GARDNER DENVER®

300FWB996 Rev B
January, 2005

WELL SERVICING PUMP

MODEL

COMPACT

OPERATING AND SERVICE MANUAL

ECN 1024021

COMPACT
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

Factory (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 cylinder end 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.

TABLE OF CONTENTS

Maintain Pump Reliability and Performance with Genuine Gardner Denver Parts and Support Services i

Instructions For Ordering Repair Parts i

Foreword ii

Index iv

List of Illustrations v

Section 1, Danger Notices 1

Section 2, Design, Description and Specifications 9

Section 3, Preparation, Operation and Maintenance 15

Section 4, Service Procedures 21

Section 5, Trouble-Shooting 27

Section 6, Rebuilding Data, Recommended Running Clearances 33

Section 6, Torques 34

Warranty ..... Last Page

INDEX

Crankshaft Assembly 26

Crosshead Assembly … 24

Crosshead Guides…..... 25

Daily Routine Maintenance Schedule..... 19

DANGER NOTICES, SECTION 1 1

- Covers and Guards..... 2
- Equipment Moving and Lifting 2
- Flammable, Hot, Cold or Corrosive Fluid Pumping..... 5
- Hammer Lug Fasteners…….. .. 1
- High Pressure Liquid Jetting, Blasting and Cleaning..... 6
- Pressurized Pump Systems..... 3
- Valve Seat Pulling..... 2

DESIGN DESCRIPTION AND SPECIFICATIONS, SECTION 2..... 9

Fluid End Description..... 13

Fluid End Removal and Installation 21

Fluid End Service..... 21

Foreword ……..…….. ii

Gear Reduction Unit 11,26

General Requirements and Safety Rules 21

General Specifications..... 14

Introduction 9

Lube Pump Suction Piping Sizing and Requirements..... 16

Lube System Pump..... 16

Lubrication, Plunger / Packing 17

Monthly Routine Maintenance Schedule 19

Oil Stop Head Seal Retainer and Crosshead Pin Orientation for Proper loading 24

Ordering Instructions, Repair Parts i

Performance Rating..... 14

Periodic Routine Maintenance Schedule 18

Plunger / Packing Lubrication..... 17

Plunger Packing Lubrication Recommendation Chart..... 20

Plungers and Packing Replacement 22

Power End 10,24

Power End and Gear Reduction Unit Lube System..... 12

Power End Lubrication System 16

Preparation after Shipping and Storage 15

PREPARATION, OPERATION AND MAINTENANCE, SECTION 3..... 15

Pump Design 10

Pump Mounting Instructions..... 15

Quarterly Routine Maintenance Schedule..... 19

Rebuilding Data 33

REBUILDING DATA, RECOMMENDED RUNNING CLEARANCES AND TORQUES, SECTION 6 33

Recommended Running Clearances – Actual 33

Repair Parts, Ordering Instructions i

SERVICE PROCEDURES, SECTION 4 21

Specifications, General..... 14

Startup and New Pump Run-In Procedure..... 17

Torques..... 34

TROUBLE-SHOOTING, SECTION 5 27

Warranty ..... Last Page

Valve and Seat Replacement..... 22

LIST OF ILLUSTRATIONS

Figure #	Description	Page
Figure 2-1	COMPACT Triplex Pump	9
Figure 2-2	COMPACT Power End	10
Figure 2-3	COMPACT Power End Top View	11
Figure 2-4	COMPACT Gear Reduction Unit	12
Figure 2-5	COMPACT Fluid End	13
Figure 3-1	Lubricant Recommendations	17
Figure 4-1	Fluid End Assembly	22
Figure 4-2	Packing Assembly	22
Figure 4-3	Crosshead Assembly	25

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 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 Seat 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 at 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 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 35 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.

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 COMPACT is a 600 brake-horsepower, high rod load multi-purpose pump for various applications such as oil and gas well fracturing and acidizing. Other applications include cementing with a single pump, or back-to-back mounted twin pumps. The standard fluid end is a valve-over-valve design. The parallel-shaft gear drive was designed in accordance with the most recent standards, procedures, and computer software developed by American Gear Manufacturers Association.

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.

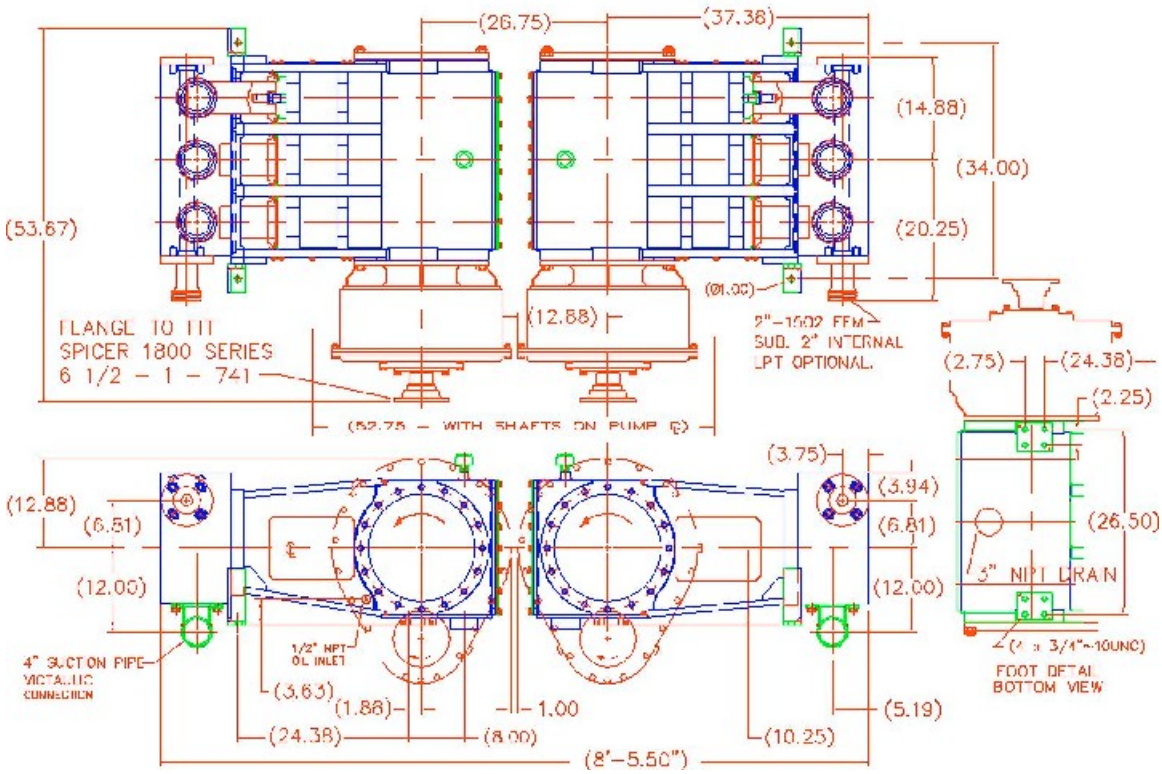


FIGURE 2-1 COMPACT Pump

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.

Section 4, "Service Procedures," describes the various assembly / disassembly procedures.

Section 5, “Trouble–Shooting,” describes possible problems, causes and solutions related to pump performance.

Section 6, “Rebuilding Data, Recommended Running Clearances and Torques,” presents information useful for pump rebuilding and assembly, including dimensional and tolerance data, running clearances for all bearings, and recommended fastener torques.

PUMP DESIGN

The COMPACT pump uses three major assemblies: power end, fluid end, and gear reduction unit. The pump is designed with a modular concept. Each assembly is a module that can be assembled, handled, installed, fixed, or transported separately from the rest of the pump (See FIGURE 2-1, page 9). The following is a brief description of the essential design features for each modular assembly.

POWER END (FIGURE 2-2,FIGURE 2-3)

The power end is a welded fabrication utilizing high-strength low-alloy frame members, stress relieved and precison machined to provide stability and strength. The crankshaft is a one piece, forged alloy steel, heat-treated and precision ground.

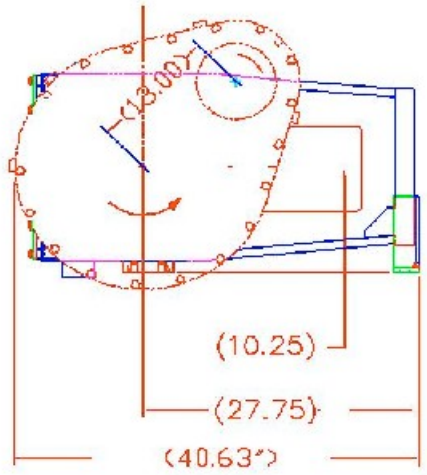


FIGURE 2-2 COMPACT Power End

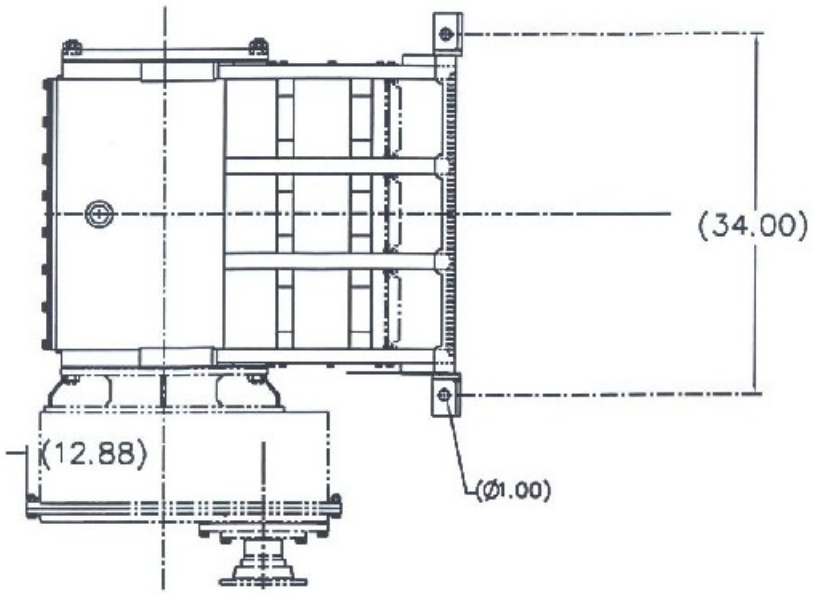


FIGURE 2-3 COMPACT Power End Top View

NOTICE

Assembled for clock-wise rotation of the input shaft. For counter-clockwise rotation, reverse position of the crosshead-pin location.

The crankshaft is supported by four main roller bearings. The drive end of the crankshaft is a male spline which mates with a female spline in the gear-reducer bull gear. The connecting rods are precision machined from high-strength alloy steel castings. Connecting rod bearings are automotive type, with round, grooved sleeve-bearings on the crosshead end. Crossheads are machined from one piece high strength ductile iron castings. Precision machined replaceable crosshead guide shoes allow easy repair and power-end rebuild. The pony rods are steel with a hard metalized and ground surface. The oil-stop heads are light-weight aluminum to help reduce weight. The power end is a dry-sump pump, which means that the connecting rods do not "dip" into the oil for splash-cascade lubrication. The power end must be supplied with lube oil from an external source, supplied by others. Large drain openings are provided in the bottom of the power end and reducer, and should be connected to an external oil sump (see lubrication section for more details). A power end breather allows rapid equalization of internal pressure in the power end, as well as the gear reducer.

GEAR REDUCTION UNIT (FIGURE 2-4)

The light weight, parallel shaft gear reducer consists of a crankshaft-mounted helical gear driven by a smaller input pinion gear, bolted to the power end. The overall ratio of the reduction gear unit is 4.609:1. The reducer can be mounted on either side, in 16 different locations - (including horizontal and vertical) - in 22-1/2° increments. The installation and removal of the gear reduction unit is easy and convenient due to a splined gear coupling between the bull-gear carrier and the pump crankshaft. All gears are carburized, case hardened, heat treated and precision made of aircraft quality steel to ensure the highest reliability and long life of the gear box.

POWER END AND GEAR REDUCTION UNIT LUBE SYSTEM (FIGURE 2-2, FIGURE 2-3, and FIGURE 2-4,)

Both the gear reduction unit and power end are connected to the same lube oil inlets. The power end inlet is located toward the rear of the pump. The inlet is a 1/2" NPTF which divides the lube flow between the lube manifold for the crosshead guide and the rotary union. Pressurized lubrication for each crosshead is delivered from the lube manifold through the underside of the crosshead guide. An aluminum cover houses the rotary union, which is attached to the crankshaft. Lubrication for the power end components comes from forced lube through the crankshaft. Lube oil enters the crankshaft and first lubricates the #4 main bearing. Oil from the main bearing also lubes the thrust bearing. As oil reaches the first crankshaft journal, oil exits the journal oil hole and lubes the journal and journal bearings, passes through the center of the connecting rod to the wrist pin and bushing. Oil is supplied thru the crosshead slide to lube the crosshead. This is repeated for the rest of the main bearing and connecting rod components. Oil is removed from the power end through one 3" NPT drain in the bottom center of the frame near the rear of the power end.

The gear reduction unit oil inlet connection is connected externally with the power end oil supply. One connection supplies both.

The lube oil is drained from the gear reduction unit from one of six drain holes, depending on the position of the gear reducer. It is important that the oil sump drain hose size be maintained to the primary external sump and include as few restrictions and direction changes as is practical. Gear unit heating problems are most often related to drain restrictions causing buildup of oil inside the unit, thus generating excessive heat.

NOTICE

It is also extremely important to maintain some downward slope in the entire drain system back to the lube reservoir or external sump.

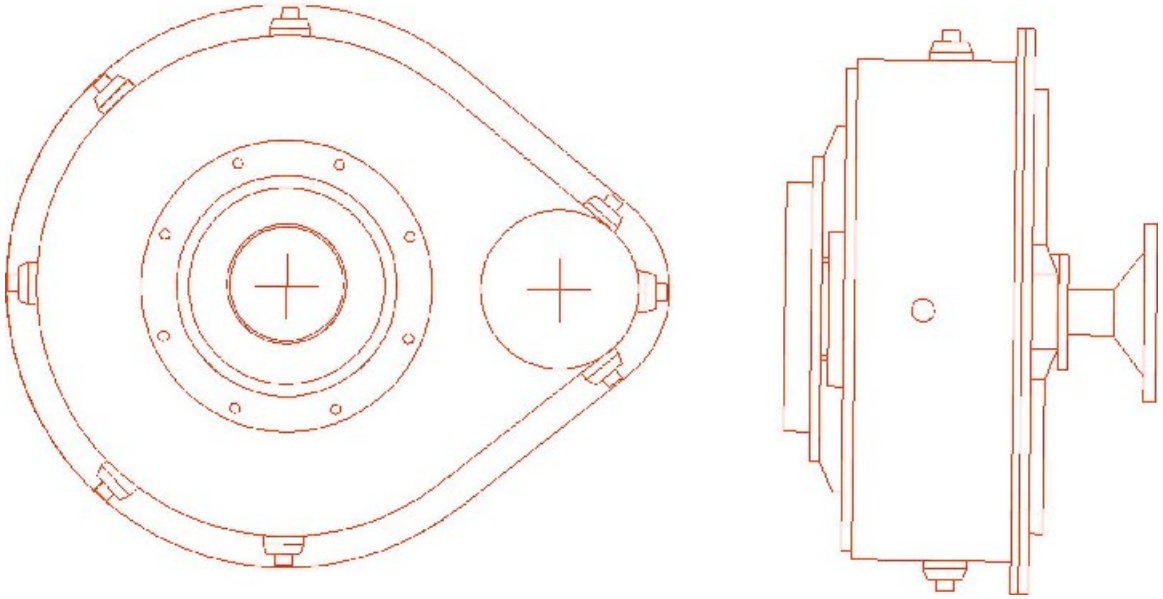


FIGURE 2-4 COMPACT Gear Reduction Unit

FLUID END (FIGURE 2-5)

One basic fluid end style is offered on the COMPACT as standard. This standard fluid end is the V-0-V (**V**alve-**O**ver-**V**alve) Monoblock, or one piece fluid end. The 3" V-O-V fluid end uses one valve size, and the 3-1/2, 4" , and 4-1/2" use the larger valve block size for higher flow, lower pressures.

The standard **V-O-V** fluid end configuration is shown in Figure 2-5. The V-O-V Monoblock features a one piece, heat-treated forged alloy steel block, precision machined with hand ground and polished radii at all bore intersections. Wing guided type valves and seats with replaceable inserts are standard. The one piece plungers are precision ground and polished hard overlayed steel. The stuffing boxes are replaceable alloy steel for ease of maintenance and repair. Standard flanges include one Fig.1502 or Fig. 1002 series discharge flange and one blanking flange. Suction manifold is a 4" pipe with victaulic connections on each end. Optional equipment available includes a 5" suction manifold.

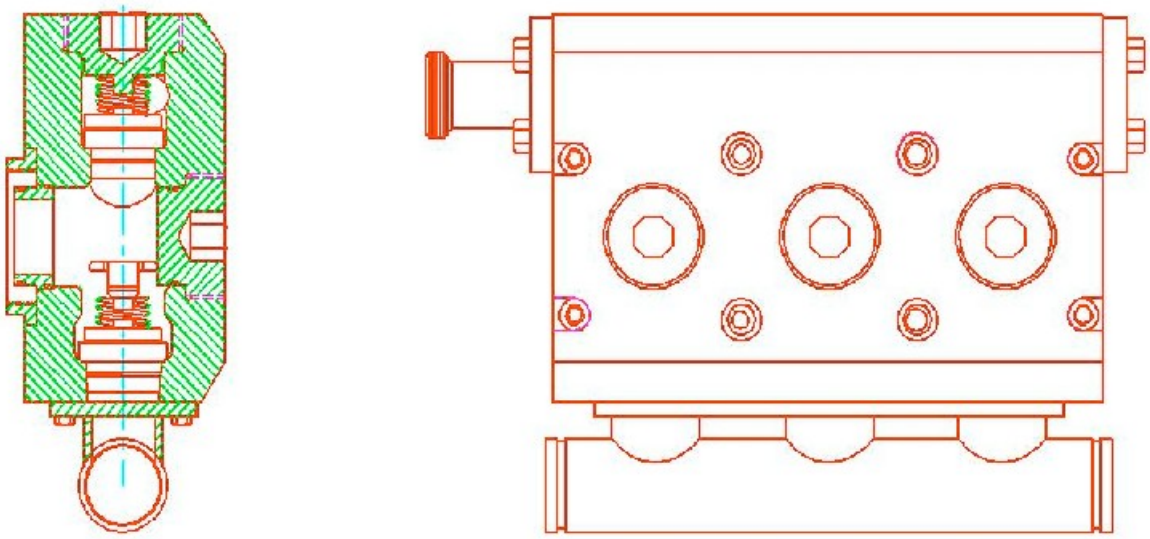


FIGURE 2-5 COMPACT Fluid End

GENERAL SPECIFICATIONS

This section presents the pump basic specifications. The first set of specifications deals with the pump's power, rod load, plunger stroke, and overall dimensions. The other table presents allowable pressures and flows for various pump speeds along with data on power requirements.

COMPACT PERFORMANCE RATING

Rated Brake Horsepower	600 bhp
Stroke Length	6.0 inches
Maximum Rod Load	100,000 pounds
Gear Box Ratio	4.609 : 1
Overall Length	50.25
Overall Width	53.67
Overall Height	32.38
Weight (system dry)	4,600

GD Compact Intermittent Duty Well Service Ratings

Plunger Diameter		Displacement per Revolution		Displacement at Pump RPM - Well Service Application															
				100				200				300				450			
in.	mm.	Gal/ Rev.	Liter/ Rev.	GPM	LPM	PSI	kg/cm	GPM	LPM	PSI	kg/cm	GPM	LPM	PSI	kg/cm	GPM	LPM	PSI	kg/cm
4.5	114	1.24	4.7	124	469	6288	442	248	938	3734	263	372	1407	2489	175	558	2111	1660	117
4	102	0.98	3.7	98	371	7958	559	196	741	4726	332	294	1112	3151	222	441	1668	2100	148
3.5	89	0.75	2.8	75	284	10394	731	150	568	6173	434	225	851	4115	289	337	1277	2743	193
3	76	0.55	2.1	155	208	14147	995	110	417	8402	591	165	625	5601	394	248	938	3734	263
2.75	70	0.46	1.8	46	175	15000	1184	93	350	9999	703	139	526	6666	469	208	788	4444	312
Input Power:			BHP	480				600				600				600			
			kw	358				447				447				447			

Ratings are 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 tempera-tures, 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 inlets.
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

Follow this procedure to shim the feet of the pump. This will require the use of (8) Grade 5 or Grade 8, ¾-10" hex-head screws for the rear mounts, and (2) 7/8" Grade 5 or Grade 8 cap screws with nuts and washers to secure front mounts. The fluid end is supported by the power end frame.

1. Set the pump in its location.
2. Install one ¾" bolt in each of the two feet at the rear corners of the power frame. Snug but do not tighten these bolts.
3. Be sure all suction and discharge piping connections are dis-connected to allow free movement of the fluid end.
4. Using a feeler gauge, check under the front feet of the power frame. Both feet must be in firm contact with support bracket or skid.
5. Select the proper number and thickness of shims to fill the gap under the high foot .
6. With shims in place (if required), install all bolts in the power frame mounting feet.

7. Tighten all bolts. Use the appropriate torque for the type of bolts.
8. Connect the suction line to the inlet of the suction manifold, making sure that no strain is placed on the suction manifold.

9. Connect the discharge line with high-pressure hose or high-pressure pipe utilizing swivel joints to allow movement between the pump and the sub-base supporting the discharge line.

10. Vibration isolation connections or tie-downs for the discharge lines are recommended to help reduce vibrations.

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.
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 time. Therefore, early warning devices are essential to the successful operation and should be set according to the following operating limits:

NOTICE

Maximum lube system pressure should be set at 120 psi (relief valve setting.)

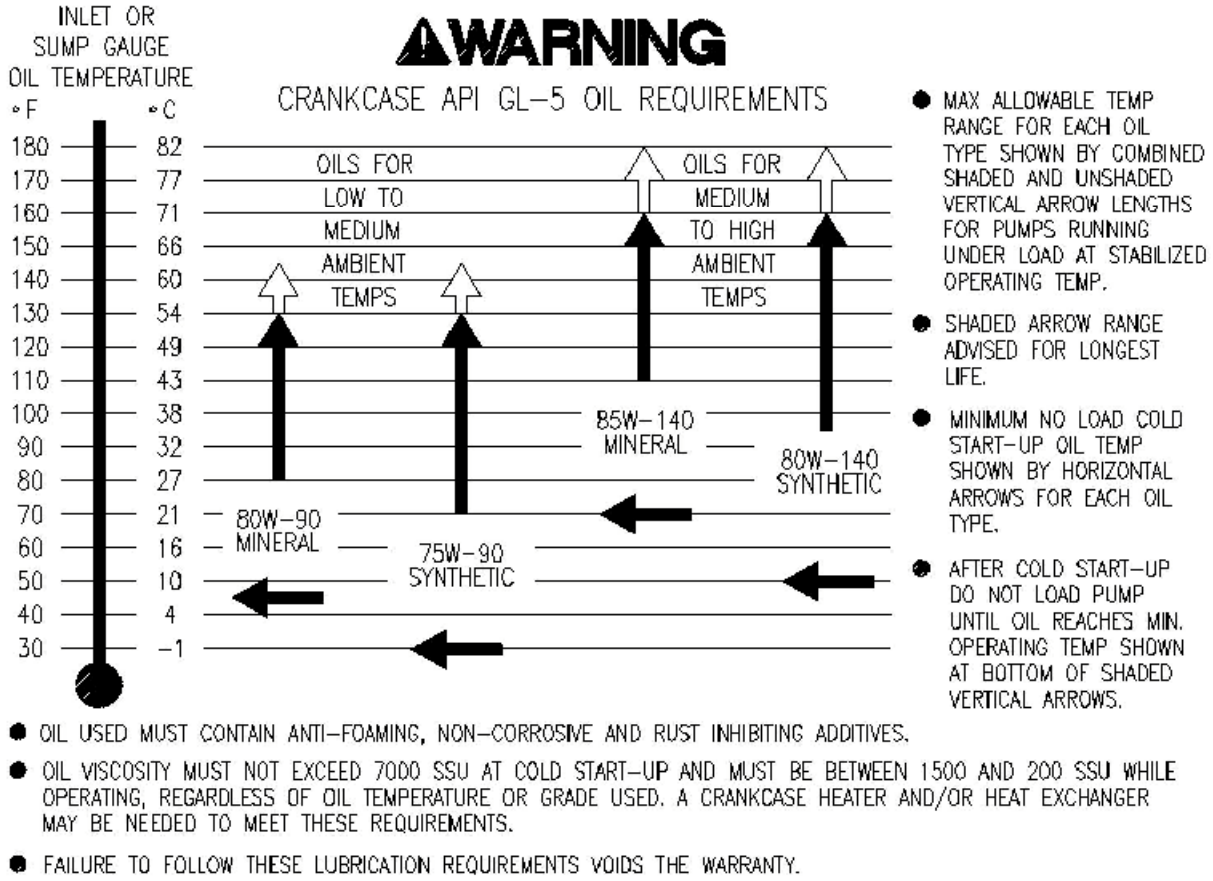
<u>Minimum</u> lube pressure : 40 psi.
Normal Temperature: 150 F.
<u>Max</u>. Operating Temp: 180 F.

<u>Minimum</u> lube flow is 20 gpm. Approximate flow is 5 gpm to gear reducer and 15 gpm to power end. <u>Design Flow</u>: 30 gpm.

Max. lube system vacuum at lube pump inlet 8 Hg.(4 psi /0.28 bar)

FIGURE 3-1 indicates API-GL5 oil grades recommended for use in the pump power end and the gear reducer lube system. Crankcase operating temperature ranges and minimum startup temperatures for each listed grade of oil for various inlet or sump temperature ranges. .

FIGURE 3-1 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 is not provided with the unit.

See "Plunger Packing Lubrication Recommendation Chart," page 20, 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 30 psi the following guidelines are presented for the maintenance personnel to follow during the critical startup and break-in period:

charge when the triplex pump operates at its maximum flow.

The first startup and several hours of the pump run-in are 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 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 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 may cause serious problems. To assist the user,

1. Fill the lube oil reservoir with recommended grade of oil. See "Power End Lubrication," and FIGURE 3-1, page 16.

2. Fill the packing lube reservoir with proper oil. See "Plunger/Packing Lubrication Recommendation Chart," page 20.

3. Remove all inspection covers on the top 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, knuckle joints, and crankshaft bearings are properly lubricated.

5. Increase the engine RPM to maximum 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 also be 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 to see whether it is adjusted properly.

9. Run at low speed to "work out" any trapped air in the fluid cylinder 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 min 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 min in each gear in the higher gear ranges pulling full horsepower in each gear. Observe closely oil pressures and temperatures, and lube oil suction vacuum.

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 strainer every 10-15 hours, till it becomes apparent that wear-in process is finished.

19. Tighten all fluid cylinder attachment nuts, procedure listed in "Fluid End Removal and Installation," page 21, after 50-70 hours of pump operation. See FIGURE 4-1, page 22.

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

21. Follow the routine maintenance schedule described in the next section after completion of the wear-in period.

PERIODIC ROUTINE MAINTENANCE 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, based on previous experience, 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 period. For the tasks performed during the wear-in period, see "Startup and New Pump Run-In Procedure," page 17.

Daily Routine Maintenance Tasks

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

2. Periodically monitor lube oil operating pressure and temperature. Minimum oil operating pressure is 40 psi. The maximum oil operating temperature depends on the particular grade of oil used. **Maximum Oil Temp is 180°F**. (See FIGURE 3-1, page 17).

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. Insure stuffing box is tightened sufficiently into fluid cylinder. Recheck tightness after extended continuous operation.

Monthly (100 hour) Routine 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 plunger seals and replace them as necessary.

Quarterly (300 hour) Routine 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 all bare metal components 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, O-rings, oil and breather filter elements, and also maintenance tools. Order to replenish supplies as necessary.

The recommended routine periodic maintenance procedures are very simple and can be performed in a short period of time. At the same time, close adherence to these procedures will ensure long, economical, and trouble free operation of the pump.

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	------

STEAM CYLINDER OILS - HIGH TEMPERATURE PUMPED FLUIDS

Source	Type
Amoco	Amoco Cylinder Oil 460
Arco	Modco Cylinder Oil 125, 175
Conoco	Inca Cylinder Oil
Exxon	Cylesstic TK-460 or TK-1000
Gulf Oil (Chevron)	Senate #375 Compound
	Security #460 Non-Compound
Mobil Oil Co.	Mobil Cylinder Oil 600W
Pacer Oil	Com-Cyl Oil
Phillips Petroleum	Hector Cylinder Oil
Shell Oil Co.	Valvata J-460
Sun Oil Co.	Occident
	Gear Oil 7-X, Gear Oil 8-C
Texaco Oil Co.	Pinnacle Cylinder Oil

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: the fluid end, the power end, and the gear reduction unit. (See Section 2) 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 cylinder assembly and proceeds to the removal and replacement of expendable parts such as valves, valve seats, and packing.

Fluid End Removal and Installation

1. Disconnect suction manifold from unit piping and discharge lines at the discharge flanges on the fluid end, plunger lubrication lines, and also any accessories such as stroke counters, pressure gages, etc. from the fluid end

2. Remove all three (3) suction valve covers, using the special hex hammer wrench furnished with the pump. (By hand, reach in, twist, and remove the suction valve stops to remove valves).

3. Unscrew and remove all three plungers with the plunger removal tool furnished with the pump. (Loosening the stuffing boxes may be helpful on newly packed pumps.)

4. Connect a hoist to the fluid end and tighten the slings 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 six (6) 12-Point Flange Screws on the outside face of the fluid end, utilizing 12 point sockets with a long break-over wrench or hydraulic torque wrench.

6. Pull the fluid end assembly horizontally forward, straight away from the power end until the stuffing boxes and adaptors are completely free from the power end pilot bores.

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 alignment and critical nature of the connection between the power end and the fluid end.

To reinstall the fluid end proceed as follows:

1. Check the three stuffing box adaptors (102443) for possible thread damage. Replace if threads are damaged. Install stuffing box assemblies.

3. The fluid end alignment is achieved by the stuffing-box adaptor-to-frame pilot-bore fit. Make sure surfaces are clean.

3. Using an overhead lift, position the fluid end in front of the power end and slide into place.

4. Lubricate the 12-Point screw threads with Never-Seize, Dow-Corning 1000 anti-seize or equivalent. Install the six screws by hand.

5. Using a hand-held torque wrench, or hydraulic torque tensioning tool, torque the four (4) 1-3/8" 12-Pt. Screws to 1300 ft.-lbs., and the 1" 12-Pt. Screws to 500 ft.-lbs. Re-check all torques.

6. Re-install the plungers, piping connections and auxiliary equipment.

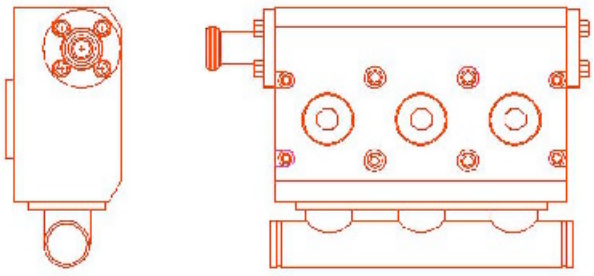


FIGURE 4-1 COMPACT Fluid End

Plunger and Packing Replacement

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

1. Remove the suction valve covers with the appropriate hex. Tool provided.

2. The plunger is now exposed. (Remove the suction valve stop to access valve.)

3. Loosen the stuffing box and unscrew the plunger, using the plunger removeal tool. Remove the plunger through the front of the fluid end.

4. Remove the stuffing box and place packing-side up on a work table.

5. Remove all packing and brass from the stuffing box bore.

6. Before repacking the pump, check the plunger, brass, and stuffing box bore for excessive wear or damage.

7 Install packing and brass in the stuffing box with the packing lips facing out (see FIGURE 4). Install seal ring.

8. Clean and Anti-Seize the stuffing box threads, check the stuffing box seals, and screw the stuffing box in hand-tight.

9. Slide the plunger thru the cylinder and the stuffing box, making up tight against the crosshead.

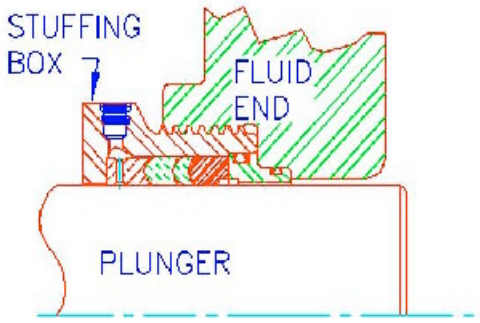


FIGURE 4-2 Packing Assembly

10. Install the suction valve, spring, & stop.

11. Tighten the stuffing box with the tool provided with the pump.

12. Replace the suction cover seal if the seal shows any damage or cuts.

13. Check the fluid end suction cover seal area for damage. Clean and polish if necessary.

14. Add grease to the cover seal, and install the suction covers.

15. The suction covers MUST be maintained tight during operation to prevent seal leakage, as well as thread fatigue. This is accomplished using the hammer wrench provided with the pump and a 10 pound sledge hammer.

16. Re-connect the lube lines.

Stuffing Box Replacement

This procedure is to be performed if it is determined that the plunger size must be changed to meet job performance requirements.

1. Follow steps 1 through 3 of the "Plunger and Packing Replacement" section on page 22.

2. Be sure to remove the plunger lubrication lines from the stuffing box.

3. Support the stuffing box using a nylon sling attached to a hoist, or a thin metal band that is hand-held.

4. Loosen the stuffing box using the stuffing box wrench.

5. Carefully remove the stuffing box from the cradle area by lifting up with the sling or metal band.

6. Place the stuffing box packing-side up on a work table.

7. Remove the seal-ring from the stuffing box (or cylinder, if it remained in place.)

8. Complete packing installation by following steps 5 thru 7 of the "Plunger and Packing Replacement" section on page 22.

9. Lubricate the stuffing box threads with Dow-Corning 1000 anti-seize or equivalent.

10. Install sling on stuffing box and position to install in the fluid end.

11. Hand-tighten the stuffing box in the fluid end. Install plunger. The stuffing box will "bottom out" in the fluid end bore when tightened properly.

12. Repeat this procedure for each cylinder.

Valve and Seat Replacement

This procedure may be performed with the fluid end on the pump.

WARNING

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

Before starting, make sure that special tools required for this procedure are available. For part numbers of the tools see the Parts Manual.

1. Remove the discharge valve covers with the tool provide with the pump, and a 10 pound sledge or other hammer.

2. You should now be able to remove the discharge valves and springs by hand.

3. Remove the suction covers, taking care not to damage the seals.

4. Remove the suction valve stops by twisting until they become free.

5. The suction valve spring and suction valve are now easily removed by hand.

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.

8. Be sure the O-ring is installed on the seat and snap the valve seat into the taper by hand to fit tightly.

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

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

11. Reinstall the suction and discharge valves and springs and suction valve stops, depressing the spring and twist.

12. Install new seals for the discharge cover and reinstall the cover.

13. Install the suction valve covers. With the hex. Tool provided with the pump, tighten all covers securely.

14. Run the pump at or near maximum discharge pressure to secure the valve seats into the fluid end tapered bores.

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.**

The power end service procedures deal first with major assemblies, namely connecting rods, crossheads, crankshaft, and gear reducer assemblies and then describe how to access all individual parts.

TO REPLACE A ROD BEARING:

1. **Disconnect the pump drive and remove the side and rear covers.**
2. **Remove the rod cap. The rod and cap are match-marked for correct reassembly, with two dowel pins.**
3. **With a rubber hammer or wooden hammer handle, tap on the edge of the bearing to remove it.**
4. **Check the following at reassembly: (a) bearings and crankshaft must be clean and have at least a 16 RMS finish, (b) match-marks line up and dowel pins are in place, (c) the rod bearing is free to move on the crank.**

TO REPLACE CROSSHEAD AND SLIDES:

NOTE THAT CROSSHEAD WRIST PIN MUST BE INSTALLED OPPOSITE GEAR REDUCER SIDE FOR PROPER LOADING.

1. Steps 1 thru 3 above.
2. Remove wrist-pin retaining plate.
3. Remove wrist pin using slide hammer.
4. Roll pump until conn. rod is free of crosshead, and roll crosshead out the side of the pump, conn. Rod out rear.
5. Remove crosshead slide bolts and slides. (Disconnect lube lines to slides.)
6. Replace slides, roll crosshead into place from the side, and check clearance between crossheads and the slides. The diametrical clearance should be 0.010” to 0.016”.
7. If clearance is less than 0.010”, replace the crosshead or slides, or lap to size.
8. If the clearance is more than 0.016”, add shim stock between the slide and main frame to obtain the 0.010” to 0.016” clearance.
9. Loctite the two internal slide capscrews, one at a time. See Torque Chart in back of this manual.
10. Re-connect the slide lube lines.
11. (The connecting rod assmy, and crosshead should be marked as a set.)

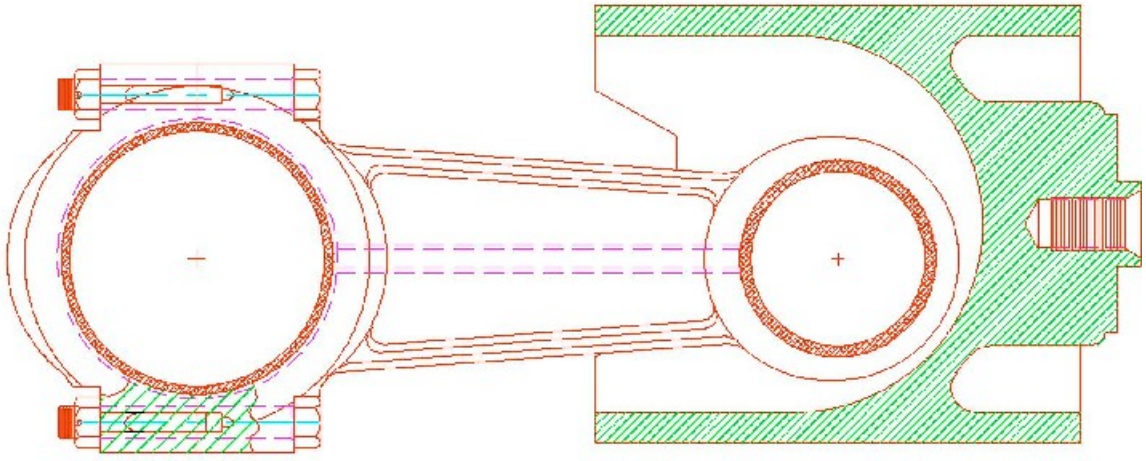


FIGURE 4-3 Crosshead Assembly

12. The clearance between the connecting rod bushing and the crosshead pin should be 0.002" to 0.006".
13. If the clearance is more than 0.008" replace the bushing and/or wrist pin.

TO REPLACE GEAR REDUCER:

1. **It is recommended that the gear reducer be removed as a unit.**
2. **Remove the pump from its mounting.**
3. **Support the gear reducer with an overhead lift.**
4. **Remove the gear reducer by disconnecting the lube line and removing the eight (8) 7/8" Hex. Nuts.**
5. **Using the jack-screw holes, slowly remove the gear reducer assembly.**
6. Install the new gear reducer to the main frame on the splined end of the crankshaft. Add enough gasket material between the main frame and the gear reducer to insure free rotatin of the crankshaft when the reducer is tightened in place. (The end main-bearing will be end-loaded if insufficient gaskets are used).
7. Re-connect the gear reduce lube line.
8. Rotate the power end slowly, and check to see that all parts are operating and oiling properly, before replacing covers.

TO REPLACE CRANKSHAFT AND MAIN BEARINGS:

1. Remove the gear reducer as described above.
2. Remove the connecting rods and crossheads as described in "TO REPLACE CROSSHEADS AND SLIDES."
3. Remove the end main bearing housing and inside main bearing retainers from the main frame.
4. One bearing is a held bearing. With the bearing retainers removed, the crankshaft is now free to SLIDE OUT OF THE FRAME (toward the splined-end). USE CAUTION TO PREVENT INJURY. Remove crankshaft carefully.
5. Bearings and races are now exposed for removal. Using a torch, rapidly heat the bearings one at a time and remove from the main shaft.
6. The bearings and races will have to be driven from the main-frame using an aluminum or brass bar and hammer.
7. The bearings can be removed from from the aluminum housing by first blocking up the housing, then heating the

housing with a torch and allow the bearing to drop out the bottom.

8. NOTE THAT one of the bearings is a held bearing, and should be installed on the crankshaft next to the splined end.
9. Uniformly heat the bearing races and place on the crankshaft. Bolt the inner race bearing retainers to the crankshaft to secure the two center bearing inner races in place.
10. Chill the outer races prior to installation in the main frame. Use caution when installing the held bearing outer race, making sure to locate it on the gear-reducer side of the pump, opening facing OUT toward the gear reducer.
11. Insert the crankshaft into the main frame. The axial position of the crankshaft is secured by the one held bearing.
12. Install the ourter race retaining ring on the held center main bearing.
13. Bolt the outer race bearing retainers to the main frame to secure the two center bearing outer races in place. A varing amount of shim stock will have to be placed tetween each retainer and the main frame. Allow approximately a 0.005" squeeze on each race when the capscrews are tight.
14. After the bearing retainers are in place, rotate the pump to check for free rotation.
15. Install the end bearing housing on the main frame. Add enough gasket material between the main frame and the housing to insure no end-loading of the outside main bearing.
16. Rotate the power end slowly and check to see that all parts are free.
17. Install the connecting rods and crosshead as described earlier in this section.

GEAR REDUCER:

1. See TO REPLACE GEAR REDUCER to remove reducer from pump.
2. The gear reducer has four tapered roller bearings: two on the gear and two on the pinion.
3. The covers must be removed to replace the gears or bearings.
4. With the gear reducer laying with the input shaft facing up, remove the drive flange and both gear retaining covers.
5. Remove the cap screws and nuts holding the gear reducer together.
6. Remove the gear cover, taking care not to damage the dowell pins.
7. Both the gear and pinion are now free to be removed from the housing.
8. The bearings and races may be removed using a brass bar and hammer.

NOTICE

WARNING

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

9. Uniformly heat the inner bearing races and install on the gear and pinion.
10. Allow bearings to cool.
11. Install outer races in housing and cover.
12. Install gear and pinion in gear housing.
13. Install gear cover, aligning with dowell pins.
14. Install all cap screws, lock washers and nuts retaining the gear cover.
15. Shims will be required when installing the bearing covers. Both tapered bearings require approximately 0.003" to 0.005" preload. DO NOT ALLOW BEARINGS TO RUN LOOSE.
16. After installing bearing retainers, check for free rotation of the gears. Re-check the pre-load to insure that the preload is within the approximate range given.
17. Re-install on power end.

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. Insure 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 cylinder.	5. Check plunger for proper length.
	6. Frozen fluid in cylinder.	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, RECOMMENDED RUNNING CLEARANCES AND TORQUES

REBUILDING DATA FOR COMPACT PUMP (in.)

PUMP STROKE	6 Inches
Crankshaft Throw Diameter	5.249 / 5.250
Crankshaft Shaft Diameter at Main Bearing	11.5034 / 11.5022 & 8.0026 / 8.0014
Distance Between Main Bearing Centers	9”
Bore in Frame for Inner Main Bearings	15.2482 / 15.2496
Bore in Hsng. & G.R. for Outer Main Bearings	10.7484 / 10.7500
Connecting Rod Centers	9”
Connecting Rod Bearing Bore	5.294/5.295
Crosshead Guide Bore	11.005/11.009
Crosshead	8.985” / 8.983”
Wristpin	3.500” / 3.499”
Wristpin Bushing Bore	3.505” / 3.506”

RECOMMENDED RUNNING CLEARANCES – ACTUAL

	New (in.)	Maximum Allowable Wear Limit (in.)
Connecting Rod Bearing to Crankshaft	.005/.008	.016
Main Bearing Installed Clearance*	.0000” / .0063”	.012
Crosshead to Guide*	.010” /.016”	.045
Crankshaft End-play	.005/.015	.030
Pinion Bearing Pre-load	-.003” /-.005”	+.003
Gear Reducer Main Bearing Pre-load	-.003” /-.005”	+.003
Wrist-Pin-to-Bearing Clearance	.004”/.007”	.020

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

COMPACT PUMP

TORQUES

DESCRIPTION	FASTENER	FOOT-LBS. TORQUE W/ LOCTITE	FOOT-LBS. TORQUE W/ ANTISEIZE
Main Bearing Retainers	3/8" – 16	19	-
Rear and Side Covers	3/8" – 16		16
	1/2 "- 13		45
Rod Cap to Rod	5/8" - 11		110
Crosshead Guide to Frame	5/8" – 11	80	-
Suction Manifold to Fluid End	3/4" - 10		160
Main Bearing Housing/Gear Reducer to Frame	7/8 - 9		315
Discharge Flange to Fluid End Nuts	1" - 8		475
Plunger / Pony Rod to Crosshead	1" - 8		475
Fluid Cylinder Screws (fluid-end to frame)	1" - 12		500
	1-1/8"- 7		675
	1-1/4"- 7		955
	1-3/8"- 8		1080
Fluid Cylinder Screws (fluid-end to frame)	1-3/8" -12		1300
	1-5/8"- 8		2300
	1-3/4 "- 8		2400

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 cylinders 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 cylinder 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