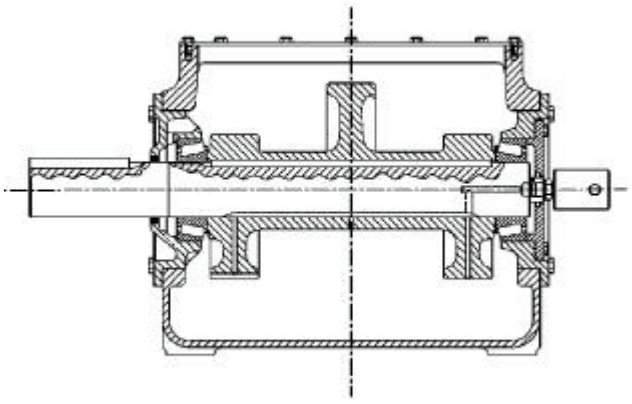


FIGURE 4 – SECTIONAL VIEW SHOWING ECCENTRIC

ECCENTRIC (FIGURE 4, above, and FIGURE 5, page 15) - The drive shaft extension can be located on either side of the pump by installing the eccentric in the desired position.

To remove eccentric, remove end plates from both sides. Main bearings are tapered roller type and the cups remain in the end plates as they are removed. The oil must be removed from the power end before eccentric removal.

Support shaft on a rope sling and remove eccentric shaft and bearing cones from sheave side of pump.

Connecting rods will slip over the cams as the eccentric is removed.

Bearings are to be replaced if worn excessively or damaged. A damaged bearing will be noisy. Do not remove protective grease in new bearings; it will not contaminate the crankcase oil.

CROSSHEAD AND PINS - Crossheads can be removed through the oil stop head openings. Remove inspection plates from side of frame. Crossheads are equipped with straight full-floating pins secured on each end by spring retainers in grooves near the ends. The retaining rings can be reached through the crosshead inspection plate openings located on the sides of the frame. It will be necessary to remove one (1) outside crosshead to gain access to the center pin.

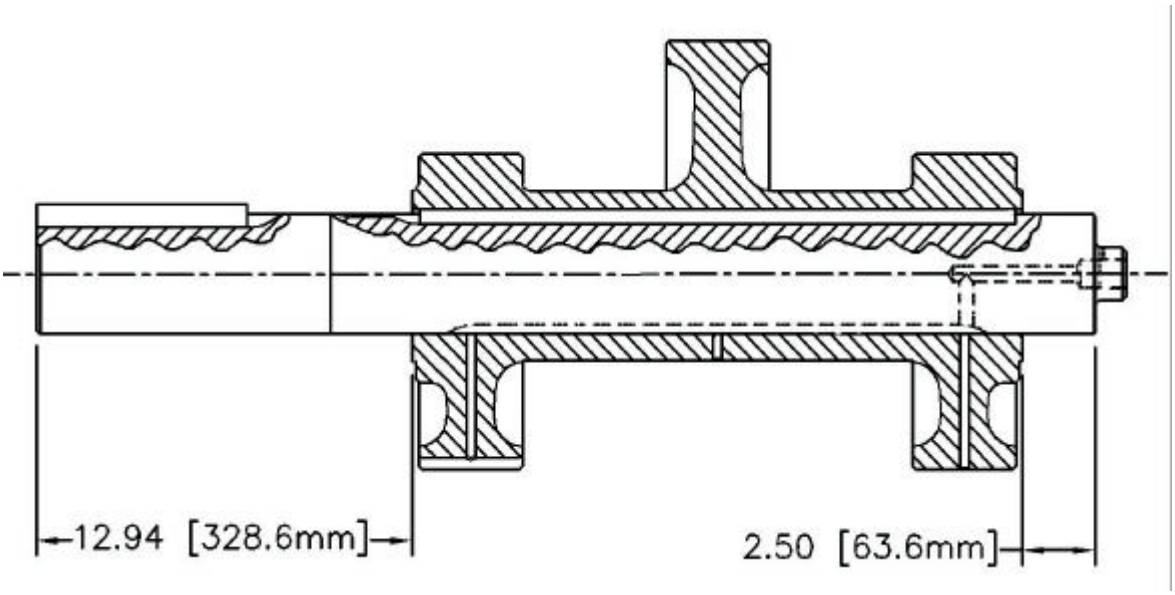
Remove the piston and liner clamp and oil stop head. Next, slide the crossheads through oil stop head bores in frame and lift clear of the pump. Be careful to protect the lower slide from damage in the frame by placing a wooden block beneath the small end of the connecting rod. When reassembling, be sure the seals are in place on the oil stop heads.

Oversize crossheads are available from Gardner Denver Inc.

CONNECTING RODS - Eccentric must be removed before connecting rods can be removed. Rods have solid bushings at the crosshead and the eccentric end. Each can be pressed out and replaced if necessary. It is best to shrink new bushings by freezing before installing in rod, instead of pressing in. Install crossheads, connecting rod and eccentric in reverse order of above.

MAIN BEARINGS – Main bearings are the tapered roller type. The largest bearing is on the drive side of the main shaft and the smaller on the opposite end. End clearance for both bearings is adjusted by the addition or removal of shims located on the end plate opposite the drive side. End clearance should be .002”/.004” (.051/.102 mm). Bearing cones are a shrink fit onto the eccentric shaft and the cups are a light fit in the end plates.

ECCENTRIC SHAFT ASSEMBLY PROCEDURE (FIGURE 5, page 15) – Install key in the eccentric shaft and freeze the shaft before assembling into the eccentric bore. Use the dimensions shown in FIGURE 5, page 15, for correct positioning of the shaft.



	Inches	mm
Eccentric ID……	**.0000/4.0015**	**101.6000/101.6381**
Main Shaft OD……..	**4.0015/4.0025**	**101.6381/101.6635**
Eccentric to Main Shaft Fit……..	**.0000/.0025T**	**.0000/.0635T**

FIGURE 5 – ECCENTRIC SHAFT POSITIONING

EXTENSION RODS – Each extension rod and crosshead assembly can be removed from the pump by working through handhole plates located on the sides of frame and also through the oil stop head openings after oil stop head assemblies have been removed. Be careful not to damage the highly polished surface on which oil seals travel.

CAUTION

Extension rods are plated and should be protected when the pump is repainted. Paint on the extension rods will damage oil stop head seals when the pump is in operation.

OIL STOP HEADS - Oil stop head seals keep crankcase oil within frame and also help keep foreign material from entering the crankcase.

Each oil stop head has two (2) lip ring seals. The seal lips should face the crankshaft. When assembling seals, care must be taken not to damage the sealing lip. Crosshead extension and seal rings should be coated with oil before seal assembly. The oil stop head must be assembled on frame, then one (1) seal at a time is installed over the crosshead extension rod into the oil stop head bore.

WARNING

When installing oil stop head seal rings, care must be taken not to damage sealing lips. Damaged lips could lead to excessive oil leakage and/or crankcase contamination and damage.

Tighten oil stop head gland to prevent seal movement while pump is in operation. These oil stop head seals are nonadjustable. When crankcase oil leakage occurs past seals, the seals should be replaced as additional tightening of the gland will not prevent leakage.

It is essential that oil stop head seals be replaced at the first indication of leakage. Oil leakage will be indicated by oil collecting on top of the liner washing water on models equipped with a reservoir. If rig water is used for washing and run to a waste area, it is difficult to check by above method. On models not equipped with a rod wash system check for oil collecting below stop heads in cradle.

If oil leakage is serious, it will appear in a lower oil level in the crankcase. In this case oil must be added to the crankcase as required until new oil stop seals can be installed.

WARNING

When mud or other foreign material is found in the crankcase, the oil must be changed before operating the pump to avoid damage to moving parts.

Leakage of mud and water into crankcase will be indicated by a milky appearance of crankcase oil.

Rubber baffles are provided as standard equipment to reduce the amount of abrasive fluid entering power end and should be installed on all three (3) extension rods. If excessive, mud can be detected by reaching through the oil with the hand, or by draining out a small quantity of oil.

Mud will also be seen below the oil stop heads on the inside of crankcase through crosshead inspection plate openings.

WARNING

Failure to properly reinstall and maintain baffles voids the warranty as they are designed to help prevent mud and other contaminants from entering and damaging the crankcase.

When mud is found in the crankcase, the oil and filter should be changed.

Drain and clean out the crankcase before putting in new oil. Replace the oil stop head seals before running the pump.

We recommend oil stop head seals be changed every six (6) months of operation, even though leakage is not evident.

CRANKCASE OIL REQUIREMENTS

API-GL5 Oil Grade Oil Grade	Ambient Temperature	Crankcase Operating Oil Temperature*	Minimum Start-Up Oil Temperature
75W – 90	-20º F TO 60º F (-29º C TO 16º C)	60º F TO 140º F (16º C TO 60 º C)	20º F (-7º C)
80W – 140	10º F TO 100º F (-12º C TO 38º C)	90º F TO 180º F (32º C TO 82º C)	50º F (10º C)
80	-10º F TO 45º F (-23º C TO 7º C)	70º F TO 125º F (21º C TO 52º C)	30º F (-1º C)
90	20º F TO 80º F (-7º C TO 27º C)	100º F TO 160º F (38º C 59 71º C)	60º F (16º C)
140	50º F TO 115º F (10º C TO 46º C)	130º F TO 195º F (54º C TO 90º C)	80º F (27º C)

* An 80º F (27º C) crankcase oil temperature rise over ambient air temperature is typical for the pumps covered by this manual when operating at or near rated horsepower.

Oil viscosity must not exceed 7000 SSU at start-up and must be between 1500 SSU and 200 SSU while operating, regardless of the oil temperature or grade used. A crankcase heater and/or an oil heat exchanger may be needed to meet these requirements.

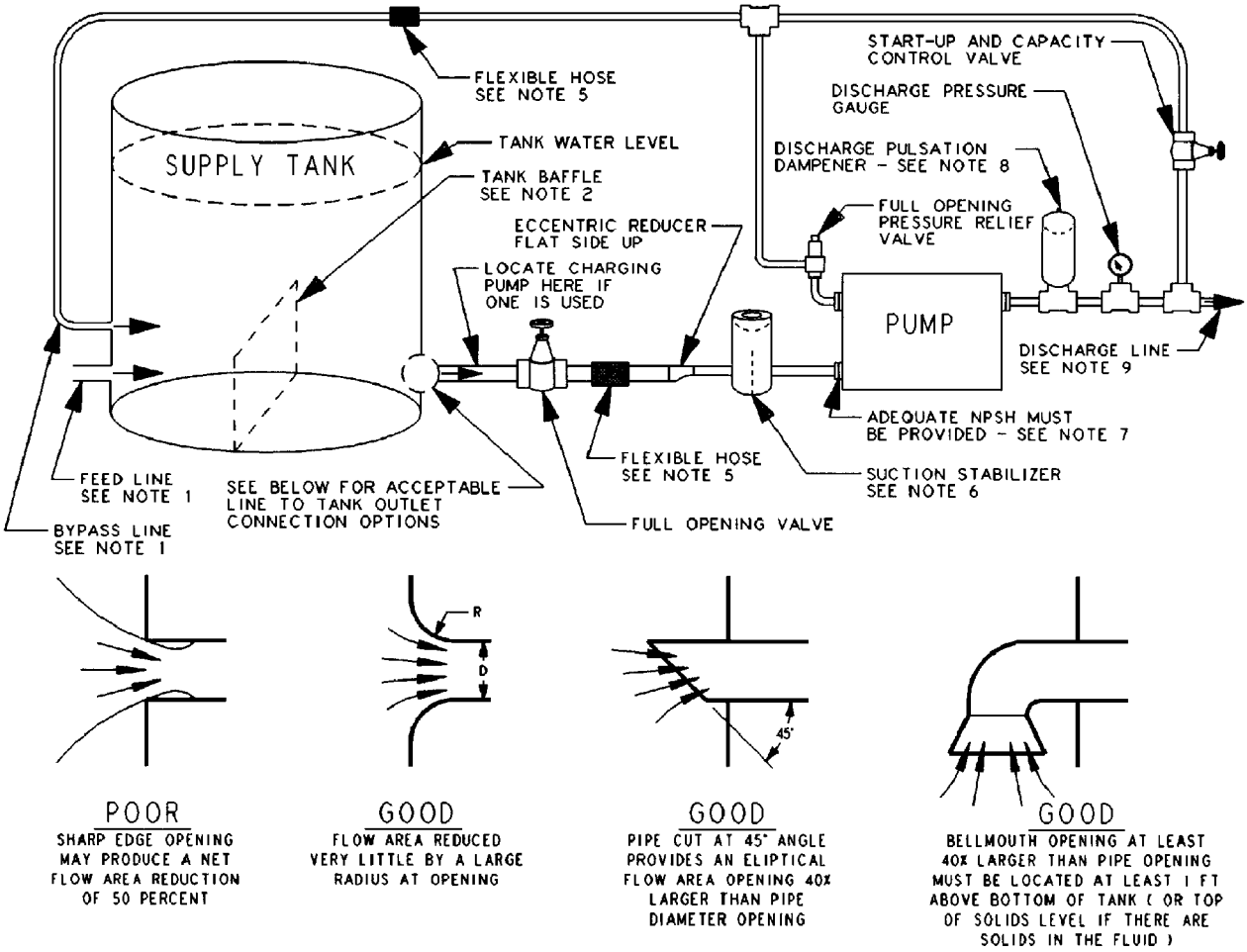
Crankcase capacity is 12 gallons (45.4 liters).

WARNING

Failure to follow these lubrication requirements will void the warranty.

Some operating conditions and/or oil brands produce excessive oil foaming, even when the specified GL-5 oils containing the antifoaming additives are used. Oil foaming can cause pump damage, as oil bubbles will not lubricate moving parts properly. If significant oil foaming occurs, contact Gardner Denver Marketing or Service for the current factory recommended defoamant to be added to the lubricating oil. When it is not possible to contact Gardner Denver people, a small amount of kerosene added to the oil will usually reduce foaming. One half of a fluid ounce of kerosene added to each gallon of oil should be sufficient to control foaming. The use of larger amounts of kerosene per gallon of oil will reduce the oil viscosity, which could result in rapid pump wear and failure.

GARDNER DENVER HORIZONTAL PUMP
RECOMMENDED SYSTEM LAYOUT FOR PROPER PERFORMANCE



NOTES:

1) Feed line and bypass line openings in tank must be located below the top of baffle and on opposite side of tank from outlet opening.

2) The baffle must be completely submerged at minimum liquid level in the tank. The baffle must be placed between the feed line and tank outlet to pump and should extend from one side of the tank to the other.

3) If a tank baffle cannot be installed, flow into the tank must be directed away from tank outlet to pump so entrained gasses do not flow directly into tank outlet.

4) A short straight suction line is preferred from the tank to the pump. If this is not possible, use as few bends as possible and use long radius elbows. The smallest portion of the line should be at least as large as the pump suction opening. Flow velocity should be 3 ft/sec or less.

5) Suction and discharge lines should each contain a section of flexible hose to remove piping strain and vibration.

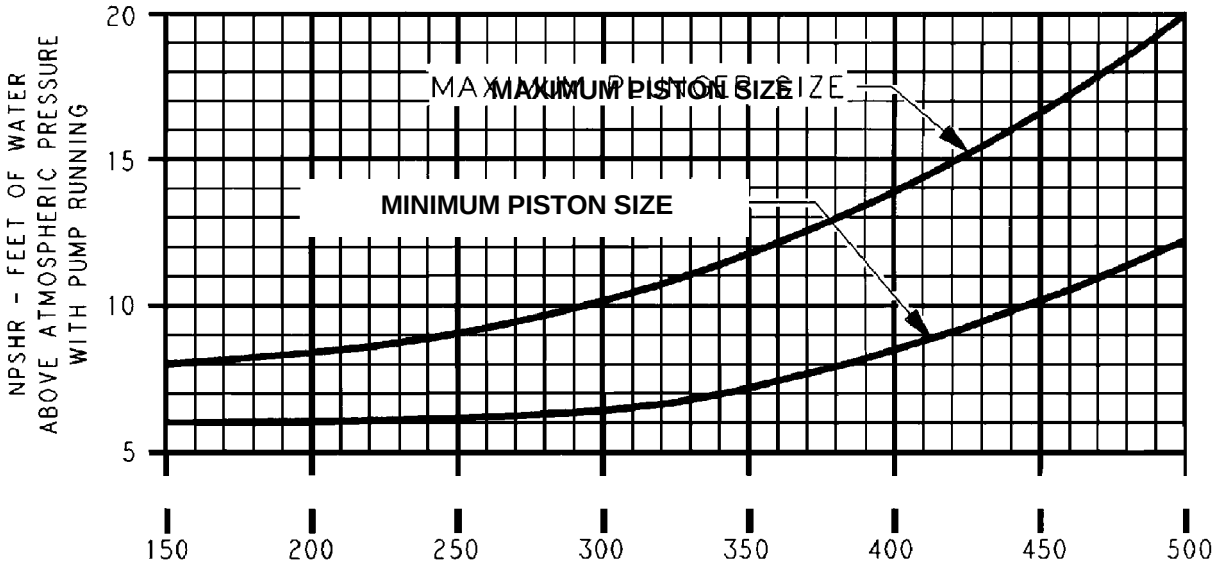
6) The suction stabilizer should be a bladder type with an internal baffle between the inlet and outlet connections.

7) NPSH provided by suction system must be adequate to satisfy pump requirements. Refer to NPSHR curve or consult Gardner Denver Marketing.

8) A bladder type discharge pulsation dampener is recommended.

9) Discharge line flow velocity should be 10 ft/sec or less.

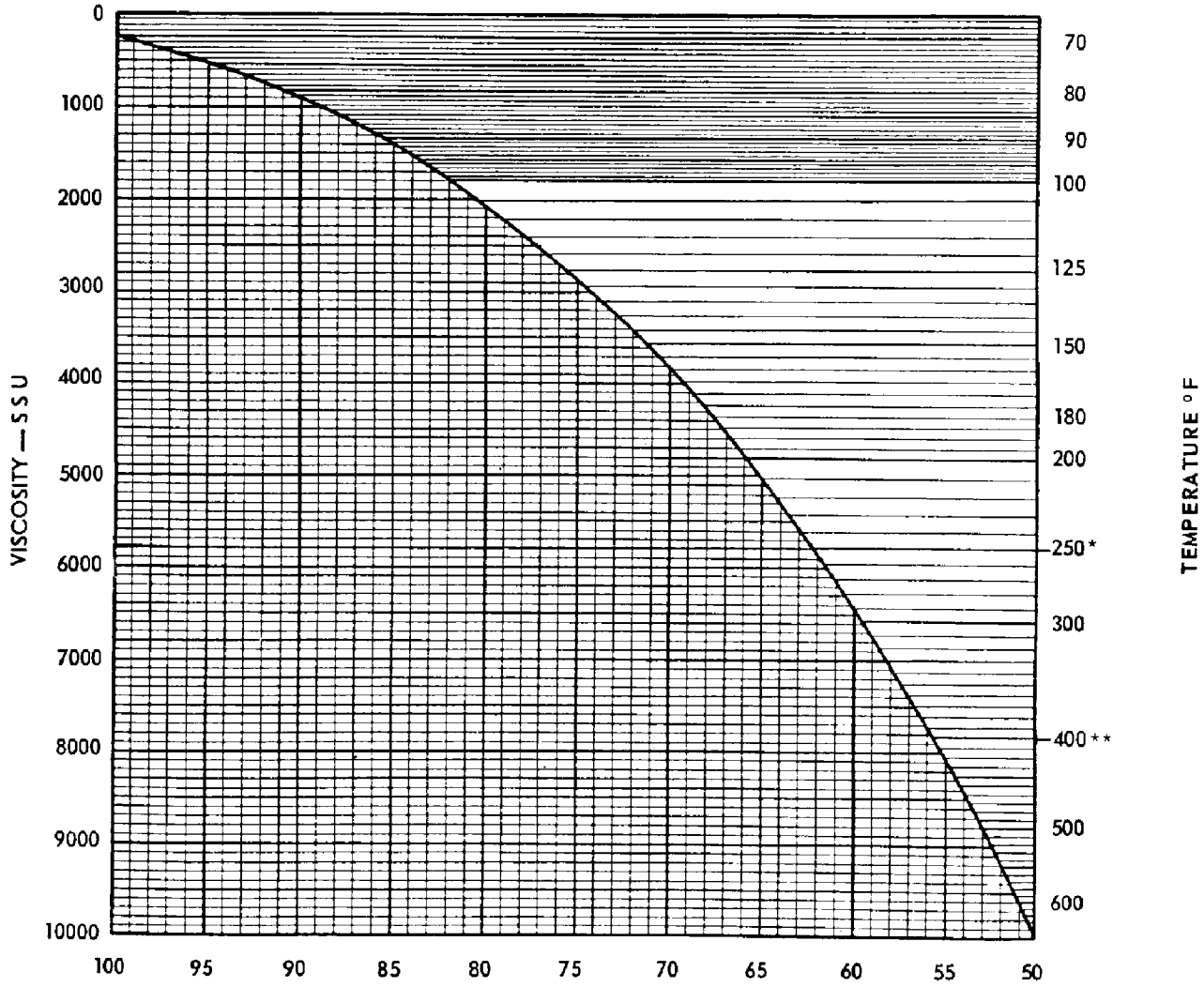
NET POSITIVE SUCTION HEAD REQUIRED (NPSHR)*
AT FLUID CYLINDER SUCTION CONNECTION WITH SUCTION STABILIZER
AND DISCHARGE PULSATION DAMPENER INSTALLED



Pump Bulletins list the maximum and minimum piston sizes.
Interpolate between NPSH curves for each piston size.

*NPSHR is defined at a 3% flow drop below maximum capacity.
Added suction head above that shown by the curves must be provided for the higher vapor pressure of warmer water (curves are based on 60? F water) and/or other fluids and for acceleration head and friction losses in systems having long and/or restricted suction lines.

CORRECTION CHART FOR TEMPERATURE OR VISCOSITY



VISCOSITY CONVERSION TABLE

This table lists a comparison of various viscosity ratings, when the viscosity is given in terms other than Saybolt Universal, it can be translated by following horizontally to the Saybolt column.

Seconds Saybolt Universal ssu	Kinematic Viscosity Centistokes *	Seconds Saybolt Furol Ssf	Seconds Redwood 1 (Standard)	Seconds Redwood 2 (Admiralty)	Degrees Engler	Degrees Barbey	Seconds Parlin Cup #7	Seconds Parlin Cup #10	Seconds Parlin Cup #15	Seconds Parlin Cup #20	Seconds Ford Cup #3	Seconds Ford Cup #4
31	1.00	--	29.0	--	1.00	6200	--	--	--	--	--	--
31	1.00	--	29.0	--	1.00	6200	--	--	--	--	--	--
35	2.56	--	32.1	--	1.16	2420	--	--	--	--	--	--
40	4.30	--	36.2	5.10	1.31	1440	--	--	--	--	--	--
50	7.40	--	44.3	5.83	1.58	838	--	--	--	--	--	--
60	10.3	--	52.3	6.77	1.88	618	--	--	--	--	--	--
70	13.1	12.95	60.9	7.60	2.17	483	--	--	--	--	--	--
80	15.7	13.70	69.2	8.44	2.45	404	--	--	--	--	--	--
90	18.2	14.44	77.6	9.30	2.73	348	--	--	--	--	--	--
100	20.6	15.24	85.6	10.12	3.02	307	--	--	--	--	--	--
150	32.1	19.30	128	14.48	4.48	195	--	--	--	--	--	--
200	43.2	23.50	170	18.90	5.92	144	40.0	--	--	--	--	--
250	54.0	28.00	212	23.45	7.35	114	46.0	--	--	--	--	--
300	65.0	32.50	254	28.00	8.79	95.0	52.5	15	6.0	3.0	30	20
400	87.6	41.90	338	37.10	11.70	70.8	66.0	21	7.2	3.2	42	28
500	110	51.60	423	46.20	14.60	56.4	79.0	25	7.8	3.4	50	34
600	132	61.40	508	55.40	17.50	47.0	92.0	30	8.5	3.6	58	40
700	154	71.10	592	64.60	20.45	40.3	106.0	35	9.0	3.9	67	45
800	176	81.00	677	73.80	23.35	35.2	120.0	39	9.8	4.1	74	50
900	198	91.00	762	83.00	26.30	31.3	135.0	41	10.7	4.3	82	58
1000	220	100.7	896	92.10	29.20	28.2	149.0	43	11.5	4.5	90	72
1500	330	150	1270	138.2	43.80	18.7	--	65	15.2	6.3	132	90
2000	440	200	1690	184.2	58.40	14.1	--	86	19.5	7.5	172	118
2500	550	250	2120	230	73.00	11.3	--	108	24.0	9.0	218	147
3000	660	300	2540	276	87.60	9.40	--	129	28.5	11	258	172
4000	880	400	3380	368	117	7.05	--	172	37	14	337	230
5000	1100	500	4230	461	146	5.64	--	215	47	18	425	290
6000	1320	600	5080	553	175	4.70	--	258	57	22	520	350
7000	1540	700	5920	645	205	4.03	--	300	67	25	600	410
8000	1760	800	6770	737	234	3.52	--	344	76	20	680	465
9000	1980	900	7620	829	263	3.13	--	387	86	32	780	520
10000	2200	1000	8460	921	292	2.82	--	430	96	35	850	575
15000	3320	1500	13700	--	438	2.50	--	650	147	53	1280	860
20000	4400	2000	18400	--	584	1.40	--	860	203	70	1715	1150

* Kinematic Viscosity (in centistokes) = $\frac{\text{Absolute viscosity (in centipoises)}}{\text{Specific Gravity}}$

Above 250 SSU, use the following approximate conversion:

SSU = Centistokes x 4.62

Above the range of this table and within the range of the viscosimeter, multiply their rating by the following factors to convert to SSU:

Viscosimeter	Factor
Saybolt Furol	10.0
Redwood Standard	1.095
Redwood Admiralty	10.87
Engler - Degrees	34.5

Viscosimeter	Factor
Parlin cup #15	98.2
Parlin cup #20	187.0
Ford cup #4	17.4

SECTION 3
TROUBLESHOOTING

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. Improper bypass conditions.	3. 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 prop.
Low Discharge Pressure.	1. Worn or fluid cut valve assembly.	1. Replace valve assembly.
	2. Valve propped open.	2. Remove prop.
	3. Pump cavitating.	3. See Cavitation, Fluid Knock or Hammer problem.
	4. Fluid leakage.	4. Replace 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).
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 dampener not used.	3. Install suct ion stabilizer and pulsation dampener.
	4. Defective stabilizer or dampener.	4. Repair and recharge or replace.

PROBLEM	POSSIBLE CAUSE	SUGGESTED ACTION
Cavitation, Fluid Knock or Hammer (continued).	5. High fluid temperature or viscosity.	5. Reduce pump speed per chart in manual.
	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 more flexible spring. Remove inner spring from two spring valve.
	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 o r rod bearings, crossheads or bushings.	4. Check and adjust clearance. Replace parts as required.
Knock In Power End.	1. Improper main bearing clearance.	1. Check and adjust clearances.
	2. Incorrect pump rotation.	2. Reverse rotation.
	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 eccentric bearing.	7. Replace.

PROBLEM	POSSIBLE CAUSE	SUGGESTED ACTION
Knock In Power End (continued).	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 or 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 packing.	2. Replace packing.
	3. Oil level too high in crankcase.	3. Reduce oil level.
	4. Excessive crosshead wear. *	4. Replace crosshead.
	5. Pressure in crankcase.	5. Clean or replace air breather.
	* Oversize crossheads are available.	
Oil Seal Leakage.	1. Worn sealing lip.	1. Replace seal.
	2. Damaged sealing lip.	2. Replace seal.
	3. O.D. 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.
Pumped Fluid In Crankcase.	1. Worn, damaged or corroded extension rod.	1. Replace extension rod.
	2. Worn oil stop head packing.	2. Replace packing.
	3. Extension rod baffles damaged/ missing.	3. Install new baffles.
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.

PROBLEM	POSSIBLE CAUSE	SUGGESTED ACTION
	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.
Catastrophic Failures Such As Broken Shafts, Bent Rods, etc.	1. Pump overloaded.	1. Reduce pump speed and/or pressure.
	2. Start-up against closed discharge valve.	2. Insure valve is open before starting.
	3. Main bearing failure .	3. Repair or replace.
	4. Frozen fluid in cylinder.	4. Do not start pump when pumped fluid is below freezing temperature.
	5. Lube oil pump failure.	5. Replace oil pump.
	6. Low oil level in sump.	6. Check oil level frequently, and add oil as required.
	7. Contaminated oil in sump.	7. Check oil condition frequently.
	8. Cavitation shock loading.	8. 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 4
REBUILDING DATA, RUNNING CLEARANCES AND TORQUES

REBUILDING DATA FOR MODEL THE PUMPS

PUMP STROKE	5 Inches	127 mm
Eccentric Throw Diameter	10.4930/10.4915	266.522/266.484
Eccentric Shaft Diameter at Main Bearing:		
Extension End	4.0025/4.0015	101.664/101.638
Oil Pump End	3.0025/3.0015	76.264/76.238
Distance Between Main Bearings	21.000/21.010	533.400/533.654
Bore in Housing for Main Bearing:		
Extension End	7.500/7.501	190.500/190.525
Oil Pump End	5.875/5.877	149.225/149.276
Connecting Rod Centers	13.5	342.9
Bore in Connecting Rod Bushing for Crosshead Pin	2.0015/2.0020	50.838/50.851
Bore in Connecting Rod Liner for Eccentric	10.499/10.505	266.675/266.827
Crosshead Pin Diameter	2.0005/2.0000	50.8127/50.8000
Bore in Crosshead for Pin	2.0010/2.0015	50.8254/50.8381

RUNNING CLEARANCES - ACTUAL*

Connecting Rod Bearing to Eccentric	.007/.0145	.1778/.3683
Crosshead Pin to Bushing	.0005/.0020	.0127/.0508
Main Bearing End Clearance	.002/.004	.051/.102
Crosshead to Frame - at Crosshead Upper Edges	.006/.010	.1524/.254
Eccentric to Connecting Rod Bushing	.007/.015	.1778/.3683

* Feeler gauge clearances .001 inch or .25 mm less than actual values.

TORQUES

	foot-pounds (Dry)	Newton-meters (Dry)
Cylinder to frame stud nuts (1 ¼-7unc)	900	1220
Valve cover stud nuts (7/8-9unc)	430	583
Liner clamp stud nuts (3/4-10unc)	260	352
Piston rod nut	640	868
Suction flange stud nuts (7/8-9unc)	430	583
Discharge flange stud nuts (7/8-9unc)	430	583

Gardner Denver

Specifications subject to change without notice.

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