Weatherford®

Operations & Maintenance Manual

Model E-447 Triplex Pump

Manual Part Number 1822325

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Chapter 1: Introduction

This manual is designed to provide instruction in the use of the Weatherford E-447 pump. All personnel tasked with pump operation and maintenance should study all relevant sections in order to ensure the pump continues to operate at peak efficiency.

1.1 Product Details

The Weatherford E-447 Pump is a single acting triplex piston pump rated at 440 horsepower in continuous duty service. It is offered in a wide variety of design options, and as a result, some components may vary from unit to unit. Check the specifications sheet included with this manual to determine the exact configuration of your particular pump.

1.1.1 Specifications

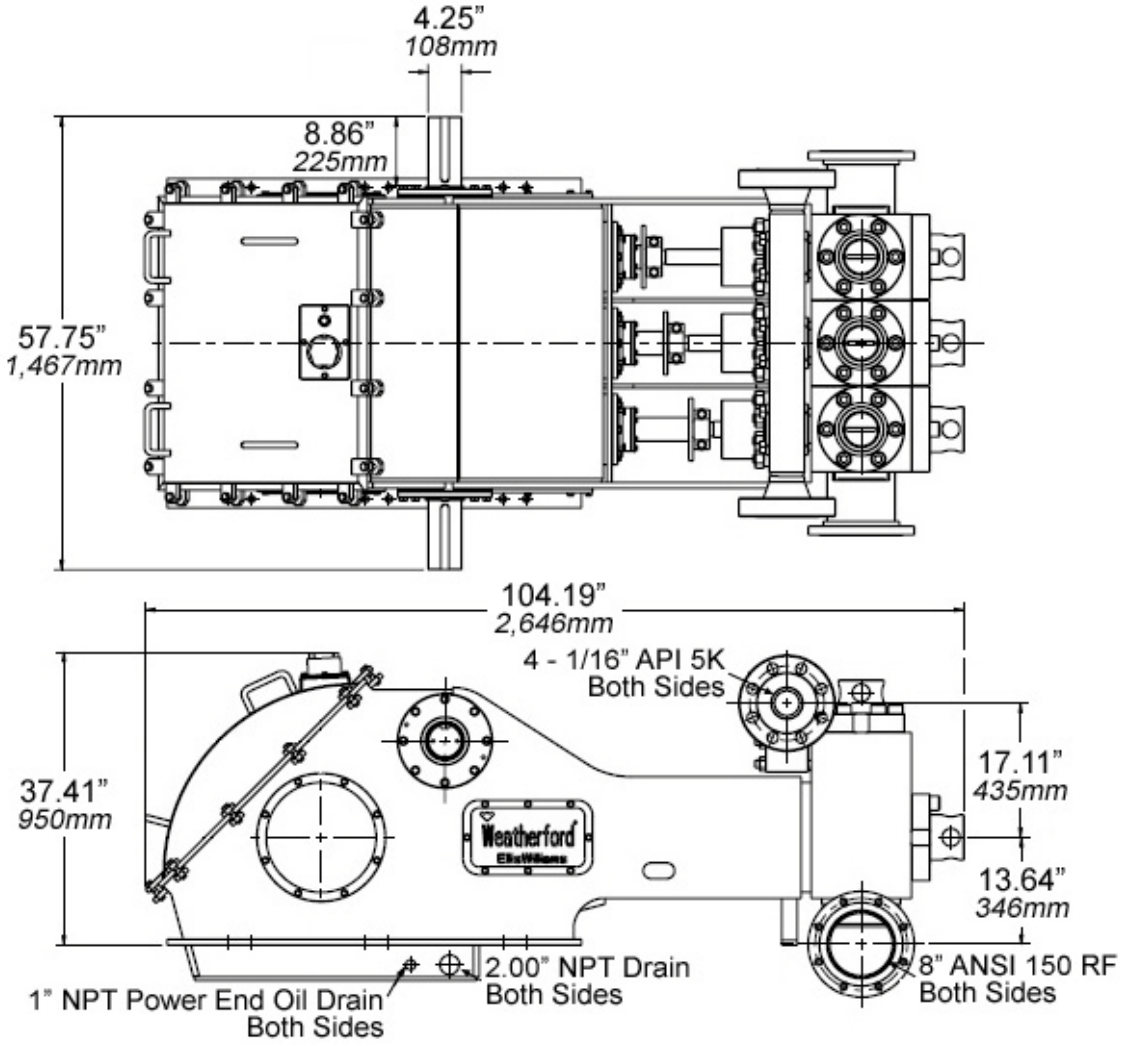
General Information	
Pump Type	Triplex
Pump Weight	13,080 lbs.
Oil Capacity	40 gal
Max Fluid Temp.	180° F
Mechanical Efficiency	95%

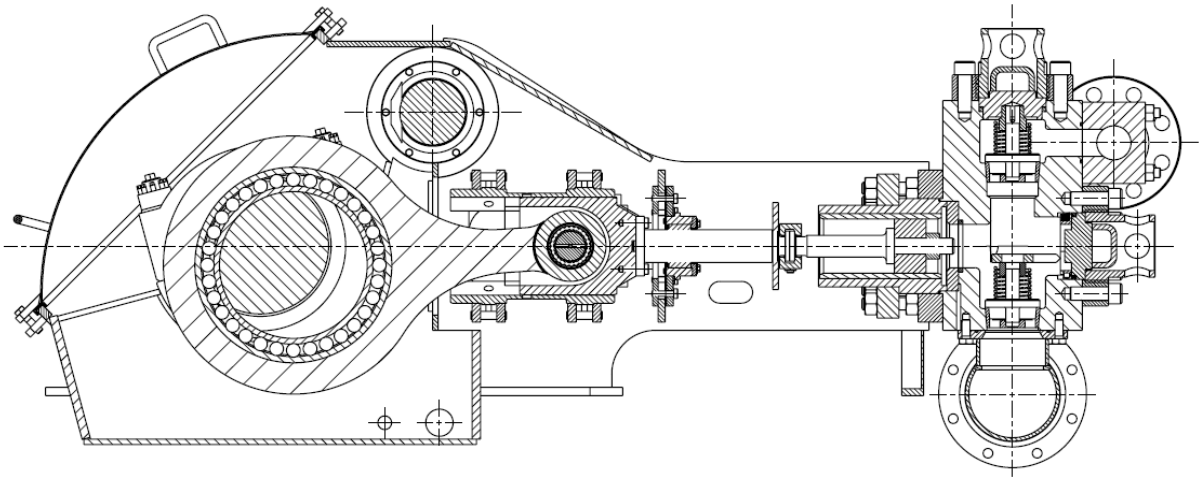
Operational Statistics	
Maximum Rated Power	440 HP
Maximum Discharge	5,000 psi
Maximum Rated Speed	220 RPM
Minimum Rated Speed	5 RPM*
Stroke Length	7.00 IN

Piston Size (in/mm)	Output (gal/rev) (l/rev)	Rated Pressure (psi/Mpa)	Rated Capacity GPM (BPD)					
			220 RPM *440 HP*	200 RPM *400 HP*	170 RPM *340 HP*	140 RPM *280 HP*	110 RPM *220 HP*	80 RPM *160 HP*
6.000 *152*	2.570 *9.729*	1,267 *8.736*	565 *19,369*	514 *17,621*	437 *14,981*	360 *12,341*	283 *9,702*	206 *7,062*
5.500 *140*	2.160 *8.176*	1,508 *10.397*	475 *16,284*	432 *14,810*	367 *12,581*	302 *10,353*	238 *8,159*	173 *5,931*
5.000 *127*	1.785 *6.757*	1,824 *12.576*	393 *13,473*	357 *12,239*	303 *10,387*	250 *8,570*	196 *6,719*	143 *4,902*
4.500 *114*	1.446 *5.474*	2,252 *15.527*	318 *10,902*	289 *9,907*	260 *8,913*	202 *6,925*	145 *4,971*	101 *3,462*
4.000 *102*	1.142 *4.323*	2,851 *19.657*	251 *8,605*	228 *7,816*	194 *6,651*	160 *5,485*	126 *4,320*	91 *3,120*
3.500 *89*	0.875 *3.312*	3,723 *25.669*	192 *6,582*	175 *6,000*	157 *5,382*	122 *4,182*	87 *2,982*	61 *2,091*
3.000 *76*	0.643 *2.434*	5,000 *34.474*	141 *4,834*	129 *4,422*	109 *3,737*	90 *3,985*	71 *2,434*	51 *1,748*

* For operations below 30 RPM, an auxiliary power end lubrication system is required.

1.1.2 General Dimensions





1.2 Scope

This manual is intended to provide instruction and guidance on standard and frequently used procedures and processes regarding the E-447 pump. These include the setup and installation of the system, basic operations, storage, routine maintenance and basic troubleshooting, as well as a parts list for the various components of this system.

The information contained in this document has been expanded to include not only the core systems and functions of the E-447 pump, but also optional features that may be incorporated into the system. This information is included to ensure that the guidance provided remains applicable in most expected operating conditions and situations. As a result, some of the features described may not be present on a specific unit, and allowances should be made accordingly.

This document was designed for use by pump operators, maintenance personnel and other personnel familiar with the equipment and its expected use. As such, this document will not go very deeply into theory and basic processes, but will focus primarily on equipment-specific issues and procedures. Individuals without proper training or experience should always have experienced personnel supervising their use of this or any other powerful and potentially hazardous equipment.

This manual has been prepared with the system's expected uses in mind. For help with events, situations and uses not typical to this system, or for advanced troubleshooting issues, please contact your local Weatherford representative.

1.3 Manual Organization

This manual has been laid out in accordance with the expected need of its users. It is divided into four sections, each of which is intended to cover one aspect of the equipment's use and functions.

Chapter 2: Storage & Installation covers the non-operational aspects of using and maintaining the system, from basic storage to installing the system on location.

Chapter 3: Operations covers the basic operating procedures, from the standard startup sequence to the general operations procedures and troubleshooting tips.

Chapter 4: Maintenance covers all aspects of the regular preventative maintenance that will help to ensure that the system operates at peak efficiency for as long as possible, including the tools used, operational guidelines and basic replacement procedures.

Chapter 5: Assembly & Disassembly covers the assembly and disassembly of the pump and its components, including advanced repair and replacement procedures.

Chapter 6: Glossary provides a list of standard terms and definitions regarding triplex pumps in general and the E-447 pump in particular.

Chapter 7: Parts Lists provides a comprehensive inventory of all the standard components used in the E-447 pump.

1.4 Safety Summary

Every year, the Unites States Occupational Safety & Health Administration (OSHA) receives reports of millions of worker related injuries and deaths associated with the use and misuse of mechanical and industrial equipment. Many of these incidents occur due to either carelessness on the part of the operator or as a result of the operator not understanding the equipment and processes he or she was using. In many cases, such incidents could have been prevented through the use of basic, commonly-accepted safety procedures.

When working with industrial equipment, or indeed at any time you are working, it is important to employ all appropriate safety measures. These exist not only to protect the operator of the equipment, but also co-workers, supervisors, contract personnel and anyone else who happens to be in the area where the work is being performed.

Always use good, sound mechanical practices when working with equipment, and as an absolute minimum, follow all safety guidelines outlined below. Failure to follow the established safety guidelines can result in damage to equipment, employee injury and/or death.

At the same time, it is important to remember that no set of procedures is perfect. While these guidelines should help to significantly reduce the chance of an incident, they are no match for an aware and reasoning human mind. Always use your best judgment, and if something seems unsafe or dangerous, do not do it.

1.4.1 Safety Symbols and Terms

Throughout this document, you will regularly see a number of information boxes labeled with safety-specific terms. These are the standard terms and conventions that will help to ensure the safety and health of those working with or near this equipment. It is important to make sure that the operator and others know what each one means.

WARNING	WARNING safety notes MUST be followed carefully. Failure to do so may result in catastrophic equipment failure, serious injury and/or death.

CAUTION	CAUTION safety notes are very important and should be followed carefully. Failure to do so may result in equipment damage and/or personal injury.

NOTE	NOTE safety notes are used to notify personnel of information that is important, but not hazard related.

1.4.2 General Safety

The following are general safety practices which should always be used when working.

Qualified Personnel Only

Personnel without a thorough understanding of all processes and procedures required to operate and maintain equipment can unintentionally create hazards for themselves and others. Only individuals with proper training should ever operate or perform maintenance on industrial equipment in a workplace environment. This includes not only the appropriate procedures for the equipment being used, but also requires an understanding of all attached systems, equipment in the area, and general safety and hazard recognition training.

Equipment Ratings & Guidelines

Always follow all of the manufacturer's instructions when using a piece of equipment or machinery. Never use any equipment or machines for any purpose for which they are not specifically designed without first receiving approval from the manufacturer. When using equipment and machinery, always ensure it is properly rated for the work performed, and never exceed the listed ratings and guidelines.

Safety Systems & Countermeasures

All equipment should have guards and other safety systems to protect personnel from exposed moving parts and other dangers. It is the responsibility of every employee on site to ensure that all safety systems and countermeasures are in place, secure and effective.

Lock Out Tag Out

Before performing repairs or maintenance on any industrial equipment, you should always follow standard "Lock Out Tag Out" procedures. This includes not only shutting down the equipment, but also isolating it from any potential power sources (electric, hydraulic, mechanical etc…). In addition, be sure to lock controls and tag the equipment as under maintenance to ensure that it is not accidentally reconnected or activated by a third party. Never activate systems tagged out of service.

Environmental Hazards

Never attempt to perform work in an environment in which your senses are significantly impaired, that is, if you cannot adequately visualize the area you are working in, the work you are performing, or you cannot be adequately alerted to potential dangers and hazards.

Appropriate Dress

It is the responsibility of employees to ensure that their clothing, hair and accessories do not pose a potential safety hazard when on the job. In industrial environments, this includes, but is not limited to, wearing all appropriate clothing and PPE, keeping hair short or restrained, avoiding loose clothing or jewelry like skirts or ties. Consult with the site supervisor or safety coordinator to ensure you meet all safety requirements.

Exercise Good Judgment

Especially when working in an industrial environment, it is important to remain alert and aware to avoid causing or entering potentially hazardous situations. Always be alert for potentially unsafe activities and situations, and do not attempt to work or operate equipment when sick, taking certain medications or in any other circumstances in which your senses or your judgment is in any way impaired.

1.4.3 Common Hazards

The following are major risks and hazards that may occur in an industrial environment. Each of the following is a WARNING level hazard, meaning personnel should obey all regulations or risk serious injury or even death.

Securing Equipment

Unsecured equipment can shift and move during operation, not only causing damage to the components but serious injury or death to personnel. All truck, trailer or skid mounted equipment should be secured with blocks and/or moorings prior to use, which should be inspected for damage before equipment is activated.

Hoisting and Lifting Equipment

Equipment that swings or falls while being hoisted can crush body parts caught between the equipment and other objects, causing serious injury and death. Always use lifting equipment not only rated for load to be lifted, but also complying with all applicable regulations, both governmental and corporate.

Before lifting, check to ensure that all parts of the load are secure. Any time a piece of equipment is being hoisted or lifted; all personnel should clear all locations in which the equipment could swing, fall or any combination of the two.

Drive Systems

Drive systems can catch on body parts and loose clothing, dragging personnel into the system and inflicting serious injury or death. When working with drive systems, keep all guards in place and in good condition, and keep hands and clothing clear of the drive system cavity at any time when the drive is in motion.

Hydraulic & Pneumatic Systems

Hydraulic and Pneumatic systems operate by means of high-pressure fluids that can cause serious injury or death if vented improperly. Avoid striking or puncturing any hydraulic or pneumatic components or connections. When performing any work on these systems, even tightening a leaking joint, fitting or connection, slowly drain to zero pressure before commencing work, and disconnect and tag systems as “Out of Service.”

Electrical Systems

Most electrical systems contain high voltage current which can cause serious injury and death when improperly grounded. Avoid striking or puncturing any electrical components or connections, and ensure that the power is turned off, the system is disconnected and that it is tagged out of service before commencing work.

Lubrication & Filtration Systems

Failure to properly maintain lubrication and filtration systems can result in various types of catastrophic system failures which themselves can cause serious injury and death. Institute a complete lubrication program at regular intervals, and inspect all systems before operation.

1.4.4 Pump Specific Safety

The following are standard guidelines and practices which should be used when working with the E-447 triplex pump.

Disengage / Vent Pressure

As per standard Lock Out Tag Out procedures, be sure to completely shut down the pump and vent all pressure from the pump and piping before performing any work on the equipment, and tag all equipment being worked on as “Out of Service.” Failure to do so may result in electrical shocks, crushing injuries or the sudden release of potentially hot fluids at high pressure.

Pressure Relief

Never operate the pump without a pressure relief valve, rupture disk or other type of over-pressure safety device installed. All such equipment must be properly sized and fitted before they are used, and operators must ensure that there are no valves of any type between the pump and the safety device.

Fluid, Lubricant & Solvent Use

Only use fluids, lubricants or solvents approved for the equipment. Always exercise extreme care when using solvents to clean or degrease equipment. Many solvents are flammable or toxic, and some solvents may damage or deteriorate system components. Both of these conditions can lead to system failures and injury, so be sure to use only approved solvents, read all safety precautions before using and follow all appropriate procedures. Never mix fluids, lubricants or solvents.

Fluid, Lubricant and Solvent Disposal

Follow all normal health and environmental guidelines when disposing of fluids, lubricants or solvents. In the event of a spill, follow the appropriate steps and procedures to ensure the spill is cleaned up with minimal risk to fellow employees or the local environment.

Return Connector

The hydraulic tank return connector must be connected before the system is operated. Failure to do so can cause reservoir drain, fluid starvation and equipment damage.

Polished Areas

Never grip polished areas with tongs or other gripping devices, as it can result in equipment failure and potential injury.

Shields and Covers

When pumping hot fluids, it is important to always use shields and covers to protect service personnel from any accidental exposure.

Guards

Likewise, guards should always be used on belt drives, couplings and shafts to prevent personnel or objects from becoming entangled in rotating or reciprocating parts. Failure to do so can result in severe injury or death.

Battery Connections

Ensure the battery connections are made up to the positive (+) terminal only. Failure to do so can result in equipment damage and potential injury.

Zerk Fittings

Do not leave Zerk fittings installed on this high-pressure equipment, as the extreme pressures handled by these systems can cause the Zerk check ball to blow out.

Teflon Tape

In general, it is better to use pipe sealant over Teflon Tape due to the chance of pieces of the tape coming loose and clogging the lube system. However, if the situation mandates the use of Teflon Tape, always start the wrap two (2) or more threads from the opening to prevent Teflon contamination of the hydraulic system.

Do Not Modify

Never modify the pump to perform beyond the rated specifications or use substitute parts or components without first consulting and receiving written consent from Weatherford. Failure to do so may put too much stress on certain components, which can result in catastrophic equipment failure, serious injury and/or death.

Chapter 2: Storage & Installation

This section shall provide a basic guide to all of the non-operational aspects of utilizing the E-447 triplex pump. It includes general guidelines and procedures for installing the pump, as well as a general guide to storing the equipment, including recommendations for dealing with severe environments.

2.1 Installation

The proper installation of the E-447 triplex pump is essential to ensuring optimal performance and a long service life, as well as significantly reducing required maintenance. This can require some precise values, and so it is important to plan ahead before the pump is brought to location and the rig-up is made. It is difficult, expensive and time consuming to correct errors in piping, pulsation dampener mounting and tie downs after they have been fabricated and welded in place.

The following outline is intended to provide a guide to choosing a location and installing the pump, and so all aspects should be considered and planned out before installation begins.

2.1.1 Location and Orientation

In order to improve performance and minimize maintenance issues, the pump should be placed in a clean, dry, well-illuminated and well-ventilated location, and placed horizontally on a flat, level surface in order to ensure proper operation and lubrication. Also ensure that the mounting surface is at least strong enough to withstand the forces and vibrations generated during pump operations.

The pump should be secured using clamps or the bolt holes provided in the skid base. Ensure that the pump is mounted flat and level and that the pump is properly secured.

If there are any gaps between the pump skid and the foundation, always shim to the skid. Never draw the skid down to the foundation.

CAUTION	Always make sure pumps are mounted on a level surface and are locked down evenly. Failure to do so can place unnecessary strain on both the frame and the pump, which can result in equipment damage and potential injury to personnel.

2.1.2 The Prime Mover

Before locking the pump into position, check that the prime mover has been aligned properly in relation to the pump.

Once mounted, confirm that the pump rotation is set to drive the top of the crankshaft towards the fluid end, as this will go a long way towards establishing proper splash lubrication and crosshead loading. Then verify that no damage has occurred to the components and systems, including all safety devices and guards.

> **CAUTION** Never operate the pump without proper guards in place.

Belt & Chain Drives

For belt and chain-driven units, check the alignment of the sheaves after the unit is installed but before the belt or chain is tensioned. It is critical that the grooves are aligned on both sheaves, and that the faces of the sheaves are square, as this will assure the user that the driver shaft and pump shaft are parallel.

To check sheave alignment, first ensure that the sheaves are correctly mounted. If the sheaves are correctly installed, simply pull a string across the centerline of the two sheaves, extending it all the way to each end. If the sheaves are correctly aligned, the string should contact each sheave in two places.

If the string does not make the appropriate four points of contact, square the motor alignment to bring the string into the desired position. Doing so ensures that the motor shaft and the pinion shaft are running parallel to one another, significantly improving operational efficiency.

Belts or chains should be tensioned as recommended by the supplier. Do not exceed the recommended tension rating, as it can result in damage to the shafts. Once tensioned, perform a final alignment check and ensure all mounted bolts are secure.

Direct-Coupled Installations

For direct coupled installations, ensure that the coupling is secure, then install all cages and guards and secure into position. Check the parts list sheet that came with this particular unit for recommended guards and cages used. Do not operate pump with loose cages or guards.

2.1.3 Suction System

Single acting reciprocating pumps perform best when supplied with an appropriate level of fluid. Inadequate fluid supplies may lead to cavitation, which is one of the primary causes of premature pump failure. When setting up the pump, it is very important to ensure that there is sufficient fluid running through the pump at all times.

The fluid supply tank should be large enough to allow dissolved air and other gases to escape from the liquid, and allow suspended solids to settle out before entering the pump. For this reason, a system employing dams and settling chambers is desirable.

Charging Pumps

A centrifugal charging pump should be used to boost fluid supply and ensure proper operations. This pump should be sized to 150% of the main pump volume for the largest piston size expected to be used to allow for the varying flow demands of the triplex pump. The charging pump should be set to ensure the suction manifold pressure is between 25 and 50 PSI to ensure maximum volumetric efficiency and expendable parts life, but should never exceed 60 psi, as this will float the suction valves.

The charging pump may be driven using V-belts or chains off the mud pump input shaft, but this is not recommended as it makes mounting the pump and inlet system piping difficult, and may not provide sufficient RPMs to the charging pump for proper operation when the mud pump is operating at lower speeds. For this reason, it is recommended that a booster pump be used, powered by an electric AC motor.

The mud pump control panel should be configured so that the mud pump cannot be started until the charging pump is running and has developed at least 25 PSI. For full operating instructions and guidelines for using a particular charging pump, see the documentation provided by the manufacturer.

Piping

The suction piping can be connected to any of the available flanged connections on the suction manifold. The length of the suction piping should be minimized as much as possible to enhance pump efficiency, and utilize 45° long radius elbows to help reduce frictional pressure drops at the inlet. The suction piping should be supported to prevent unnecessary loads on the pump suction manifold.

Common Suction Manifolds

Two or more pumps can have their suction connections made to a common manifold provided that the manifold has a cross-sectional area greater than the sum of the individual pump inlet areas.

NOTE Never use a common manifold with a smaller cross-sectional area than the sum of the individual pump inlet areas, as this will significantly decrease the efficiency of all the pumps used.

Gauges and Meters

It is recommended that a pressure gauge be installed at the pump suction, and a low-suction pressure alarm be mounted in the suction line. However, do not install any metering device that causes a flow restriction on the suction piping. For full operating instructions and guidelines for this equipment, see the documentation provided by the manufacturer.

Suction Stabilizer

A suction pulsation dampener should always be utilized, as it will significantly extend the pump's operational life and efficiency. This system will typically be installed directly inside the suction manifold, though external models are available. Pre-charge the pulsation dampener to 15 psi using a hand operated air pump, adjusting as necessary to maximize the smoothness of the operation. Valves or turns should never be placed between the suction line pulsation dampener and the suction manifold inlet.

WARNING	The use of a high pressure source or nitrogen bottle to charge the suction line pulsation dampener can result in catastrophic equipment failure and serious injury to personnel.

WARNING	Do not use air to fill bladder, especially when pumping flammable fluids, as it may combust and cause catastrophic equipment failure and serious injury to personnel.

For full operating instructions and guidelines for this equipment, see the documentation provided by the pulsation dampener manufacturer.

Line Valves

Only full open valves should be used on the suction line to prevent any reduction or interruption of flow and thereby ensure the efficient operation of the pump. Drain valves should be installed at the lowest point in the piping, while vents should be located at the highest point available. Do not under any circumstances use any valve that has the potential to choke the flow of fluid through the line.

Suction Pressure Relief Valve

It is recommended that a suction pressure relief valve be used in the suction line to prevent damage to either pump in the event of a high pressure surge occurring in the line. It is recommended that the valve be located on the suction manifold of the pump, but may be located elsewhere on the suction line at the customer's discretion. The outlet line from the relief valve should gradually slope down to the tank level, and should be supported to prevent any dips or low spots where mud could collect, harden and potentially block flow.

The relief valve should be set to 50% greater than the normal operating pressure (70 psi for normal operations, but this value may vary depending on the specifics of the job).

WARNING	The pressure relief valve outlet must not connect back to the pump suction line. This can cause uncontrollable pressure surges, which can result in equipment damage and significant injury to personnel.

2.1.4 Discharge System

The discharge piping is subject to damage due to the pulsations from the pump as well as loads imposed by thermal expansion of the pipe. Generally, a single pulsation dampener should be sufficient to handle such loads, but in cases of high output rates, two pulsation dampeners may be required. By correctly handling these issues, the user can improve the pump's overall performance and longevity.

Strainer Cross

The discharge piping setup can be simplified by using a Strainer Cross. This system provides two outlets for mud lines, a mounting for the discharge pulsation dampener and incorporates a side connector for mounting a pressure gauge. In addition, it provides easy access to the strainer, which should be checked and cleaned at least once a month.

Alternately, a standard discharge cross is available, which has many of the above benefits but does not include a strainer.

The complete assembly may be flanged directly to either side of the pump discharge manifold and is provided with an integral support mounted between the cross and the pump skid. For full operating instructions, see the documentation provided by the manufacturer.

Piping

All discharge piping should be the same size as the outlet on the pump. Gradual turns should be used to prevent unnecessary frictional pressure buildup and pipe erosion, and no immediate turns next to the pump discharge should be used. 45° long radius elbows should be used to minimize flow frictional pressure concerns. Furthermore, discharge piping should be supported, but allowed to move along the axis of the pipe to ensure that any thermal expansion will not unnecessarily load the fluid end connections.

Discharge Pulsation Dampener

A discharge pulsation dampener should always be utilized, as it will prevent harmonic vibration from damaging the discharge piping and significantly extend the pump's operational life. This system should be mounted on a discharge cross or strainer cross flanged directly to the discharge manifold, before any valves or turns are placed in the discharge line.

For full operating instructions and guidelines for this equipment, see the documentation provided by the pulsation dampener manufacturer.

WARNING	Always use a regulator in the line when charging the discharge pulsation dampener. An uncontrolled increase of pressure can result in catastrophic equipment failure and serious injury or death.

WARNING	Do not use oxygen to fill bladder, especially when pumping flammable fluids, as it may combust and cause catastrophic equipment failure and serious injury to personnel. In most cases, it is recommended that nitrogen is used to fill the bladder.

Bypass Line

It is highly recommended that a bypass line be utilized. It will help to ease the start up torque requirements on the primary driver, allow a low discharge of pressure to help pump priming and ensure that lubrication is established prior to the load being applied.

Line Valves

When selecting valves for the piping, personnel should ensure that only full open valves are used. Plug type and full opening gate valves are good candidate types.

Pressure Relief Valve

A pressure relief valve should be installed on the opposite side of the pump discharge manifold from the strainer cross, and incorporate a high pressure relief line. The valve should be a full-opening reset type valve, and set to a pressure no greater than 15% of the working pressure of the piston size that is being used.

The Pressure Relief Valve discharge line should be short, straight, securely anchored and slope downwards at least ¼" per foot in order to prevent solids from settling in the line. The piping should be the same size as the valve discharge opening, and lead back to the supply tank, but not the pump suction.

WARNING	The Relief Valve must not be connected to the strainer cross, as the systems can interfere with one another, resulting in potentially life-threatening situations.

WARNING	Do not put any type of shut-off valve between the pressure relief valve and the discharge manifold, in order to protect the system against damage resulting from accidental or incorrect start-up

WARNING	The Relief Valve outlet must not be connected to the pump suction line. This can cause uncontrollable pressure surges in the suction line, which can result in equipment damage and significant injury to personnel.

For full operating instructions and guidelines for this equipment, see the documentation provided by the pressure relief valve manufacturer.

Gauges and Meters

A pressure gauge should be installed on the pump discharge, and a high-low pressure alarm system should be utilized to address problem conditions that could lead to pump failure. For full operating instructions and guidelines for this equipment, see the documentation provided by the manufacturer.

2.1.5 Auxiliary or Ancillary Systems

Any Auxiliary or Ancillary systems, such as liner wash systems and jib cranes, should be installed in accordance with the manufacturer's guidelines. If those come into conflict with the regulations here, default to the manufacturer's specifications, unless those come into direct conflict with the safety and operational guidelines outlined here. When in doubt, contact a Weatherford professional or manufacturer agent for information regarding the systems used.

2.1.6 Installation Checklist

Pump Checklist

- □ Ensure the location for installation is clean, dry, well-ventilated and well-illuminated, and as close to the fluid source as possible.
- □ Check that the pump is level.
- □ Ensure the pump rotation is set to drive the top of the crankshaft towards the fluid end.
- □ Ensure that the prime mover drives are properly aligned and configured (see 2.1.2: The Prime Mover, on page 10)
- □ Ensure all guards on the drives are in place and secure.

Suction Checklist

- □ Check that any charge pumps used are of suitable size and are configured correctly.
- □ Check that the suction stabilizer is installed and inflated correctly.
- □ Ensure that the piping is as short as possible and properly supported.
- □ Ensure that vents and drain valves are installed at the proper locations and clear for use.
- □ Ensure a pressure gauge is installed at the suction point, preferably with a thermometer and a low-pressure alarm.
- □ Check that the suction piping is properly sized and that there are no components that may choke or disrupt flow (tight elbows, partial valves, metering devices, etc…)

Discharge Checklist

- □ Ensure the discharge piping is properly sized and supported.
- □ Ensure the pressure gauge is correctly installed at the pump discharge, along with the high-low pressure alarm (if used).
- □ Install a discharge pulsation dampener as close to fluid end as possible.
- □ Ensure the pressure relief valve is installed and set to the appropriate pressure.
- □ Ensure the line from the pressure relief valve directs back to a supply tank and not the pump suction.
- □ Ensure the bypass line is properly installed and functioning.
- □ Check that the discharge piping is properly sized and that there are no components that may choke or disrupt flow (tight elbows, partial valves, metering devices, etc…)

2.2 Storage

While the E-447 pump is a sturdy piece of equipment, but it is nonetheless vulnerable to damage at certain times, especially when inactive. Over time, environmental forces can wear down even the strongest materials, and cause subtle but significant damage to vital components and systems. Unlike equipment that is in use, stored units generally do not receive regular maintenance, and even small problems can become significant if not caught.

By storing the pump in accordance with the following guidelines, users may protect it from environmental wear and tear.

2.2.1 General Storage Guidelines

If the E-447 pump is to be idle for longer than a month, it should be prepared for storage. Pumps should always be stored in a dry, temperature controlled environment to minimize environmental effects and help to prevent equipment degradation. Pumps should never be stored directly on the floor or ground, but elevated to avoid potential problems.

Fluid End

Remove the fluid end valves, pistons & liners. Clean the inside of the fluid end, including all valves and parts, and coat all components in rust inhibiting oil. Then clean the liner wash system and settling tank, and put clean oil into the liner wash system to prevent rusting. Finally, coat the liner wash tank and inner spray parts with a rust inhibiting oil.

If the pump is expected to remain in storage for six (6) months or more, the fluid end should be cleaned and flushed with water which has had its pH raised to 10 or more in order to kill any sulfide reducing bacteria in the pump. Over time, these bacteria can create sufficient Hydrogen Sulfide to attack the hardened steel parts in the fluid end and harm or even kill personnel when the pump is reopened.

Once the fluid end has been cleaned, 1 quart of internal rust inhibitor should be poured into the suction and discharge ports of the fluid end, and pipe plugs should be installed in any openings. Cover the entire pump with a plastic or canvas tarp to prevent exposure.

Power End

Remove the power end covers. Drain and clean the main sump and settling tank. Then clean and coat all bearings and finished surfaces with rust inhibiting oil, rotating the driveshaft during coating to ensure even coverage. Then coat all exposed metallic surfaces and the entire inside surface of the power end with rust inhibiting oil, and replace all covers.

Raise the fluid end of the pump so the pump slopes downwards towards the power end and secure in place. Replace the main sump drain with a 90° elbow pointed down, and cover the opening with a wire mesh screen to permit air circulation and prevent condensation buildup. In addition, a 100 watt light bulb burning continuously will also help prevent atmospheric water condensation.

WARNING	A falling E-447 pump can do significant damage to itself and has sufficient mass to crush most anything in its path, causing catastrophic equipment failures, severe injury and death. When raising a pump, be sure that it is firmly secured and supported, and all personnel should always give suspended units a wide berth.

2.2.2 Special Conditions & Procedures

Corrosive Fluids

If the fluids used in the pump are potentially corrosive, it is important to flush the fluid end with clean water or another non-corrosive cleaner, and then blow dry with compressed air. This will ensure that the majority of the flushing fluid residue has been removed.

New Pumps

Pumps come from the factory without any crankcase oil and are prepared for short term storage without any preparation. If users expect to store the unit for longer than this or in a severe environment, they should use the procedures as indicated below.

Precautions for Freezing Weather

Freezing weather can cause problems for equipment when pumping water-based fluids, or when water used to flush prior to storage is not properly dried. In environments with freezing or near-freezing temperatures, it is vital to ensure that a pump is dry prior to storage, and to thoroughly inspect the pump prior to use.

Severe Environment Precautions

In severe environments, take the following additional steps. The oil in the power end should be drained and the fill cap removed, and then refilled with 8 quarts of internal rust inhibitor vapor emitting oil. Replace the fill cap before storing.

In addition, pour 1 quart of internal rust inhibitor into both the suction and discharge ports of the fluid end, then install pipe plugs in any opening. Coat all exposed, unpainted metal surfaces with preservative oil, and cover the entire pump with a weather resistant coating, such as plastic or a canvas tarp.

2.2.3 Upkeep

Once per month, pumps in storage should be inspected and the gears rotated to ensure that there is no rust or corrosion. During the inspection, the crankshaft should be rotated by hand at least 4 turns. Then re-coat all surfaces and components with rust-inhibiting oil.

Drain and replace the rust inhibiting oil in the crankcase every six (6) months.

2.2.4 Returning to Service

The first step in returning to service is to remove all covers on both the power end and the fluid end and to clean and inspect all finished surfaces. Replace any significantly damaged, rusted or corroded components.

CAUTION	Any pump that has been in storage for any reason, including unused units shipped straight from the plant, should receive a full inspection to make sure it has not suffered damage and that all parts are properly set in place. Failure to do so can result in serious equipment damage and injury to personnel upon startup.

Power End

Check all bearings to ensure that they are clean and in good condition. Fill the power end with lubricant to the proper level with a clean EP gear oil of the proper viscosity (see 4.3: Lubrication on page 30). Make sure the oil is poured into the crosshead reservoir and worked into all of the bearings.

Fluid End

The valves, pistons, liners and all fluid end parts must be properly installed and in good working condition. Carefully tighten all of the bolts, nuts, studs, working connections and covers, and fill the liner wash system with fresh water containing either water-soluble oils or detergents in order to keep the pistons properly lubricated.

Local weather conditions may require varying concentrations of coolants for optimal operation. Some trial and error may be required to get the best concentration of coolants for local conditions.

Chapter 3: Operations

This section covers all standard procedures used to operate the E-447 triplex pump. It includes all basic operational guidelines and recommendations, as well as pump startup and shutdown procedures.

3.1 Starting Procedure

The following startup procedure will help to ensure that the pump operates at maximum efficiency and will reduce the potential for damage during start-up.

3.1.1 Pre-Start Checklist

General Systems Checklist

- □ Check the installation to ensure that the pump is securely mounted horizontally on a flat surface, and that no obvious damage to the pump has occurred.
- □ Verify that the prime mover is properly aligned.
- □ Check that the belts have the correct tension applied.
- □ Ensure that all guards and other safety devices are attached as required and functioning properly.
- □ Fill the liner wash system with coolant lubricant as per the situation and according to manufacturer guidelines.
- □ Check all valves in the suction and discharge lines to ensure they are functioning correctly.

Fluid end Checklist

- □ Remove any debris, and note any excessive rust on the system.
- □ Ensure liners are installed and torqued to the proper value.
- □ Ensure piping is attached and proper stud/bolt torque has been applied.
- □ Check that all valves have been installed and that the valve covers are tight.

Power End Checklist

- □ Check that the rods and pistons have been installed.
- □ Check that the crosshead extensions, connecting rods and liner clamps are tight and properly torqued.
- □ Check for any debris or signs of rust, remove if possible.
- □ Ensure the crankcase is filled with the recommended volume and type of oil based on the ambient temperature and environmental conditions.
- □ Check the rotation to ensure the prime mover has been connected properly. The correct rotation is when the connecting rods come over the top of the crankshaft and are driving towards the fluid end.
- □ Ensure the breather cap and covers are in place prior to starting the pump.

3.1.2 Start Up Procedure

The following is the recommended start up procedure for the E-447 triplex pump.

1) Ensure that all guards and safety devices are in place.
2) If an external lubricating pump is used, engage it for 5 minutes prior to starting the prime mover.
3) Remove the access covers on the power end and fill reservoirs with oil to ensure lubrication will be in place when the pump starts. If starting a new pump or if the pump has recently been in storage, pour oil into the pinion bearing oil trough and crosshead oil reservoir as well to ensure immediate lubrication. Then replace the access covers.
4) Check the temperature of the lubricant in the crankcase and verify that the viscosity meets the minimum listed in the tables below.
   - If oil temperature is too low, use an external heat source to reduce viscosity.
   - If oil temperature is too high, provide a cooling loop to lower temperature.

> **CAUTION** Do not operate the pump if the oil temperature is out of range.

5) Rotate the pump by hand to verify that there are no restrictions on its movement.
6) Open the bypass valve.
7) Open the valve at the suction tank
8) Start the charging pump. Ensure it is working properly before starting the E-447.
9) Apply power slowly (jog), verifying that proper rotation is established.
10) Open the discharge line fully, increasing the power and closing the bypass line. Then check the following.
    - For external lubrication, ensure a constant supply of oil.
    - Check that the lubrication in the stuffing boxes is adequate.
    - Check the suction pressure and temperature.
    - Check the discharge pressure and temperature.
    - Check that the charge pressure of the discharge dampener is stable.
    - Check for leaks of any kind and remediate.
11) If all observed levels are within range, then release for operation.

3.2 General Operations

The following are some general guidelines for operating the E-447 triplex mud pump.

Pump Speed

The pump should be brought up to full operational speed gradually. This allows the flow velocity of the fluid in the suction line to match the requirements of the triplex pump without causing cavitation in the line.

Natural Suction Operation

The maximum pump speed when operating with a "natural suction" (suction unassisted by systems such as a charging pump) is limited only by the pump's ability to fill completely during the suction stroke. This limiting speed will be different for every installation, depending on suction piping, the available head, and the weight, pressure, viscosity and aeration of the fluid being pumped.

Experienced operators should be able to determine the limiting speed by slowly bringing the pump up to speed and listening closely to its operation. As the limiting speed is approached, the pump will begin to knock and pound, indicating cavitation in the line and incomplete filling of the chamber. This is the point at which a charging pump should be utilized, and should remain in use until operating conditions change and a natural suction can again be used.

Suction Stabilizer Charge & Adjustment

The suction line pulsation dampener should only be charged with a hand operated air pump. For full instructions in the safe operation of the low pressure suction line pulsation dampener, see the documentation provided by the manufacturer of that equipment.

WARNING	The use of a high pressure source or nitrogen bottle to charge the suction line pulsation dampener can result in catastrophic equipment failure and serious injury to personnel.

WARNING	Always use a regulator in the line when charging the discharge pulsation dampener. An uncontrolled increase of pressure can result in catastrophic equipment failure and serious injury to personnel.

WARNING	Do not use oxygen to fill the bladder in either the suction stabilizer or the discharge pulsation dampener, especially when pumping flammable fluids, as it may combust and cause catastrophic equipment failure and serious injury to personnel.

Low Speed Operation

The E-447 pump can be operated as slow as 5 strokes per minute and still achieve proper lubrication. However, it is recommended that any time the pump is operated at 30 strokes per minute or less, that the crosshead access covers be removed to check that the crossheads are being sufficiently supplied with oil.

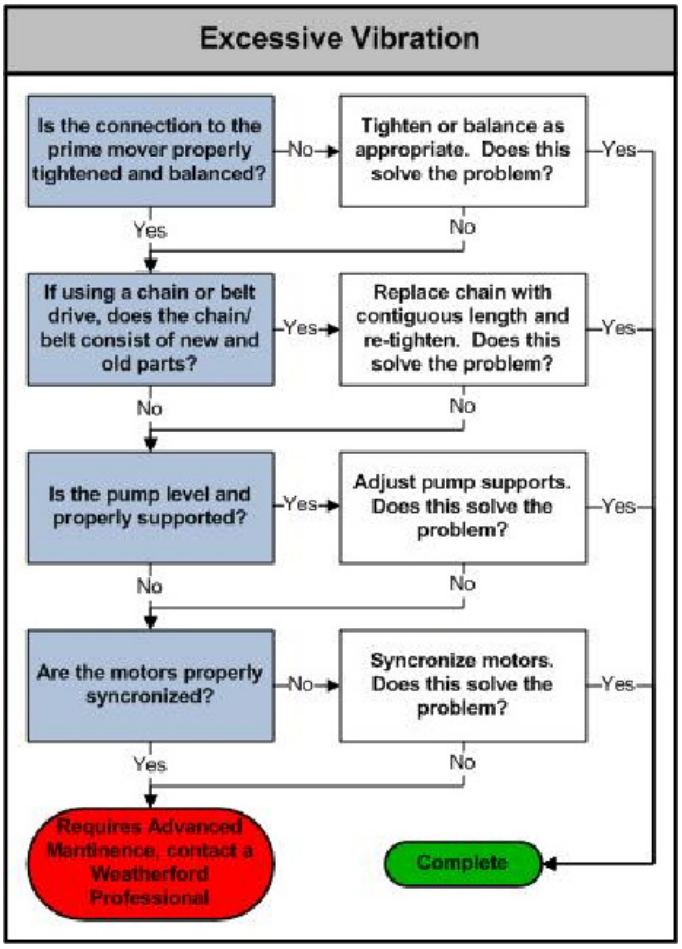
3.3 Basic Troubleshooting

The following section provides a basic guide to dealing with potential problems which may occur while using the E-447 pump. This section is intended only as a basic problem solving tool, to help users ascertain the nature of the problem and allow for basic repairs should something go wrong. If problems do not match those outlined, or persist after all recommended solution options have been exhausted, do not attempt further work, but contact a Weatherford professional to examine the system and make a recommendation.

3.3.1 Excessive Vibration

If there is excessive vibration coming from the pump, the most common cause is an unbalanced or loose connection between the prime mover and the pump itself. If using a direct connection, check that the sprockets and sheaves are properly balanced and aligned. If using a chain or belt drive, check that the chains/belts are not a mixture of new and old sections, and that they are taut on the sheaves and spacers.

If the drive connection seems normal, check that the pump is level and properly supported. Then check that the motors are properly synchronized on a dual shunt wound D.C. Motor Drive. To do so, isolate one motor by disconnecting one drive chain or belt and operating the pump with one motor. If the vibration ceases, then the motors will need to be properly synchronized before proceeding.



3.3.2 Knocking in the Fluid End

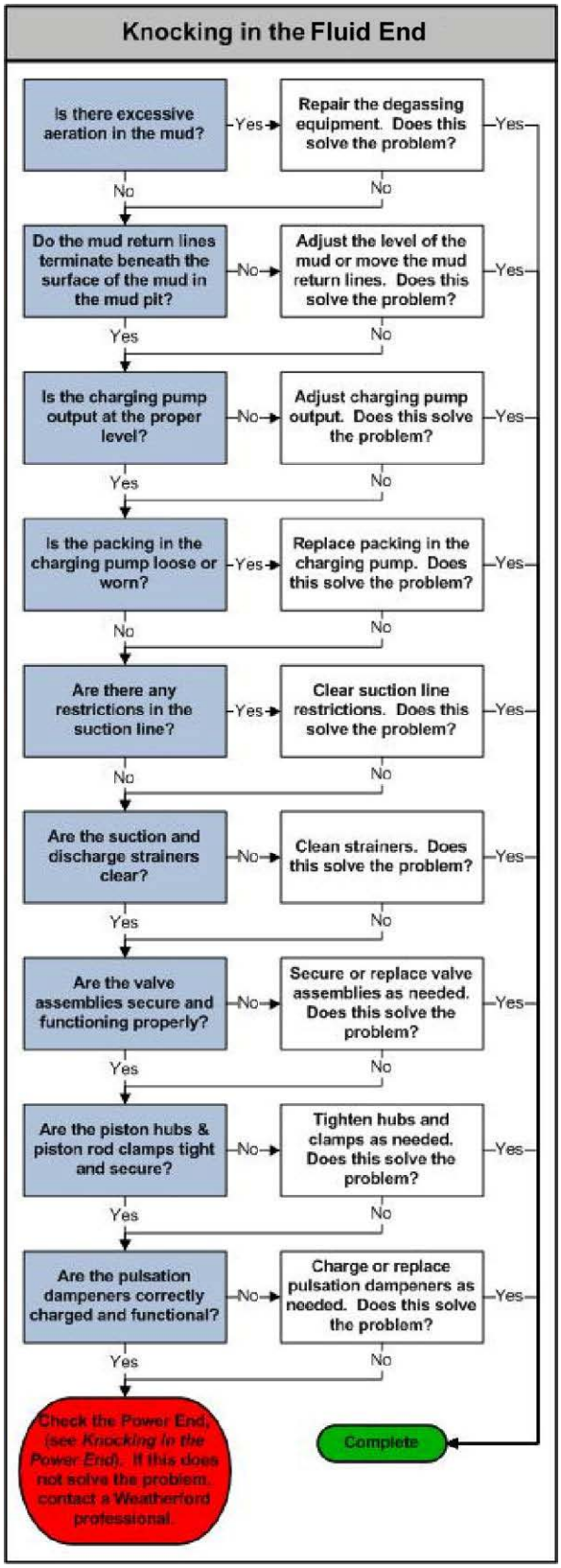
Most often, knocking is caused by aeration of the mud. Examine the mud pits for excessive bubbles, and check any degassing equipment used. Also check that the mud return lines terminate beneath the surface of the mud level in the pit.

Next, check that the charging pump output is at the proper levels (between 25 and 50 psi during operations). Run water over the packing. If this causes the knocking to stop, then the packing is loose or worn, and should be replaced. Also check that there are no restrictions in the suction line, and that both the suction and discharge strainers are sufficiently clear to allow fluid to pass through. If plugged, clean and reinstall.

If this does not solve the problem, then shut down the pump and check the valves. Ensure the valve seats are secured in the bore, and that neither they nor the valves are misaligned, washed out or damaged. Also check that the valve stem guide inserts have not swollen, as this will cause the valves to stick.

Finally, check the pistons for potential problems. The piston hubs and piston rod clamps should be tight and secure, and if not, adjust as appropriate. Also check that both the suction and discharge pulsation dampeners are properly charged and functional.

If none of these solutions help, contact a Weatherford professional.



3.3.3 Knocking in the Power End

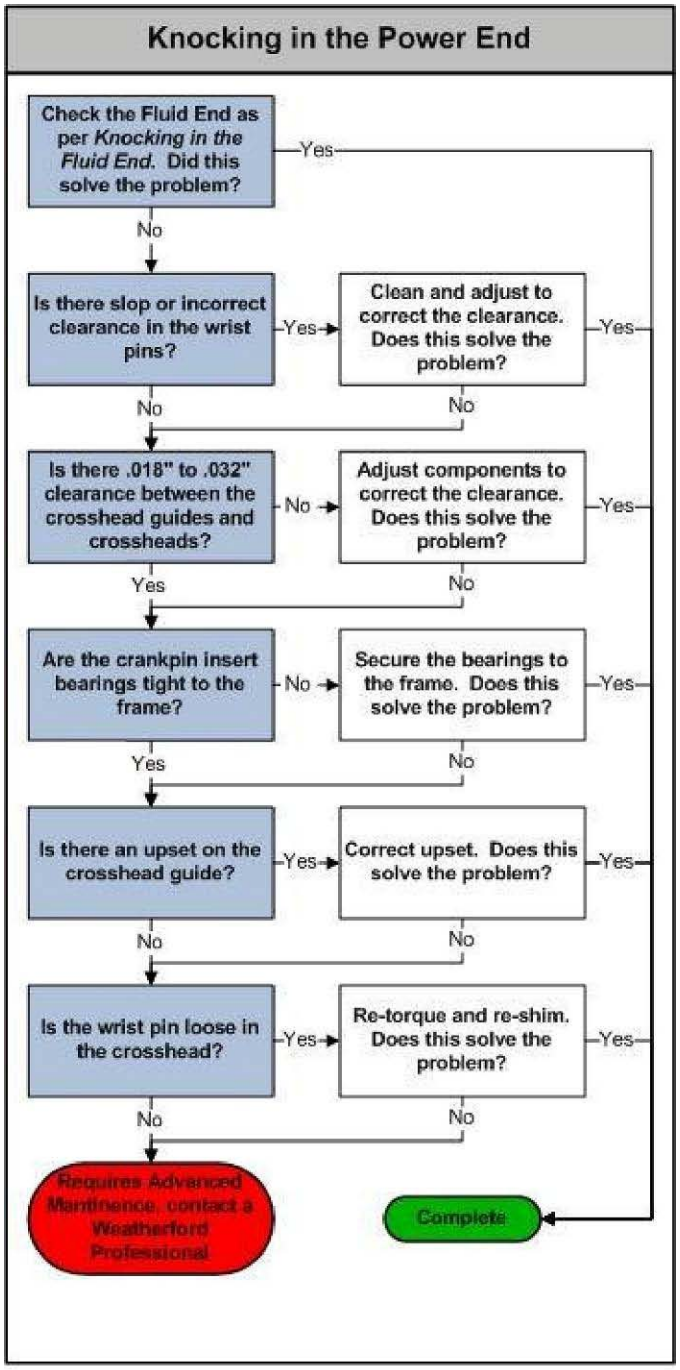
Even in cases where the knocking appears to be coming from the power end of the pump, it is much more likely that they are caused by conditions in the drilling fluid than by the actions of the power end equipment. Therefore, before checking the power end for potential causes, you should consult 3.3.2: Knocking in the Fluid end (page 24) and follow the procedure outlined there.

If the problem is not in the fluid end, then check for slop in the wrist pins. The wrist pins should have a clearance of no more than 0.002" between the wrist pin and the crosshead. Insert a 0.002" feeler gauge and see if it will fit through all 360.

Next, check the clearance of the crossheads, which should have between 0.014" and 0.030" between them and the guides. Also check the crankpin insert bearings, which should be tight in the frame, and can cause knocking when loose. Finally, check the crosshead guides for upsets, as these can also cause knocking.

If none of the above is the case, you will need to disassemble the power end so you can access the wrist pin (see 5.3: Power End Disassembly Procedures, page 63). Remove the outer screws in the retaining plate and bump the pin lightly. If it moves easily in the crosshead, then the pin and bearing should be removed and reinstalled or replaced if damaged (as per 5.4.5: Installing the Wrist Pin Bearing, page 86).

If none of these solutions help, contact a Weatherford professional.



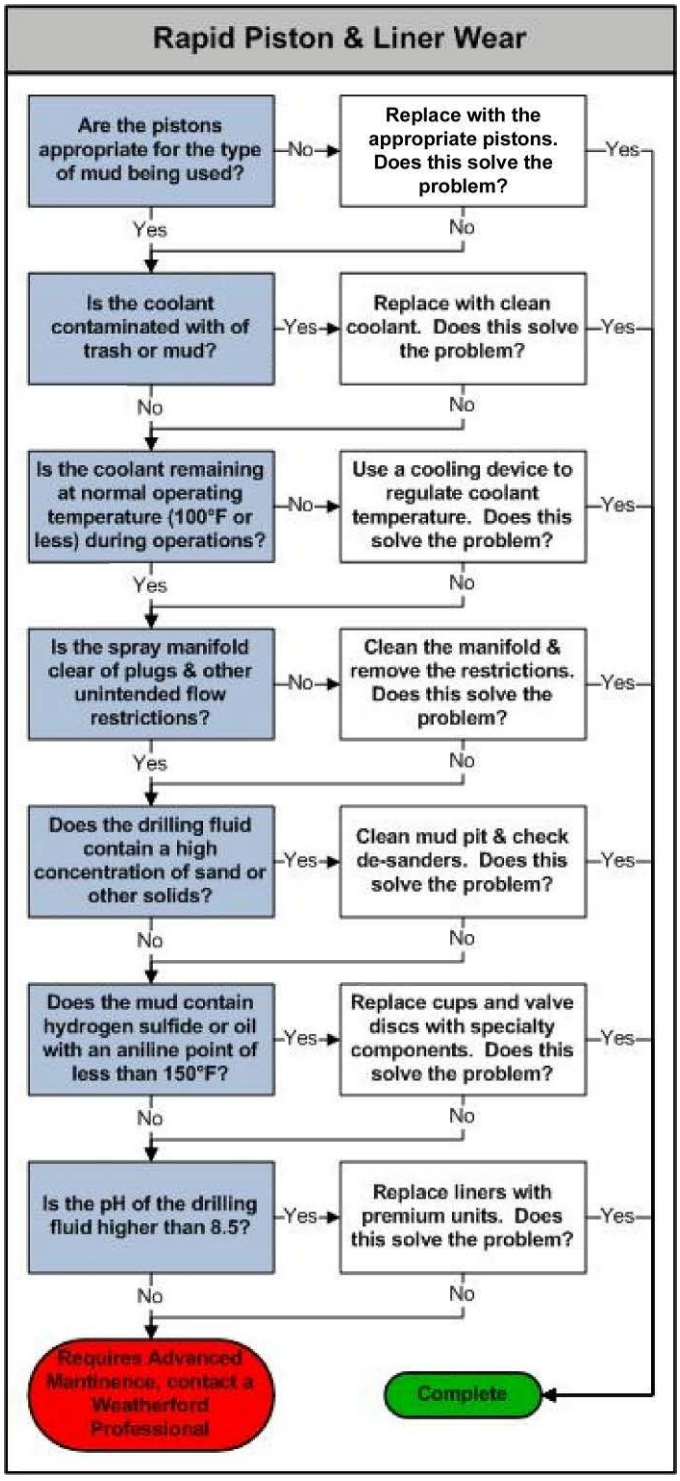
3.3.4 Rapid Piston & Liner Wear

In most cases, faster than normal wear of the pistons and/or liners is the result of either problems with the coolant or the mud. First, make sure the pistons being used are appropriate for the type of mud being run. Then check that the coolant is at a normal operating temperature (100°F or less), and is not contaminated with trash or mud. Then double check the spray manifold nozzles and holes drilled in the coolant rods to ensure that they are spraying sufficient coolant into the liner. Remove any plugs or restrictions on the coolant flow.

Drilling fluid that contains a high concentration of sand or other solids will rapidly degrade pump components, usually evidenced by streaks in the liner bores. In such cases, the mud tanks should be cleaned, and the desanders should be checked and replaced as needed.

If the drilling fluid has a pH above 8.5, then it is considered corrosive, and will cause excessive damage to normal liners. If the mud contains hydrogen sulfide, or if oil-based and the aniline point of the oil is less than 150°F, then it will attack and rapidly deteriorate the piston cups and valve discs. In all such cases, premium or specialty components should be used to reduce deterioration.

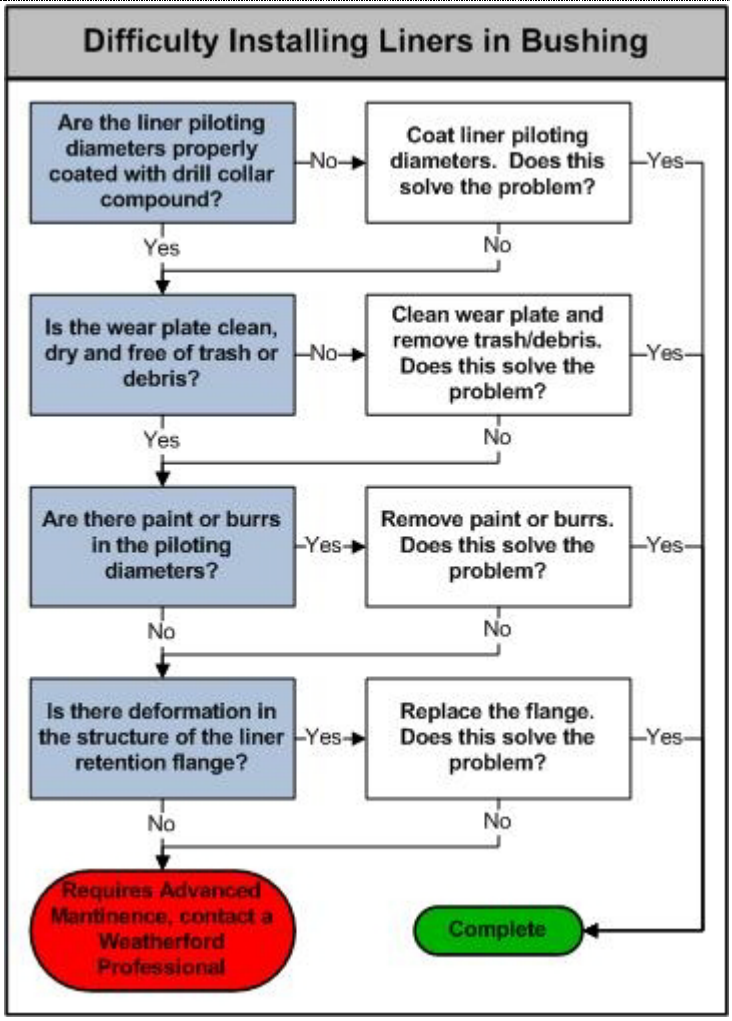
If none of these solutions help, contact a Weatherford professional.



3.3.5 Difficulty Installing Liners in Liner Retention Flanges

Be sure that the liner piloting diameters are lightly coated with drill collar compound before installation. Then check for trash on the wear plate, as it must be clean and dry for the liner to seal properly.

Check the piloting diameters for paint or burrs, and remove if discovered. Also check the liner retention flange, looking for an egg-shaped deformation in its structure. If found, remove and replace.



Chapter 4: Maintenance

4.1 Tools & Equipment

4.1.1 Tools & Equipment Used

The following list includes all of the standard tools and equipment used to perform basic maintenance on the E-447 triplex pump. All are included in the basic maintenance kit, but the part numbers have been included here for easy replacement of lost or damaged items.

One (1) pipe wrench

One (1) torque wrench

One (1) standard metric socket set

One (1) liner puller

One (1) hydraulic pump & four (4) hydraulic tools for valve housings

One (1) valve cover puller assembly

One (1) valve seat driver

One (1) hook magnetic retriever tool

One (1) dampener charging kit including three (3) charge hoses

One (1) crankshaft / pinion rotating tool

One (1) wear ring (plate) puller

One (1) maintenance bar for valve closure

One (1) standard set of push/pull adjustment tools

4.2 General Maintenance Guidelines

Regular maintenance of the E-447 triplex pump will help to ensure not only a long operational life, but will also enhance the efficiency and operational stability of the pump. The guidelines provided below offer general instructions for maintaining the systems and equipment, as well as standard maintenance schedules that will help to ensure optimal performance and lifespan.

All procedures outlined for the E-447 triplex should be followed in accordance with their scheduled timelines. Any third-party equipment and systems should be maintained in accordance with the manufacturer's guidelines.

4.2.1 Initial Operations Maintenance

Magnets in the Lube Oil Strainer/Filter

During the first 500 hours or so of new pump operation, special attention should be given to the magnets in strainer cage. After every 50 hours of operation, the strainer should be removed and the lubrication oil magnets inspected. Look for any particulate matter on the magnets, and clean them each time in accordance with standard procedures.

Repeat this process until such a time as the magnets cease accumulating particulate matter. At that point, simply apply normal regular maintenance procedures.

Pinion and Main Gear

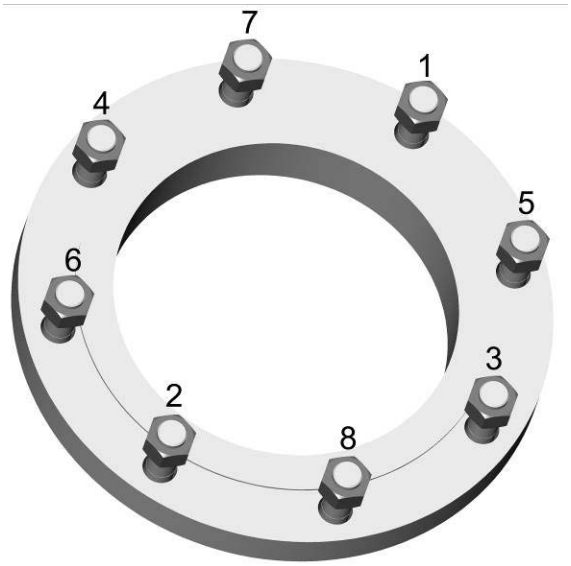
Some corrective pitting of the main gear is expected during the initial operation period. These pits should be small, round or oval in shape and dispersed along the pitch line of the gear teeth. If they expand significantly, form single larger pits or do not slow down and halt during or after the initial operations period, the entire gear train should be thoroughly inspected and the cause of the problem rectified. Replace any components that are worn beyond the recommended clearance.

4.2.2 Fastener Torque Specifications

When tightening multiple bolts on flanges, it is considered the best practice to tighten opposite bolts first, to ensure a tight flat seal. The diagram below provides a recommended order in which to tighten the bolts to best ensure a tight seal.

In addition, it is generally best to first tighten each bolt as far as possible by hand without inflicting pain or injury. Once all bolts are so tightened, tighten each bolt to one-half torque tightness, and then finish by tightening each to full torque tightness once all bolts are at the half-torque level of tightness.

For exact torque values for specific bolts, consult the Torque Chart on page 54.



4.2.3 Biannual Inspection

It is recommended that, in addition to the procedures and processes outlined below, the E-447 triplex pump should receive a complete inspection about once every two years. This inspection should cover all components and systems, checking for wear and tear and ensuring that the pump is still in good operating condition. All damaged, defective or otherwise nonfunctional components should be repaired if possible or replaced.

4.3 Lubrication

Regular lubrication of the components is essential for pump longevity. By maintaining a regular lubrication schedule and using the correct lubricant for the type of service, the life of a pump can be extended markedly.

4.3.1 Prestart Lubrication

If the pump is idle for an extended period of time, rotate occasionally to avoid corrosion and prevent flat spots from forming on the rollers and races. Before restarting, the inspection covers should be removed and oil should be applied directly into the crosshead reservoirs to ensure immediate lubrication upon startup.

Regardless of the duration of inactivity, all drain plugs should be removed from the crankcase to allow any moisture or contaminants that have accumulated to be removed prior to startup. Likewise, any external lubrication pumps should be checked to ensure that it is operational and that oil is moving through all internal lube lines, and that the spray nozzles are properly positioned to fill the wrist pin bearing fill cups.

Any liner wash system used should be started before the mud pump to ensure that the liners are properly sprayed and lubricated in order to prevent damage to the pistons and liners.

NOTE Effective cooling of the pistons and liners can only be accomplished if the temperature of the coolant is below that of the drilling fluid. Under certain circumstances, an external cooling system may be required to remove heat from the coolant fluid.

4.3.2 Power End Lubrication Guidelines

During operation, significant loads will be placed on the crankshaft, connecting rods and crossheads, and so a heavy duty industrial gear lubricant rated for extreme pressure should be used. Consult the Lubrication Chart on page 55 for recommended lubrication based on ambient temperature. As a minimum, AGMA specification 250.04 oil that has passed a 60 lb load arm test should be used.

Check oil level periodically (see 4.4: Maintenance Schedules on page 32). The oil level should be equal to the centerline of the lowest eccentric bearing roller, set so the connecting rod is at its lowest point during rotation. Oil should always pour freely at the operating temperature, and should be free of contaminants. The oil in the power end must be changed at minimum once every six months (2,000 hours of operation), and should be changed as often as necessary to maintain proper viscosity and keep the oil free of sludge.

Replace the oil with an approved lubricant and remove and clean the breather cap. When checking the oil level during operations, always allow the pump to remain idle for five minutes in order to ensure the oil level stabilizes.

4.3.3 Pistons & Crosshead Extension Lubrication

The lubrication of the pistons and crosshead extensions is accomplished using an electric pump which directs a stream of lubricating fluid onto the pistons and liners in a regulated flow. Normally, this fluid is simply clean water, but it is recommended that a synthetic fluid (Castrol Syntilo 9951 or equivalent is recommended) or water-soluble oil be added, depending on the corrosiveness of the water and the drilling fluid. A mixture consisting primarily of clean water with 10-20% synthetic fluid or water-soluble oil is recommended, with precise values to depend on drilling conditions, size of the liner spray wash volume tank and the liner spray pump manufacturer's guidelines.

If only clean water is used, the operator must exercise greater than normal care and maintenance in order to prevent heat and corrosion damage in those parts in or adjacent to the liner piston chambers. Coating clamps and all exposed surfaces with a thread compound will minimize the effects of corrosion.

Used lubricant accumulates in compartmentalized sumps beneath the connecting rods, where it is recirculated by the lubrication system. These sumps should be cleaned any time the oil is changed.

4.3.4 Temperature Maintenance

The oil temperature should be continuously monitored during operations, and it is recommended that a low-level alarm system is employed to warn of extreme temperature fluctuations. In extreme conditions, a heat exchanger may be needed to keep the crankcase temperature below 180°F (82°C).

4.4 Maintenance Schedules

4.4.1 Daily Maintenance Checklist

- □ Inspect the pump to ensure that all the exposed threads are coated with rust inhibitor.
- □ Check the oil in the power end, lubricator and chain case. If the oil is contaminated, replace. If not, ensure that the oil temperature is within range and add oil as needed.
- □ Check the extension rod packing for proper alignment and lubrication. Adjust as needed.
- □ Ensure that the liner wash and charging pumps are properly lubricated.
- □ Lubricate the shaft and packing of the liner wash pump as instructed by manufacturer.
- □ Check the pressure gauges on the external lube oil filter (if utilized). If the differential between the gauges is greater than 15 psi when the pump is at operating temperature, clean the strainer and strainer magnets.
- □ During operation, examine the belt drive (if utilized). If slipping or squealing is noticed, disengage and turn off belt drive and adjust tension as necessary. Be sure to check the sheave alignment before returning to service.
- □ Observe the condition of the pistons and liners, and look for uneven wear or corrosion, or excessive bypass on each stroke (smooth wear and minor leakage is to be expected). If this occurs, replace pistons and/or liners as necessary.
- □ Check the pressure in the suction system, ensuring it is within range.
- □ Check the pressure in the discharge system, ensuring it is within range.
- □ Check that the pulsation dampener & suction stabilizer are set to the correct pressure.
- □ Check the entire pump for oil or fluid leaks, including the diaphragm and the oil seals in the power end.
- □ Check to ensure the pump is clean and ready for work.
- □ Check to ensure the work area around the pump is clean and free from hazards.
- □ Drain any piston leakage from the pump.

4.4.2 Biweekly Maintenance Checklist

- □ Flush the fluid in the cradle drain lines.
- □ Check the valves and seats for wear, and replace any cut or worn inserts.
- □ Check the bushing in the valve stem guide and replace if visibly worn.
- □ Check over the piston/crosshead coupling for loose or damaged components, and correct the torque values as necessary.
- □ Ensure that the piston hub seal is properly mounted on the piston rod, correctly placed in the piston hub groove and has not been altered or damaged.
- □ Check the piston rod lock nut, and replace if it has been damaged or corroded, or if the locking nylon has lost its ability to effectively grip the threads. Any nut which has been used three (3) times should be replaced.
- □ Check over all guards, shields and other safety systems, ensuring that they are properly locked into position and in working order.

4.4.3 Monthly Maintenance Checklist

- □ Check over all tools used to work on the pump, ensuring that they are in good working order and readily available.
- □ If a strainer cross is used, ensure it contains a strainer sleeve. Clean the sleeve and check for damage or corrosion.
- □ Check all of the studs and nuts on the fluid cylinder for tightness, including the valve cover bolt on the rings, those affixing the fluid end blocks to the frame studs, those affixing the discharge to the suction studs and the liner retention flange.
- □ Inspect the power end for gaskets which leak excessively or loose cap screws, and replace as required.
- □ Check all of the bolting on the fluid and power ends of the pump, and make sure all are tight and secure.
- □ Check the crosshead extension rods for wear and tear, and repair or replace as needed.
- □ Clean the liner wash pump strainer and the strainer in the strainer cross.
- □ Clean out the crankcase breather, replace as needed.
- □ Check all valves, seats and springs for wear and tear to ensure they are in good working order. Replace as needed.

4.4.4 Semiannual Maintenance Checklist

- □ Drain and clean the power end oil sump and the settling area under the crossheads, and refill with the proper grade of EP gear oil.
- □ Clean the magnet on the oil pump strainer area.
- □ Ensure that all lubrication lines are in position, continuous and free of obstructions.
- □ Clean the foundation and/or the hold down bolts, and ensure the pump is properly oriented and secure to the skid.
- □ Ensure that the bolting on suction and discharge flanges is secure.
- □ Check the pinion sheave and bushing for wear and tear. Replace as needed.
- □ Change the liner wash fluid. The fluid should also be flushed every time the pump is moved and refilled before the drilling resumes.

4.4.5 Annual Maintenance Checklist

- □ Check the crosshead guides for grooves, which indicate improper lubrication or foreign matter in the lube oil. If found, check the lubrication system and the condition of the crosshead extension rod seals, and replace if severely worn or scarred.
- □ Check the clearance of the crossheads and the main gears, and record the data for future reference.
- □ Inspect the condition of the main gear and pinion gear teeth, as per the Pinion and Main Gear section under 4.2.1: Initial Operations Maintenance on page 29.
- □ Check the clearance of the bearings, and record the data for future reference. If bearing clearance exceeds two times the installed clearance, repairs should be made. If clearance has increased abnormally, a more thorough inspection should be made to locate the source of the wear.
- □ Check the tightness of the main frame mounting bolts and wristpin retainer bolts.
- □ Check all bolting safety wires. If broken, identify cause and correct before replacing.
- □ Check the tightness of the main bearing cap bolts and tighten as necessary. Units with “super bolts” will have the required torque stamped on top of the nut.

4.5 Routine Maintenance Procedures

4.5.1 Venting Pressure in the Fluid End

Before any maintenance is performed on the fluid modules, liners, pistons or valves, all pressure should be vented from the system. To do so, close the shut-off valves in both the suction and discharge lines and then open the by-pass line to the mud tanks. Allow all pressure to vent before performing maintenance on fluid end components.

CAUTION	Even while at rest, the fluid end of the system is under significant pressure, which if accidentally or inappropriately released can cause significant equipment damage and injury to nearby personnel. All pressure must be vented from the system before any maintenance on the fluid end is performed (see 4.5.1: Venting Pressure in the Fluid End, above).

4.5.2 Pre-Installation Procedure

Before installing any parts or components into the system, all parts should be gathered and checked to ensure they are ready for use before installation begins. This includes checking that all mountings, sealing faces and bores are clean and free of burrs, nicks and debris.

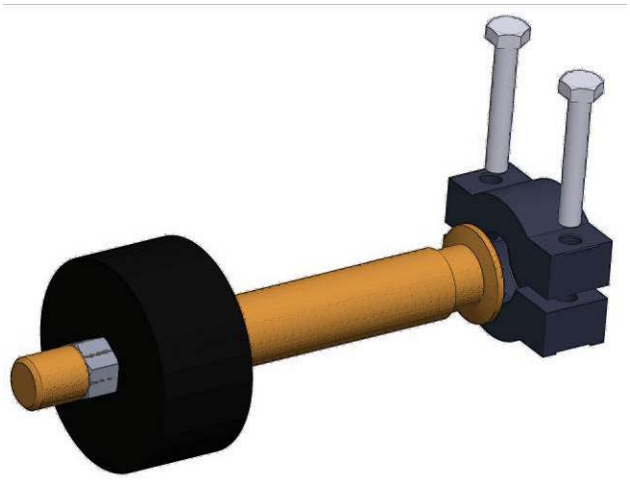
4.6 Piston & Liner Maintenance Procedures

The following are the standard procedures for safely removing and replacing the pistons and liners, as well as any attached components or parts. Remember to always vent the pump pressure as per 4.5.1 (page 35) before beginning any maintenance procedures.

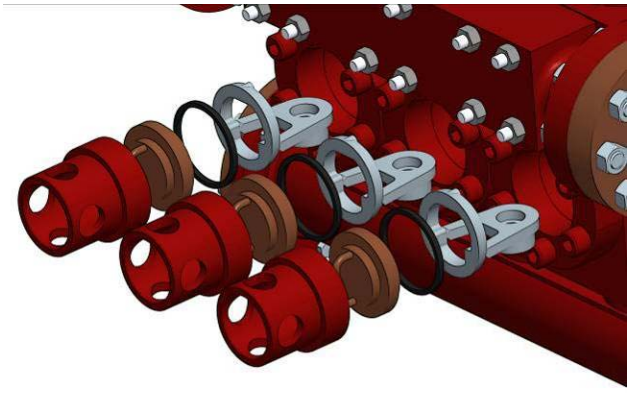
4.6.1 Removing the Piston

The three piece piston rod system permits the removal of a piston without disturbing the liner. The following procedure provides standard guidelines for this process.

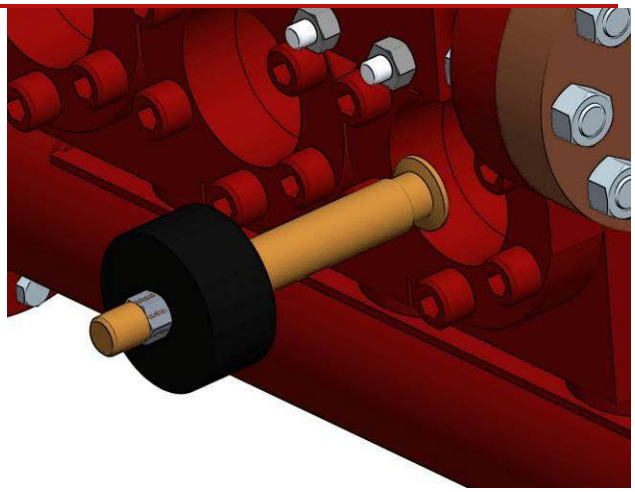
1 Remove the clamps affixing the piston rod & sub-rod to the crosshead extension, and rotate the pump until the crosshead extension is at the end of its suction stroke (fully retracted towards the power end).



2 Remove the cover plugs and valve assemblies from the front of the fluid cylinder.



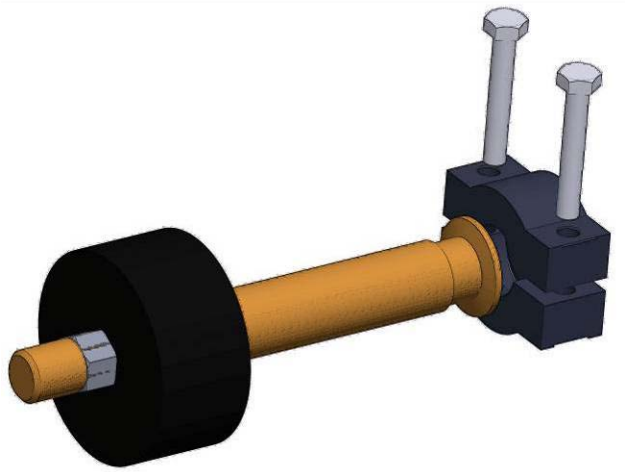
3 Remove the clamps and sub-rod at the end of the piston rod, and then slide the piston assembly out the front of the fluid cylinder.



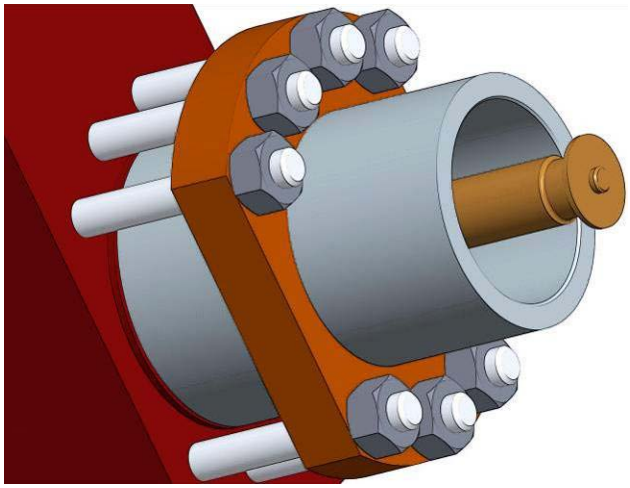
4.6.2 Removing the Piston & Liner as a Unit

The pistons and liners should be removed as a unit. The following procedure provides standard guidelines for this process.

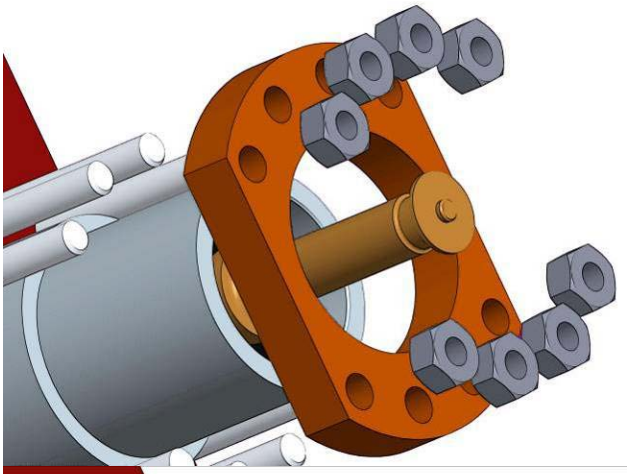
1 Remove the clamps affixing the piston rod & sub-rod to the crosshead extension, and rotate the pump until the crosshead extension is at the end of its suction stroke (fully retracted towards the power end).



2 Slide the piston assembly into the Liner.

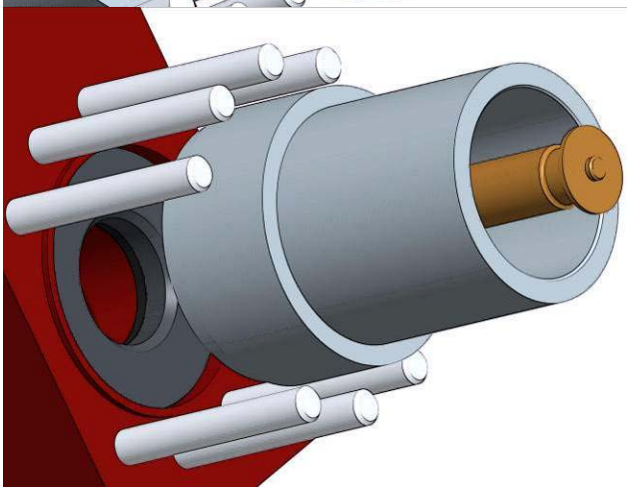


3 Remove the liner lock ring or nut depending on the style of fluid end used.



4 Extract the liner by inserting a pry bar between the liner collar and the end of the pilot bushing and carefully sliding it free of the liner retainer.

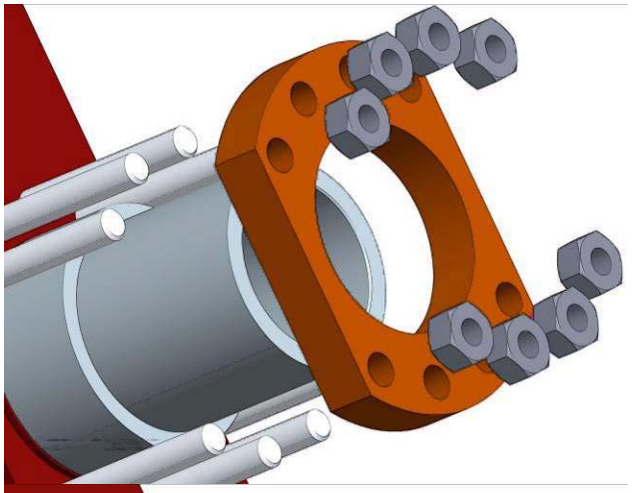
CAUTION	These parts are heavy and should be handled using a sling or other appropriate handling device in order to avoid potential injury or equipment damage.



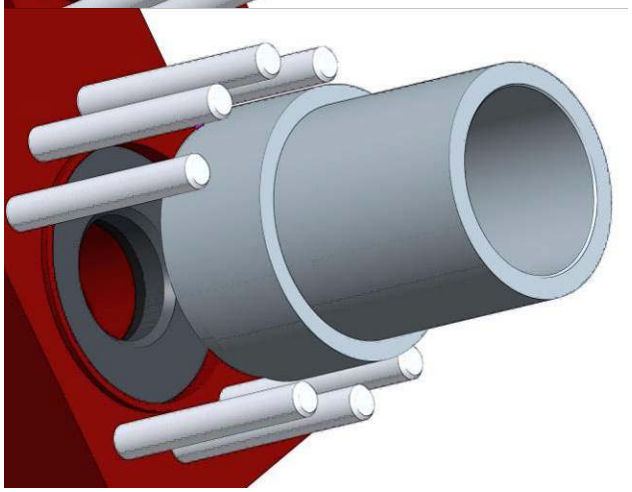
4.6.3 Removing the Liner

The following provides instructions for removing the liners in pumps in which the pistons have already been removed. It is generally considered better to remove the pistons and liners as a unit rather than separately

1 Remove the liner lock ring or nut depending on the style of fluid end purchased.



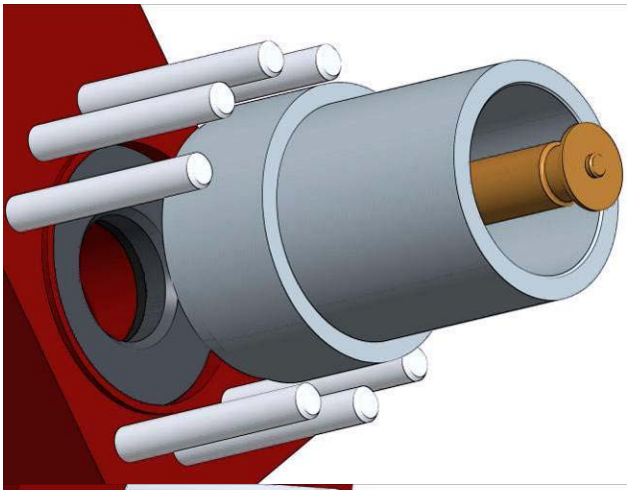
2 Extract the liner by inserting a pry bar between the liner collar and the end of the pilot bushing and carefully sliding it free of the liner retainer.



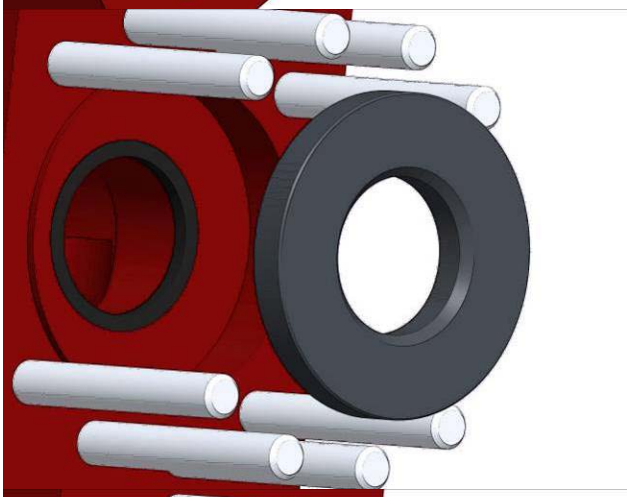
CAUTION	These parts are heavy and should be handled using a sling or other appropriate handling device in order to avoid potential injury or equipment damage.

4.6.4 Removing the Liner Seal & Wear Plate

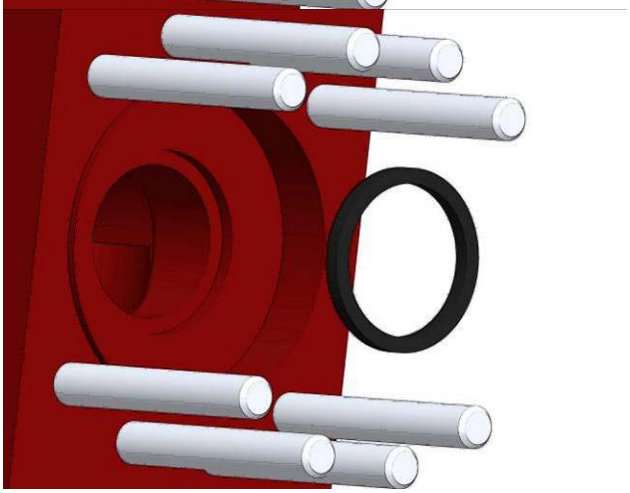
1 The liners must be removed in order to access the seal and wear plate. Use the procedure outlined in 4.6.2 or 4.6.3 as appropriate.



2 Remove the wear plate from the counter bore in the fluid end.



3 Remove the wear plate seal from the fluid end and replace. The wear plate seal should be replaced any time the wear plate is removed.

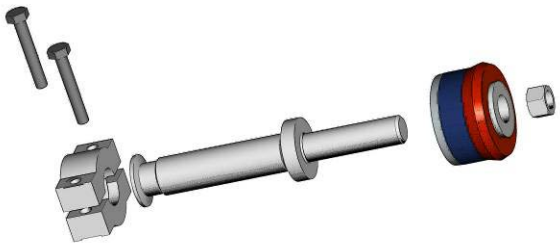


4.6.5 Piston Disassembly & Parts Replacement

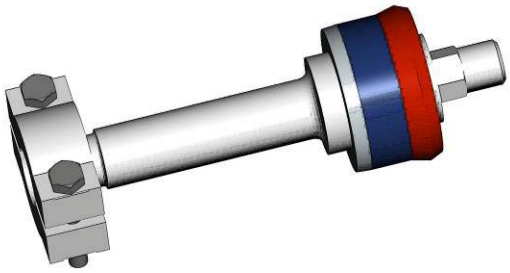
The following procedure is intended to be used to disassemble and replace the component parts for the pistons on the E-447 pump.

1 Remove the piston rod nut and slide the piston hub off of the piston rod.

NOTE Always replace seals which have been loosened or manipulated during maintenance procedures.



2 Re-install the piston, ensuring that the seal remains properly aligned with the groove in the piston hub. Lock into position using the piston rod nut, and torque to 2,300 ft. lbs. torque (on a 1.5" piston rod nut).



4.6.6 Piston Cup Replacement

The standard pistons for the E-Series pumps come with a molded piston. Some operators choose to utilize older-style pistons which have replaceable cups or "rubbers." Use the following procedure to replace the cups on this type of piston.

1 To remove, simply remove the snap ring from the front of the hub and slide the piston cup free.



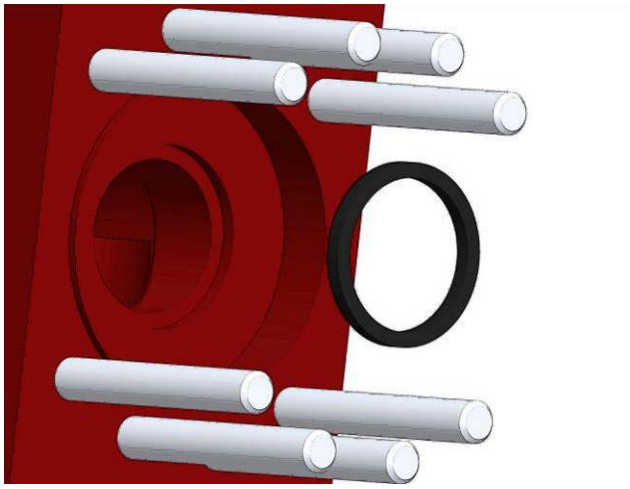
2 To reinstall, simply slide the new cup onto the hub and secure in place with a snap ring.



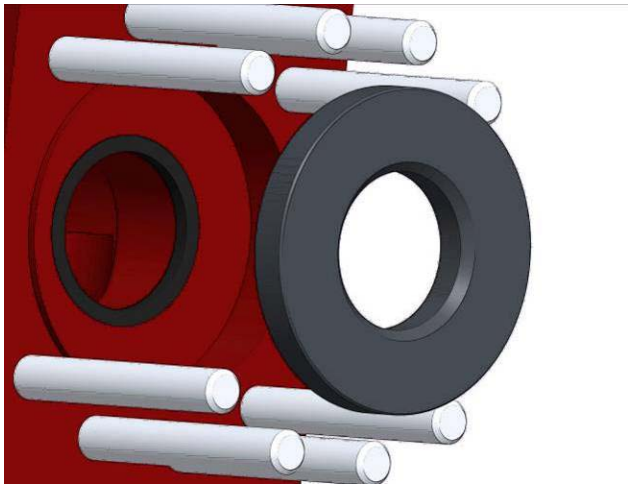
4.6.7 Installing the Liner Seal & Wear Plate

The following is the standard procedure for installing the Liner Seal and Wear Plate on the E-447 fluid end.

1 Clean the fluid end counter bore and install the wear plate seal. Slide the wear plate into the appropriate gland area until it seats properly against the fluid end. A small amount of grease may be helpful in accomplishing this.



2 Install the liner wear plate into the counter bore.

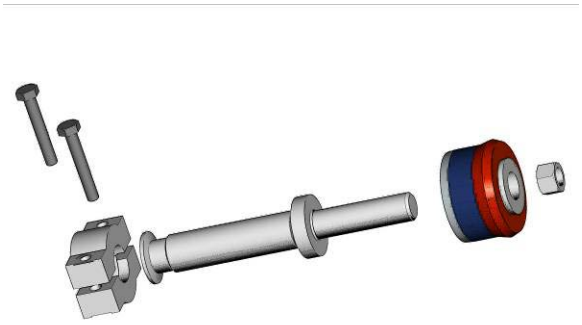


4.6.8 Installing the Liner & Piston

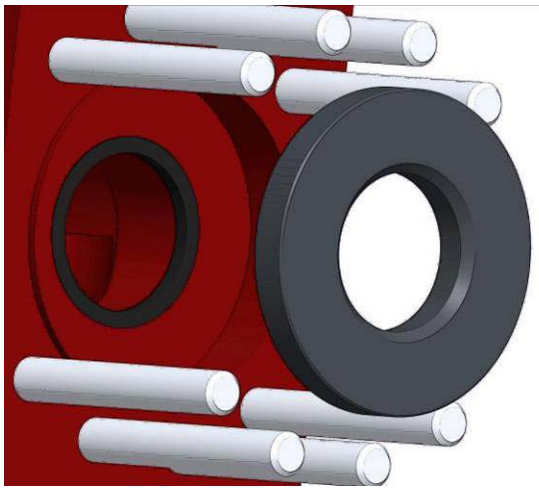
The following procedure outlines installing the liner and the piston into the E-447 pump.

NOTE If replacing components, it is important to remember that the liners are generally sturdier than the pistons, and have a significantly longer operational life. In most cases, a liner should last through about 2-3 pistons.

1 Check that all parts are clean and free of nicks and burrs as per 4.5.2: Pre-Installation Procedure on page 35.

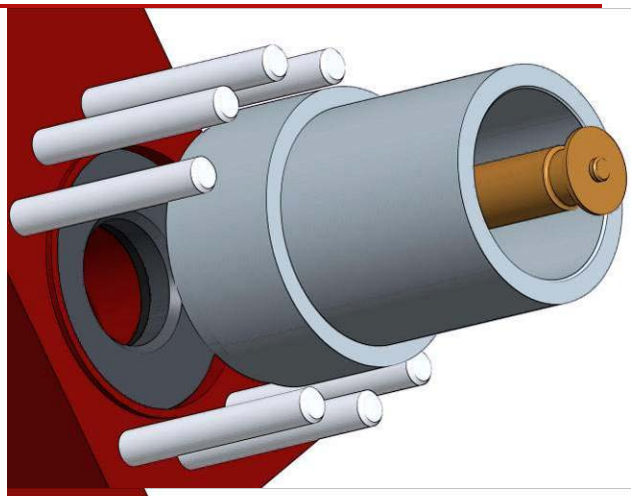


2 If necessary, Install the Liner Seal & Wear Plate as per 4.6.7.

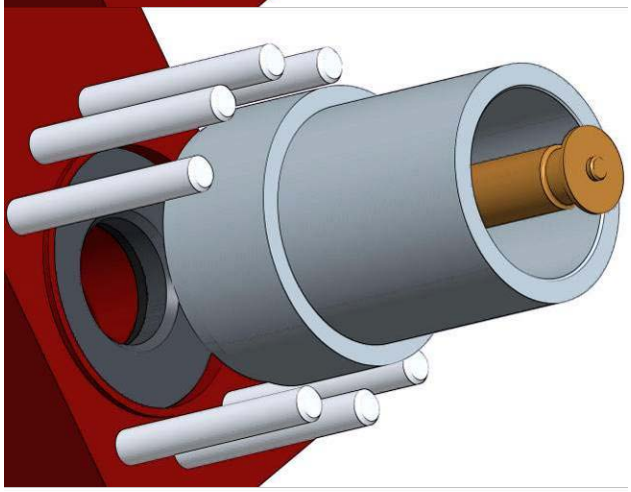


3 Coat the inner diameter of the liner and the outer diameter of the piston with grease, and insert the piston rod into the liner. Hold the piston rod centered at the rear of the liner.

NOTE Some other fluid end styles require that the piston and piston rod be inserted into the liner prior to the liner being installed into the liner retainer.

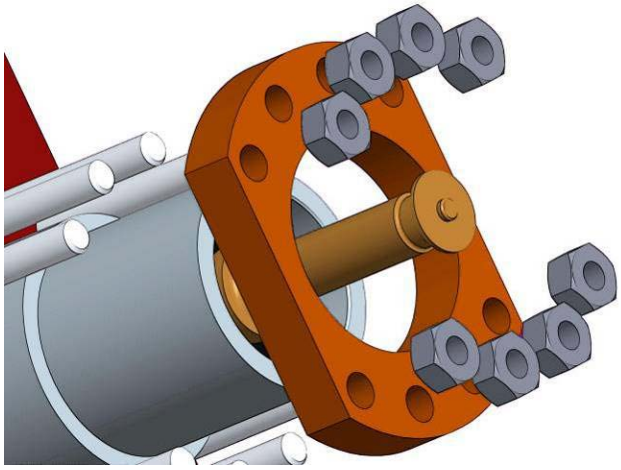


4 Lightly grease the face of the liner or apply a thin coat of grease to the inner diameter of the liner lock flange, depending on which style liner retainer is used. Insert the liner into position.

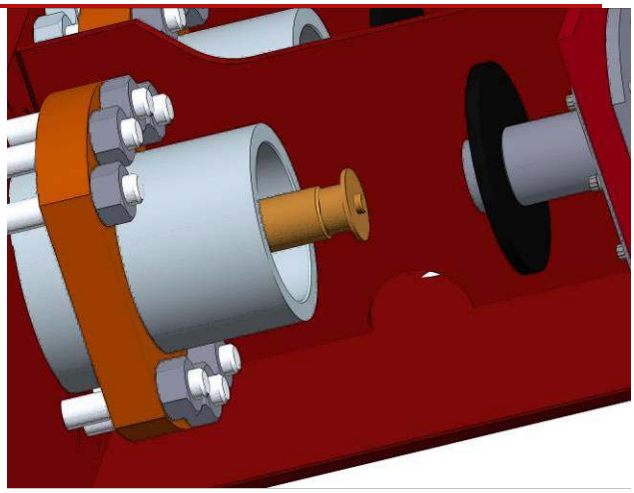


5 Apply a liberal coat of anti-seize compound to the liner lock stud threads. Slide the liner retention plate over the end of the liner and onto the studs. Torque the nuts into place at a torque of 911 ft. lbs. using an alternating torquing patter as detailed in 4.2.2: Fastener Torque Specifications (page 29).

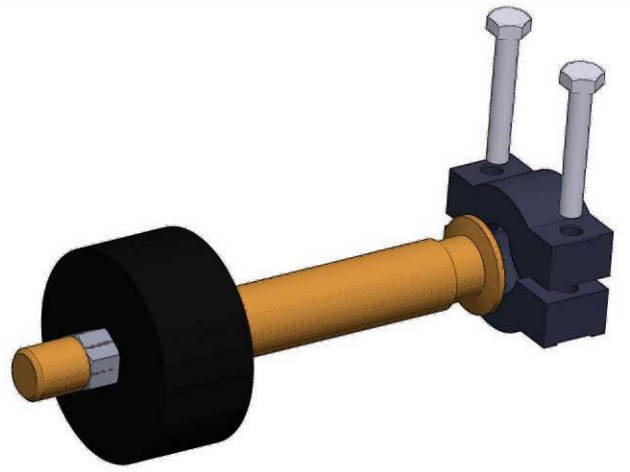
NOTE For fluid ends with a liner retention flange and nut, insert the liner into the flange and hammer on the retainer nut.



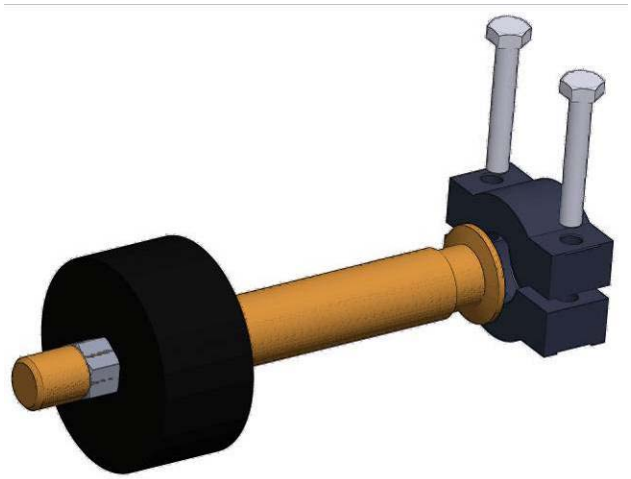
6 Support the piston rod as the pin is guided into the pilot bore.



7 Ensure that the numbers stenciled on each side of the piston rod clamps match, and install around the piston rod and crosshead extension end flanges respectively, ensuring that the water connection holes remain at the top center.



8 Assemble the clamp halves. Ensure that a gap of ½" or less exists between the clamp halves, but that they are not touching. If they touch, replace the clamps.
Torque the bolts to 314 ft. lbs.



4.7 Valve Maintenance Procedures

The following are the standard procedures for safely removing, replacing and maintaining the valves in the fluid end of the E-447 pump.

CAUTION	Even while at rest, the fluid end of the system is under significant pressure, which if accidentally or inappropriately released can cause significant equipment damage and injury to nearby personnel. All pressure must be vented from the system before any maintenance on the fluid end is performed (see 4.5.1: Venting Pressure in the Fluid End, page 35).

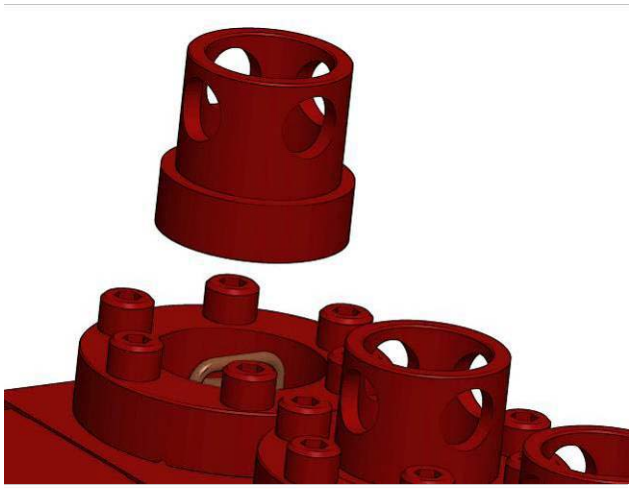
4.7.1 Valve Assembly

The standard valve assembly is as shown. It consists of the valve itself, which is mounted on the valve guide bushing and set directly atop the seal. The bushing inserts into the valve stem guide, and the spring wraps around the entire assembly, so that one end is against the valve itself and the other is shouldered up to the valve stem guide.



4.7.2 Removing the Valves

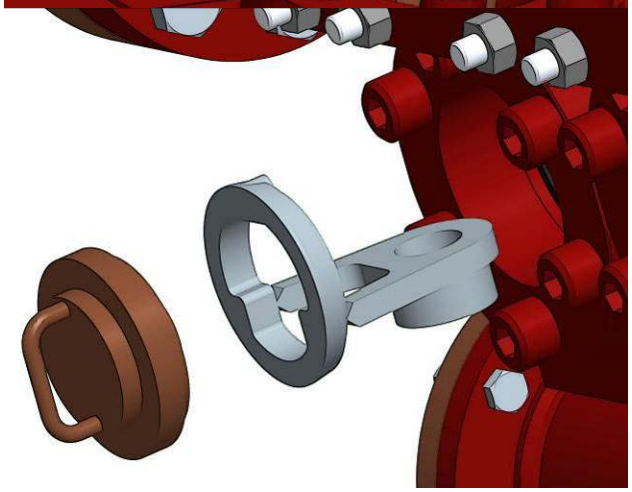
1 Unscrew the valve cover plugs and remove from the fluid end.



2 Remove the upper valve cover. The valve stem guide for the upper valve should be attached to the underside of the valve cover, and must be transferred or replaced if a new cover is to be used.

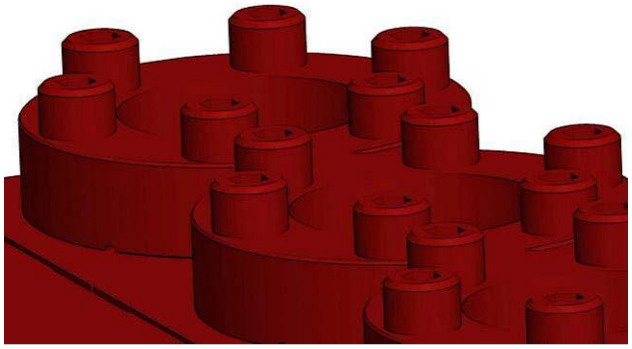


3 Remove the lower valve cover and lower valve stem guide from the fluid module.

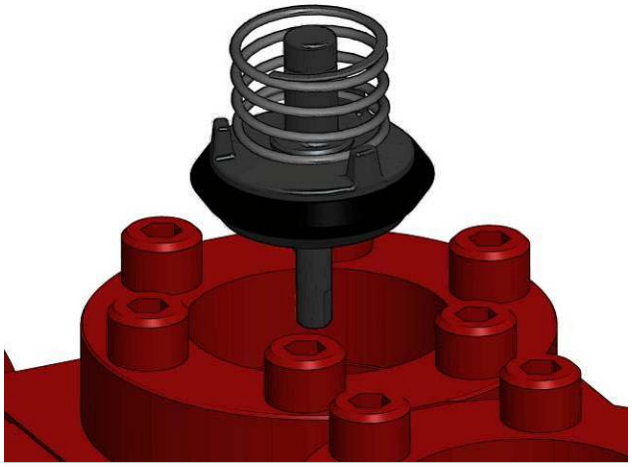


4 Remove the valve cover seals.

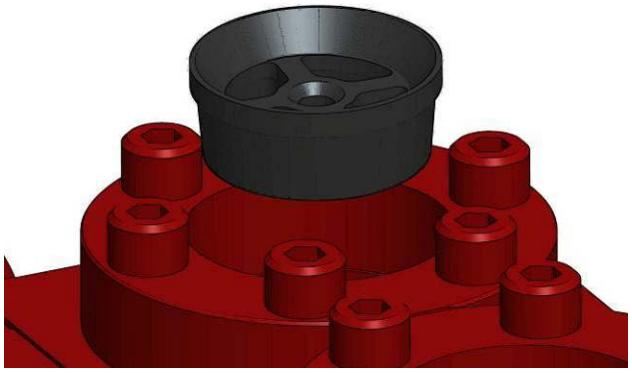




5 Lift the valve spring and valve out using the hook magnetic retriever tool.

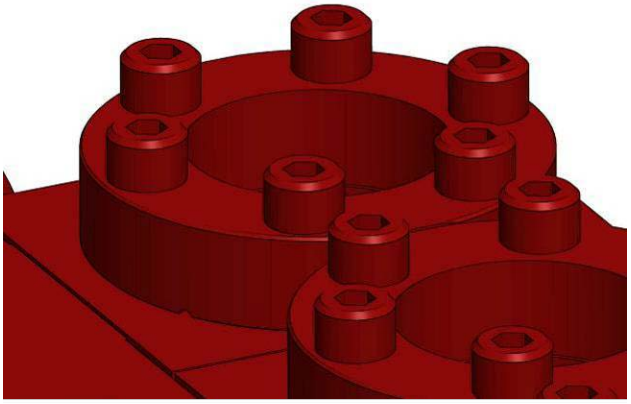


6 If removing the seat, use a hydraulic valve seat puller to remove from the bore, exercising care not to directly strike the valve seat.

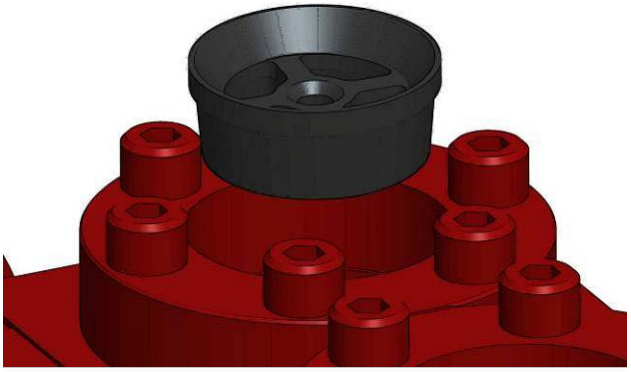


4.7.3 Installing the Valves

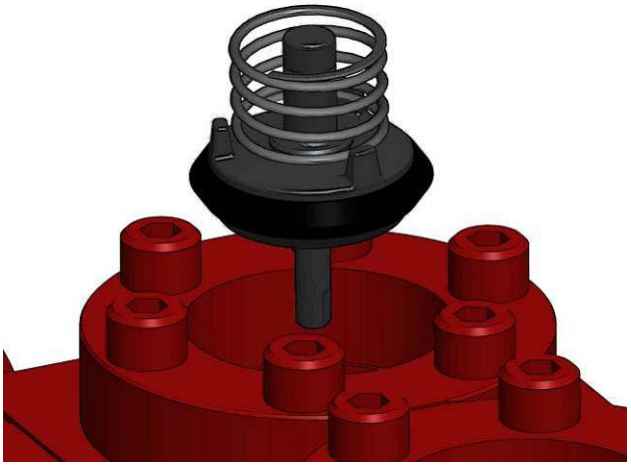
1 Ensure that the taper, valve, seat and cover are clean, dry and free of nicks, burrs or cracks as per 4.5.2: Pre-Installation Procedure.



2 Use a valve seat driver to insert the valve seat into position, and press to obtain an initial seal. Exercise care not to strike the valve seat directly.



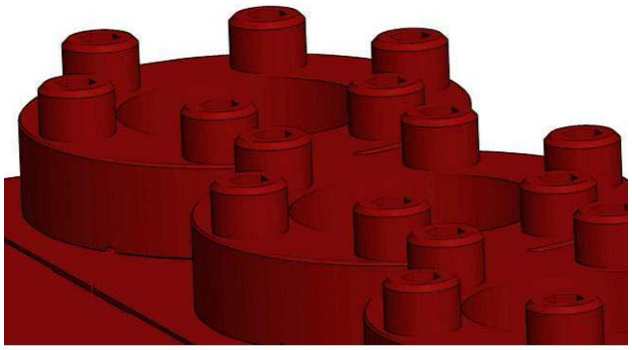
3 Install the valve into the seat and center the spring on the valve.



4 Lightly grease new valve cover seals and install into the counter bores of the fluid module.

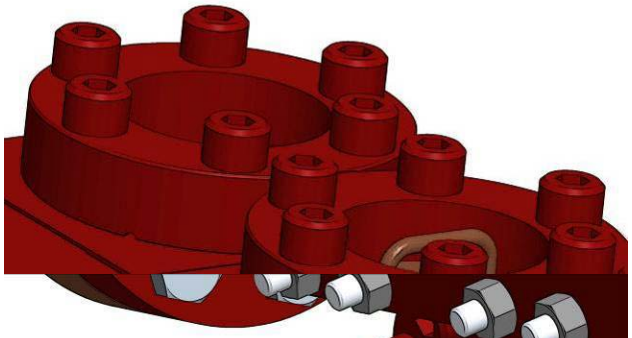


NOTE	Never reuse a valve seal, as the action of pumping causes stress and deformations that prevent it from properly sealing the bore once removed.

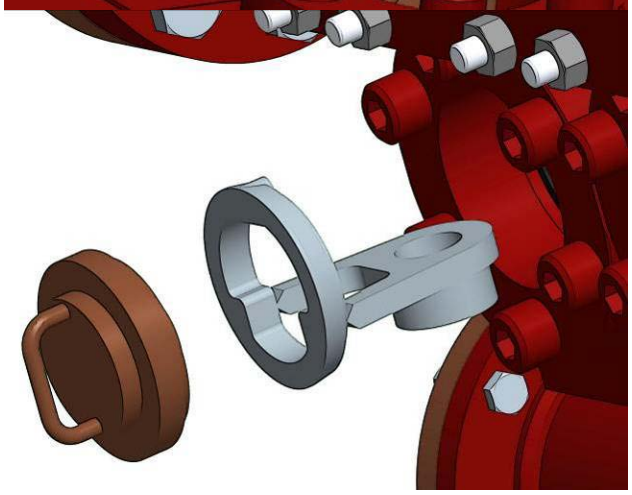


5 If necessary, install the upper valve stem guide into the upper valve cover. Then install the upper valve cover, ensuring that the valve guide lines up with the stem of the valve.

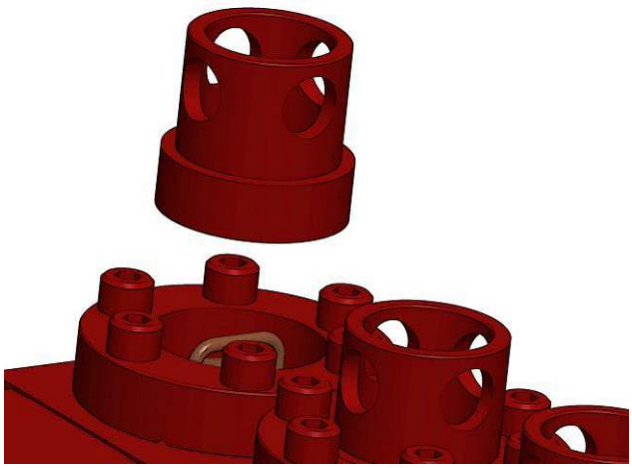




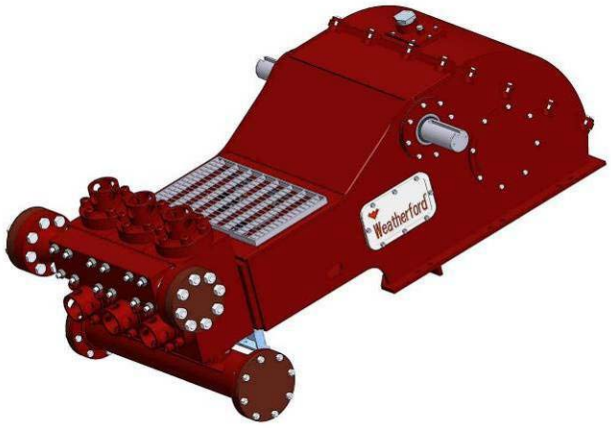
6 Install the lower valve stem guide and cover onto the valve bore.



7 Coat the bottom seating surface and outside of the valve cover plug with grease and install.



8 After the pump is reassembled, run for approximately 15 minutes, then shut down the pump and release the pressure. Tighten the valve corner again with a sledgehammer and resume pumping.



4.8 Charts & Diagrams

4.8.1 Torque Chart

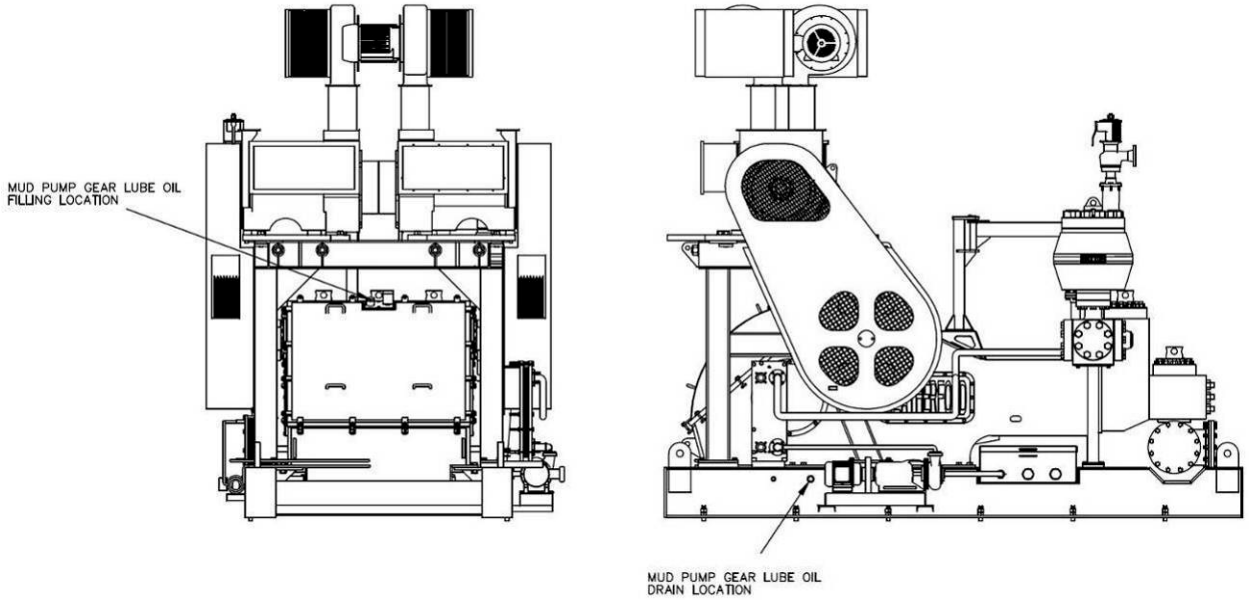
Size	Tensile Stress Area AS Square Inch	SA193 & ASTM 193 B7 Studs with A194 2H Heavy Hex Nuts		
		Clamp Load P.Lb.s	Tightening Torque	
			Dry K=0.223	Lubed K=0.223
			Ft. Lbs.	Ft. Lbs.
1/2 - 13	0.138	10,350	96	72
9/16 - 12	0.177	13,275	139	104
5/8 - 11	0.22	16,500	192	143
3/4 - 10	0.327	24,525	342	256
7/8 - 9	0.452	33,900	551	413
1 - 8	0.594	44,550	828	620
1 1/8 - 8	0.776	58,200	1,217	911
1 1/4 - 8	0.984	73,800	1,714	1,284
1 3/8 - 8	1.215	91,125	2,328	1,744
1 1/2 - 8	1.471	110,325	3,076	2,303
1 5/8 - 8	1.769	132,675	4,006	3,000
1 3/4 - 8	2.06	154,500	5,024	3,763

Size	SA193 & ASTM 193 B7M Studs with A194 2HM Heavy Hex Nuts		
	Clamp Load P.Lb.s	Tightening Torque	
		Dry K=0.223	Lubed K=0.223
		Ft. Lbs.	Ft. Lbs.
1/2 - 13	7,866	73	55
9/16 - 12	10,089	105	79
5/8 - 11	12,540	146	109
3/4 - 10	18,639	260	194
7/8 - 9	25,764	419	314
1 - 8	33,858	629	471
1 1/8 - 8	44,232	925	692
1 1/4 - 8	56,088	1,303	976
1 3/8 - 8	69,255	1,770	1,325
1 1/2 - 8	83,847	2,337	1,750
1 5/8 - 8	100,833	3,045	2,280
1 3/4 - 8	177,420	3,818	2,860

Size	Tensile Stress Area AS Square Inch	SA320 & ASTM A320 L7 Studs with A194 Grade 4 or Grade L7 Heavy Hex Nuts		
		Clamp Load P.Lb.s	Tightening Torque	
			Dry K=0.223	Lubed K=0.223
			Ft. Lbs.	Ft. Lbs.
1/2 - 13	0.138	10,350	96	72
9/16 - 12	0.177	13,275	139	104
5/8 - 11	0.22	16,500	192	143
3/4 - 10	0.327	24,525	342	256
7/8 - 9	0.452	33,900	551	413
1 - 8	0.594	44,550	828	620
1 1/8 - 8	0.776	58,200	1,217	911
1 1/4 - 8	0.984	73,800	1,714	1,284
1 3/8 - 8	1.215	91,125	2,328	1,744
1 1/2 - 8	1.471	110,325	3,076	2,303
1 5/8 - 8	1.769	132,675	4,006	3,000
1 3/4 - 8	2.06	154,500	5,024	3,763

Size	SA320 & ASTM 320 L7M Studs with A194 L7M Heavy Hex Nuts		
	Clamp Load P.Lb.s	Tightening Torque	
		Dry K=0.223	Lubed K=0.223
		Ft. Lbs.	Ft. Lbs.
1/2 - 13	7,866	73	55
9/16 - 12	10,089	105	79
5/8 - 11	12,540	146	109
3/4 - 10	18,639	260	194
7/8 - 9	25,764	419	314
1 - 8	33,858	629	471
1 1/8 - 8	44,232	925	692
1 1/4 - 8	56,088	1,303	976
1 3/8 - 8	69,255	1,770	1,325
1 1/2 - 8	83,847	2,337	1,750
1 5/8 - 8	100,833	3,045	2,280
1 3/4 - 8	177,420	3,818	2,860

4.8.2 Lubrication Chart



Oil Quantity

Approximately 185 U.S. Gallons (700L)

Oil Type

Air Temperature (°F)	Air Temperature (°C)	Industrial EP Gear Oil
50° to 176°	10° to 80°	AGMA EP 460
30° to 155°	-1° to 68°	AGMA EP 320
-4° to 125°	-20° to 52°	AGMA EP 220

Oil Cleanliness

ISO 4460 Code 16/64 (NAS 1638 Class 8)

Oil Change Period

The pump should have its first oil change after 400 hours of operation.
Subsequent oil changes should occur every six months or 2,000 running hours, whichever comes first.

Oil Change Procedure

1. Shut down and lock out the pump as per standard procedure. The drain plug should be removed and the pump gear lube oil drained immediately after shutdown is complete.
2. Remove the pump gear inspection opening cover plate
3. Visually inspect the gearing status, and report any damage, defects or other potential problems.
4. Reinstall drain plug and ensure it is secure.
5. Refill the crankcase with the correct oil type (see above) through the cover plate opening.
   NOTE Oil may require pre-filtering to obtain an acceptable cleanliness level.
6. Replace the cover plate and gasket.

Chapter 5: Assembly/Disassembly

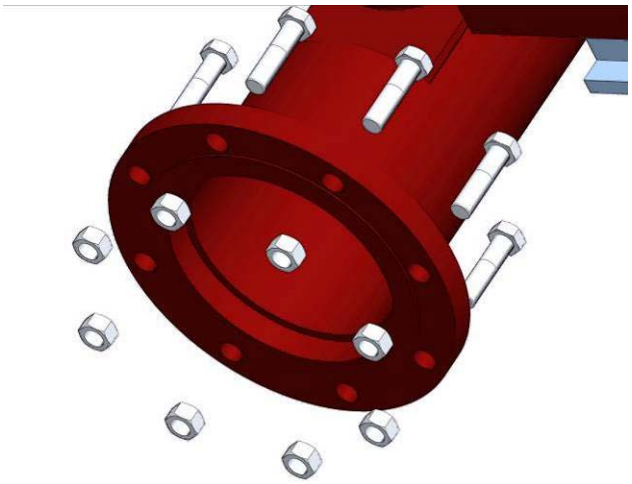
5.1 Fluid End Disassembly Procedures

The following are the standard procedures for disassembling the fluid end of the E-447 pump. All personnel involved in disassembly procedures should possess a thorough understanding of all procedures, especially any and all safety regulations involved.

CAUTION	Even while at rest, the fluid end of the system is under significant pressure, which can cause significant equipment damage and injury to nearby personnel if vented inappropriately. All pressure must be properly vented from the system before any maintenance on the E-447 is performed (see 4.5.1: Venting Pressure in the Fluid End, page 35).

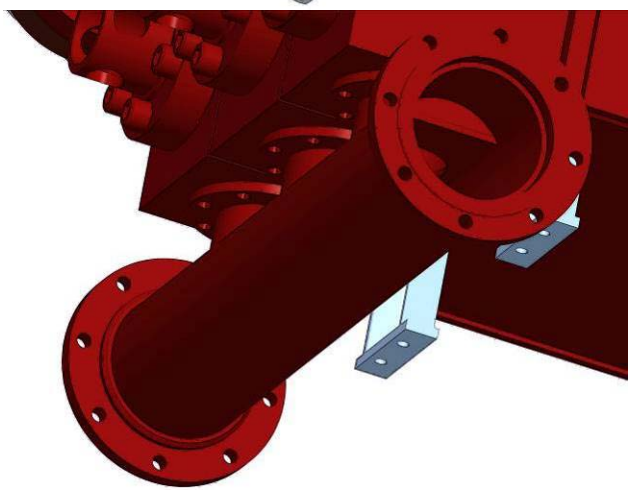
5.1.1 Replacing the Suction Manifold

1 Disconnect any piping connected to the suction manifold.

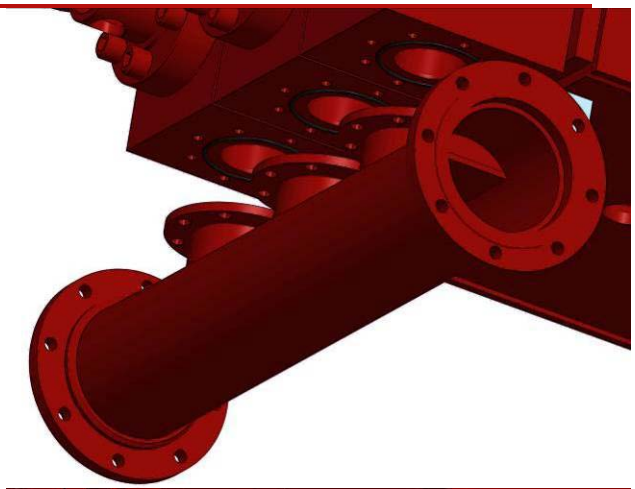


2 Remove the cap screws connecting each of the suction modules to the suction manifold.

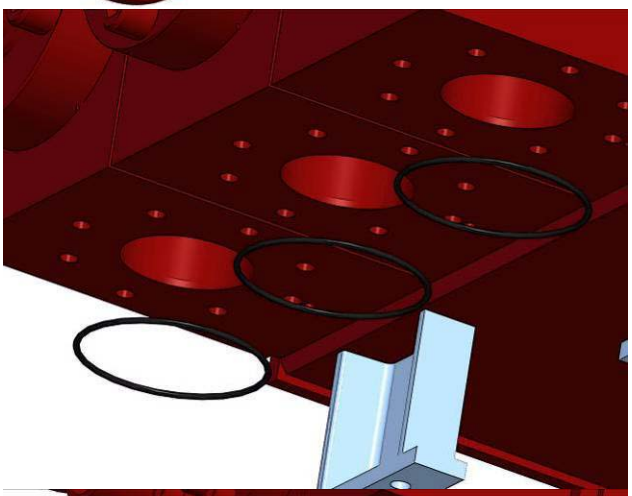
WARNING	The suction manifold is a weighty piece of metal which can cause serious injury if dropped. Be sure the manifold is sufficiently supported before removing the cap screws.



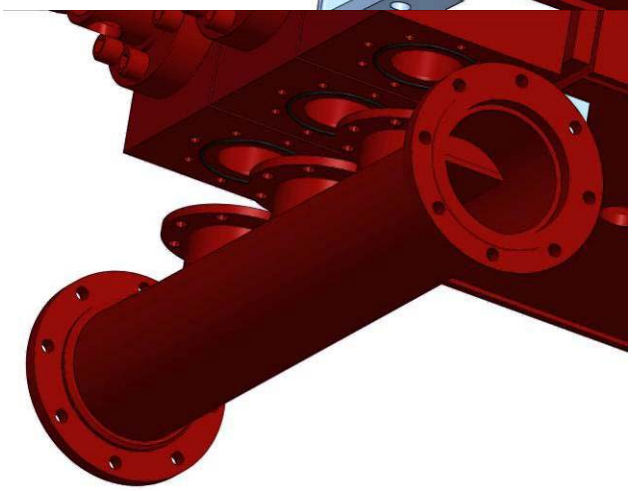
3 Carefully remove the suction manifold from the pump.



4 Replace all of the gaskets and seals connecting the suction manifold to the suction modules and to the suction piping.

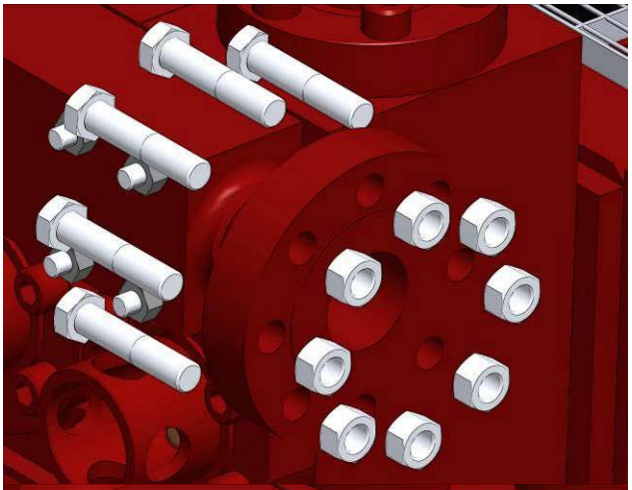


5 Slide the new manifold into position and replace cap screws. Tighten cap screws to the appropriate torque (413 ft. lbs. for a ⅞ inch capscrew).



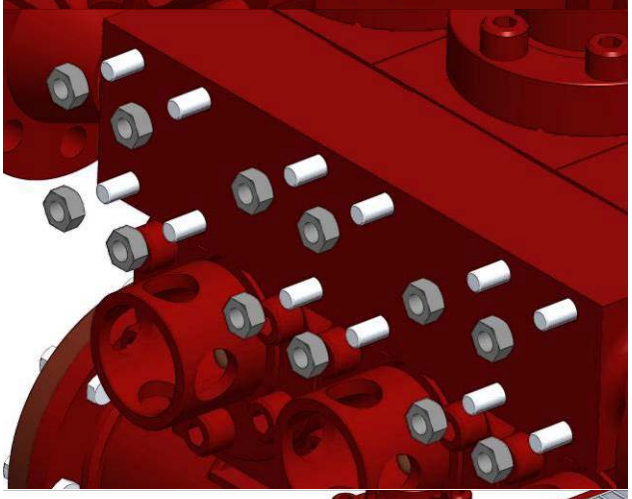
5.1.2 Replacing the Discharge Manifold

1 Remove the section of the discharge piping connected to the discharge manifold.

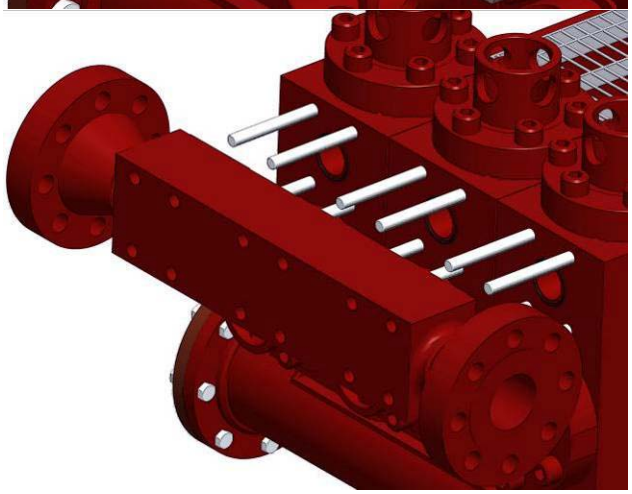


2 Remove the nuts connecting each of the discharge modules to the discharge manifold.

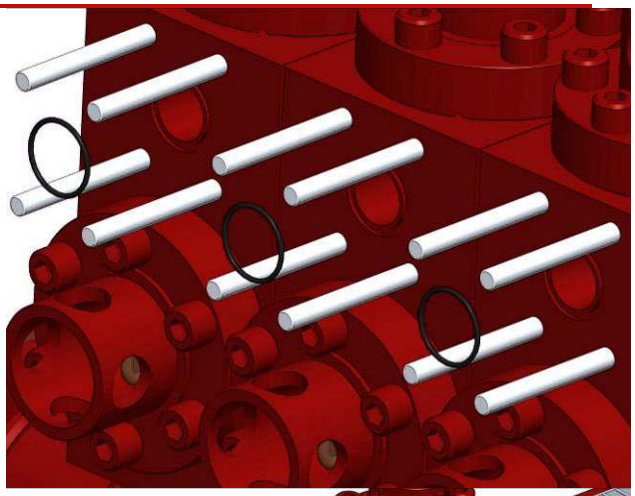
WARNING	The discharge manifold is a weighty piece of metal which can cause serious injury if dropped. Be sure the manifold is sufficiently supported before removing the fasteners.



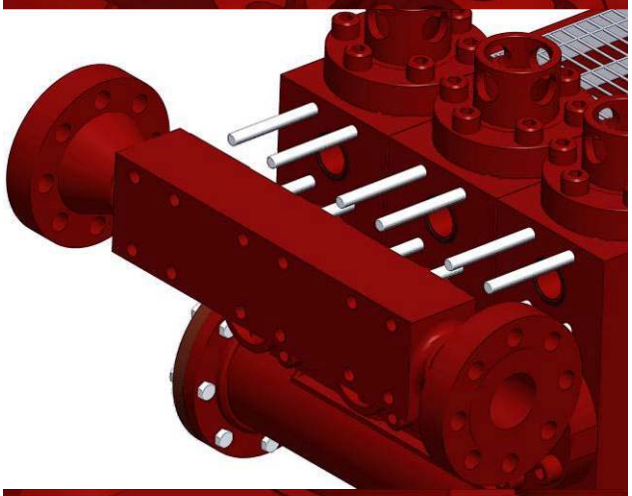
3 Carefully remove the discharge manifold from the pump.



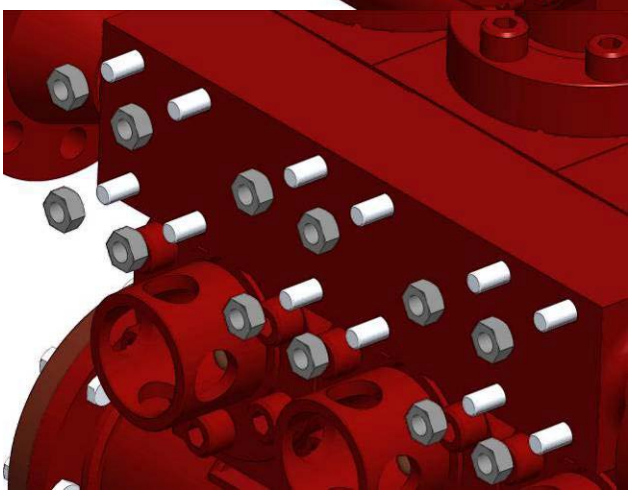
4 Replace all of the gaskets and seals connecting the discharge manifold to the discharge modules.



5 Slide the new manifold into position on the pump.



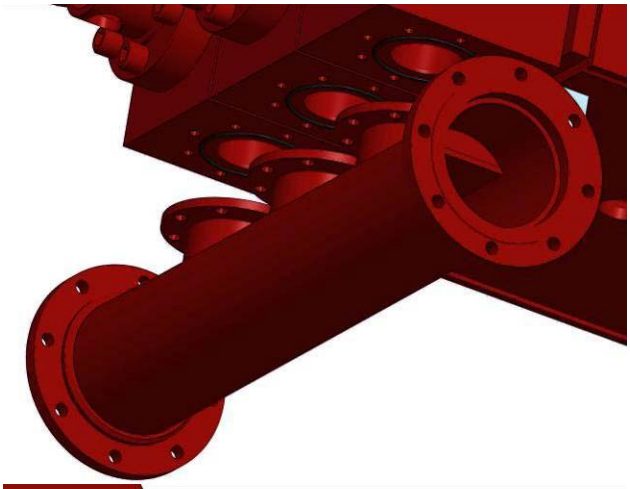
6 Reinstall nuts and tighten.



5.1.3 Removing the Fluid Modules

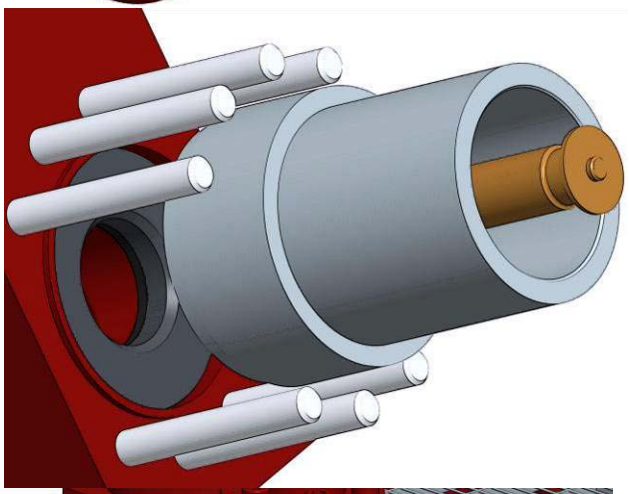
The fluid cylinder of the E-447 pump is composed of three separate modules, each of which may be removed and maintained separately from the others.

1 Remove the Suction and Discharge manifolds as per 5.1.1 (page 56) and 5.1.2 (page 58) respectively.

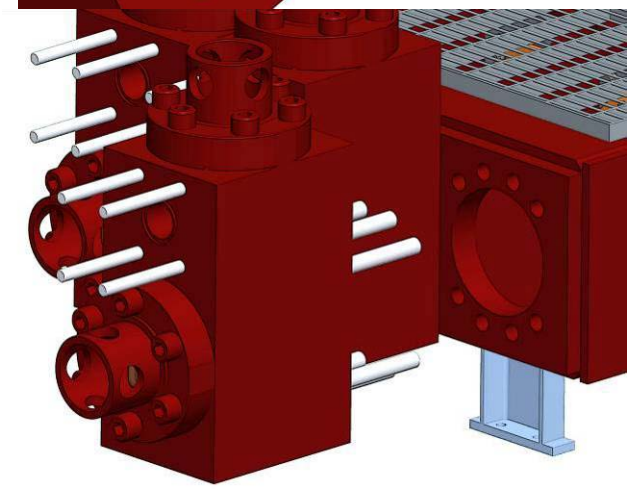


2 Remove the pistons and liners from all modules to be replaced as per 4.6.2 (page 38). Note that this process will loosen the module on the frame, so any modules to be replaced should secured using overhead lifting equipment before removing the liners.

WARNING	Each discharge module is a weighty piece of equipment and can cause serious injury if dropped. Be sure the module is properly supported before removing the cap screws.



3 Slide the fluid module free of the pump.



5.2 Fluid End Assembly Procedures

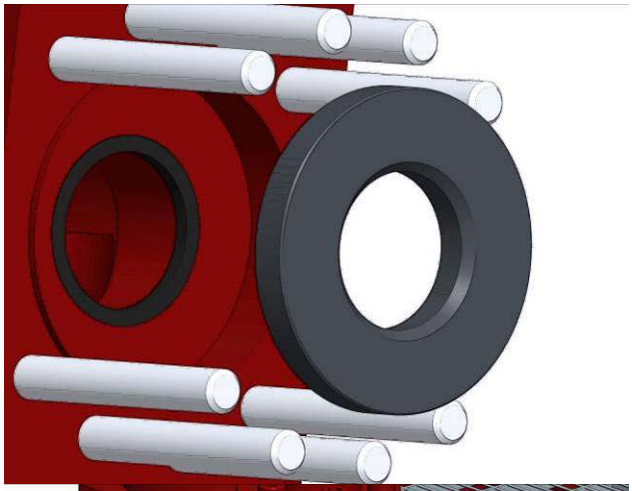
The following are the standard procedures for assembling the various components and systems of the fluid end of the E-447 pump. All personnel involved in the assembly of the fluid end must possess a thorough understanding of all of the following procedures, especially any and all safety regulations involved.

5.2.1 Installing the Fluid Modules

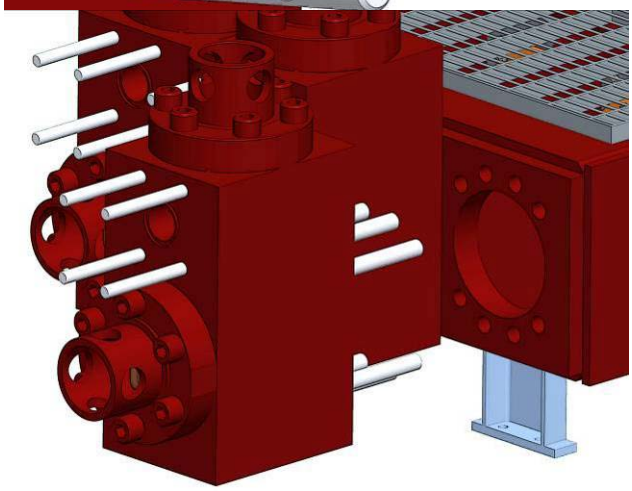
The following procedures should be used to install the fluid modules onto the pump.

WARNING	The suction and discharge modules are weighty pieces of hardened metal designed to withstand intense pressures, and can cause serious injury if dropped. Be sure that each module is sufficiently supported before hoisting and beginning installation procedures.

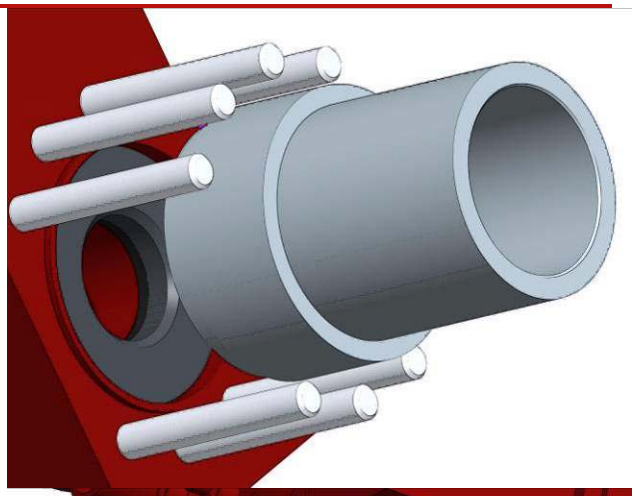
1 Install the wear plate seal and wear plates as per 4.6.7: Installing the Liner Seal & Wear Plate (page 44).



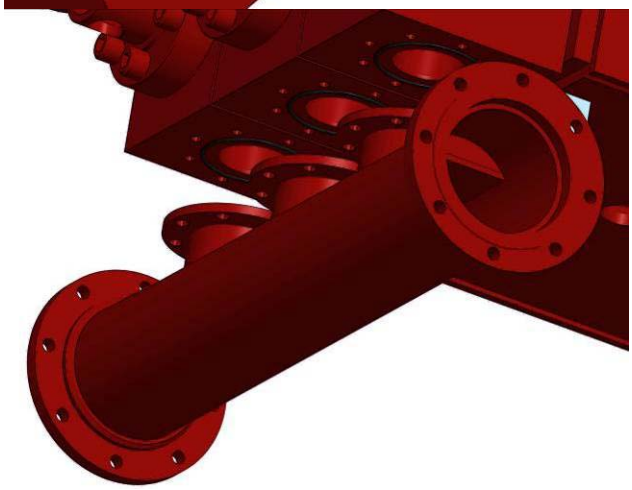
2 Slide the fluid module into position on the pump frame. Care should be taken to ensure that the threads on the studs are not damaged.



5 Install the liners as per 4.6.8 (page 45).



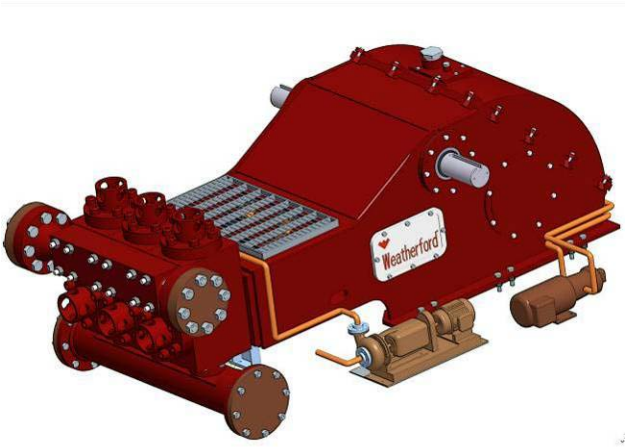
6 Once all modules have been installed, attach the suction and discharge manifolds as per 5.1.1 (page 56) and 5.1.2 (page 58).



5.2.2 Installing the Liner Wash System

The following is the standard procedure for installing a liner wash system. However, if the manufacturer provides differing instructions, always default to the manufacturer's instructions.

Drop the liner spray manifold over the piston assemblies and slide at the bottom of the chamber. The hose may be connected at either side.



5.3 Power End Disassembly Procedures

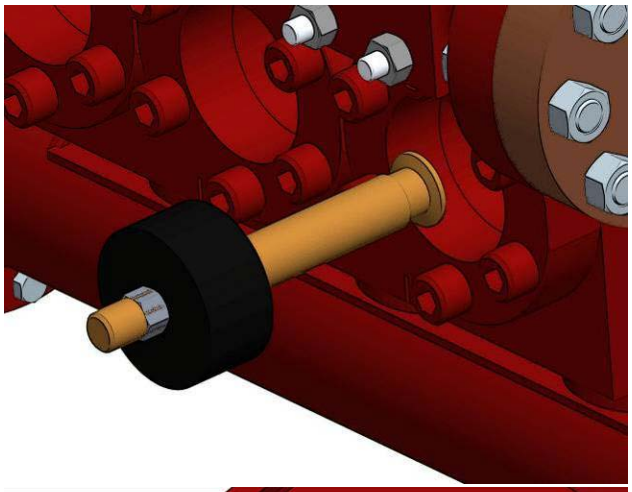
The following are the standard procedures for disassembling the various components and systems of the power end of the E-447 pump. All personnel involved in the disassembly of the power end must possess a thorough understanding of all of the following procedures, especially any and all safety regulations involved.

5.3.1 Removing the Wiper Box & Diaphragm Plate

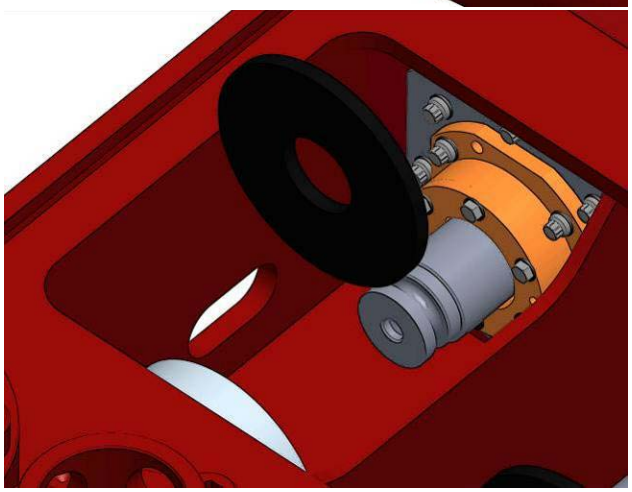
The crosshead diaphragm plates are all line bored with the pump frame, and must not be interchanged. Take note of which cylinder and pump each plate was removed from so it can be reinstalled properly. Do not attempt to remove the diaphragm plate unless the outer diameter of the stub rod flange is greater than the inner diameter of the diaphragm plate itself.

1 Remove the Pistons as per 0: The following are the standard procedures for safely removing and replacing the pistons and liners, as well as any attached components or parts. Remember to always vent the pump pressure as per 4.5.1 (page 35) before beginning any maintenance procedures.

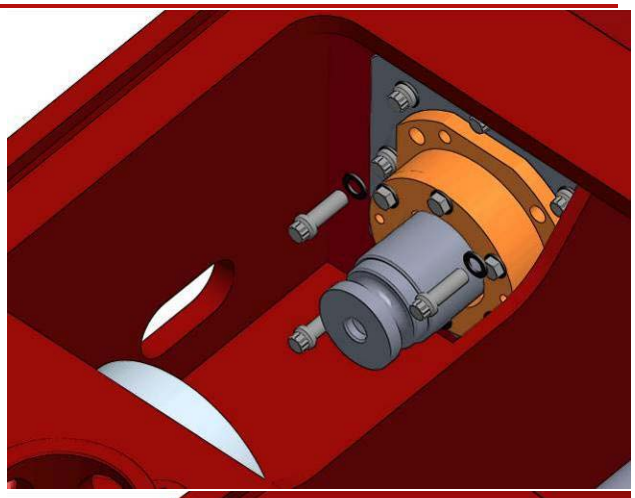
(page 36).



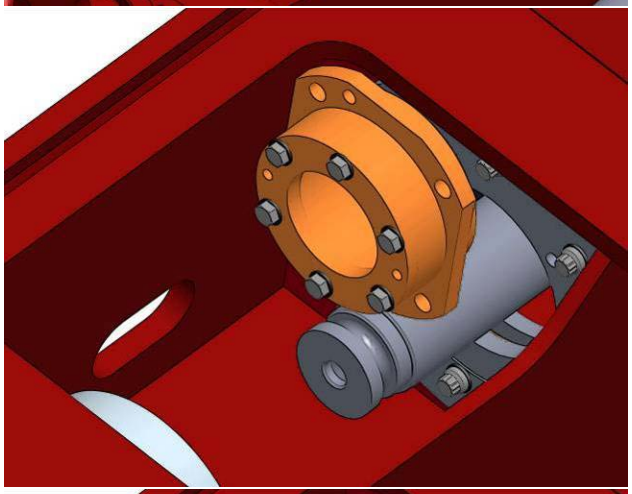
2 Mark the outer surfaces of the wiper box and diaphragm plates to indicate their orientation against the pump frame and remove the baffle from the extension rod.



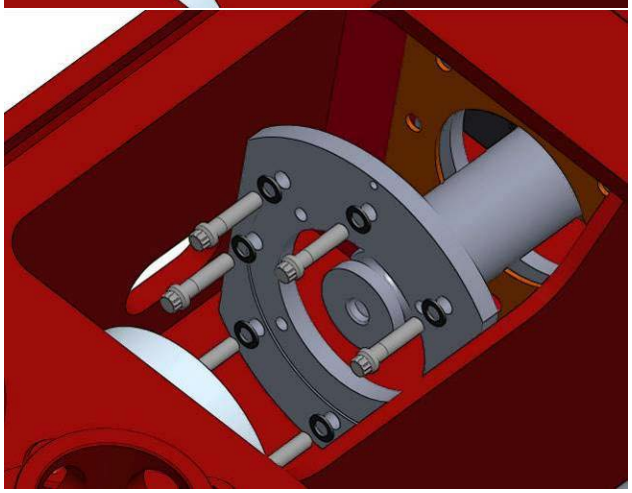
3 Remove the bolts affixing the wiper box to the diaphragm plate.



4 Slide the wiper box off the crosshead extension and out of the pump frame.

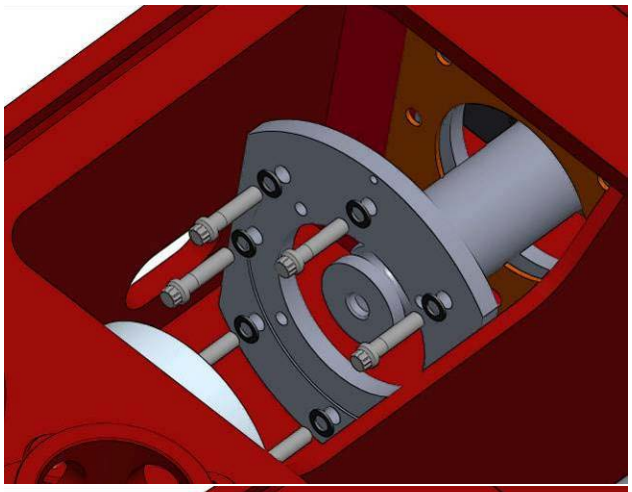


5 Unbolt the diaphragm plate and gasket, and slide free of the frame. The resulting opening should be large enough to permit the removal of the crosshead.

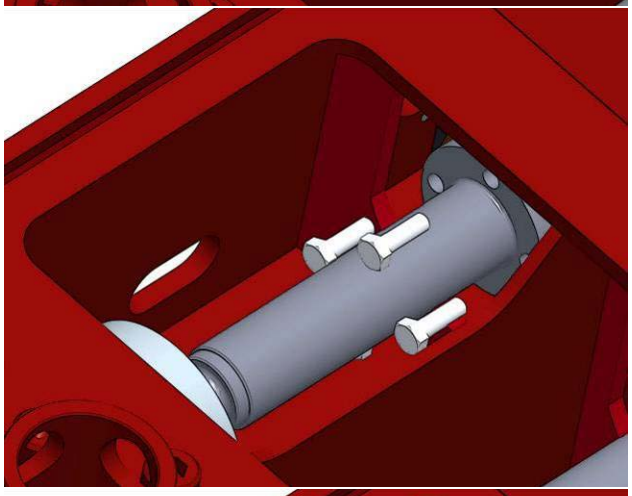


5.3.2 Removing the Crosshead Extensions

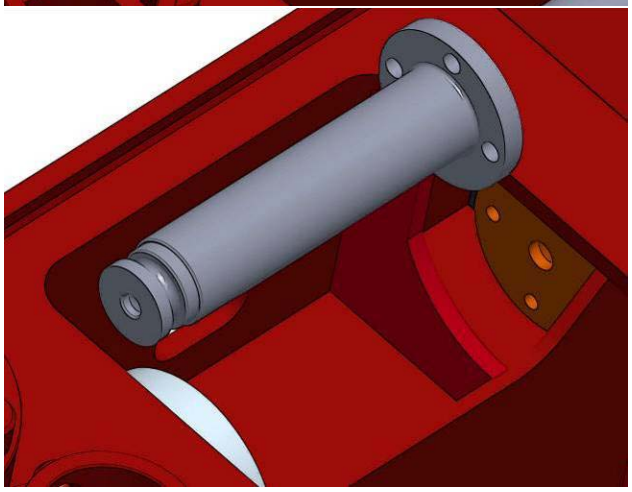
1 Remove the Wiper Box and Diaphragm Plate as per 5.3.1.



2 Unbolt the crosshead extension from the crossheads.



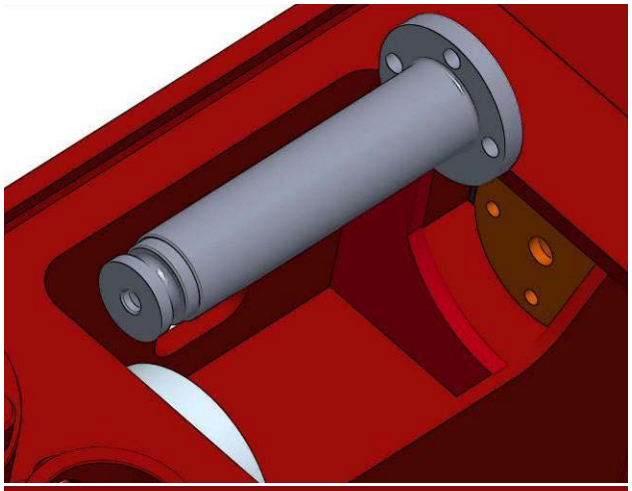
3 Carefully remove the extension rod from the pump frame. Care should be exercised not to damage the polished chrome finish unless the pony rod is to be discarded.



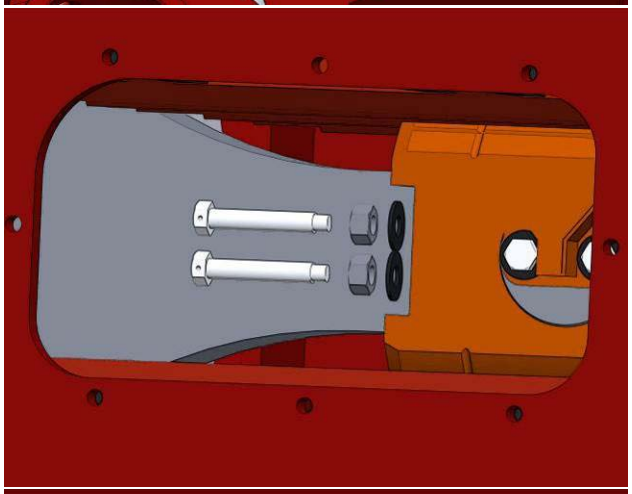
5.3.3 Removing the Crossheads

Each wrist pin corresponds to a specific crosshead, and must not be interchanged. It is best to mark each crosshead and wrist pin set to avoid confusion.

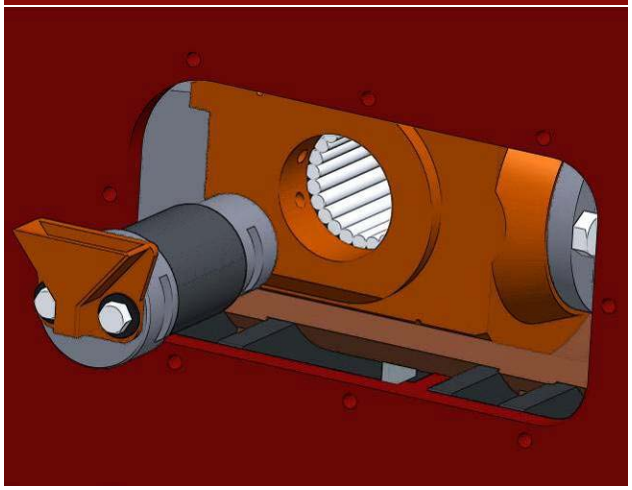
1 Remove the Stuffing Box, Diaphragm Plate and Crosshead Extensions as per 5.3.2.



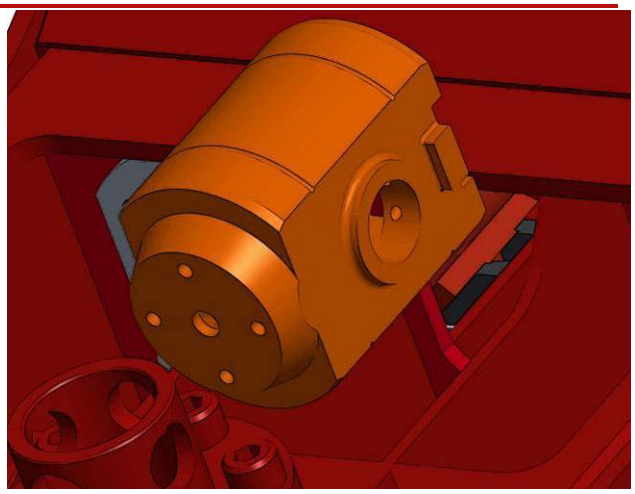
2 Remove the wrist pin retainer bolts (located on either side of the crossheads) which thread into the crossheads.



3 Utilize the tapped holes in the retainer plates to jack the wrist pin from the crossheads, and mark to indicate which crosshead they were removed from.

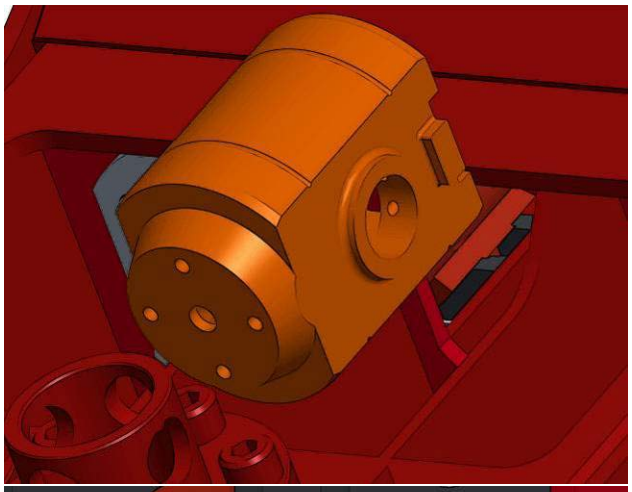


4 Remove the crossheads through the hole created by removing the diaphragm plates. Place wooden boards on the crosshead guides to prevent scoring by the connecting rod ends.

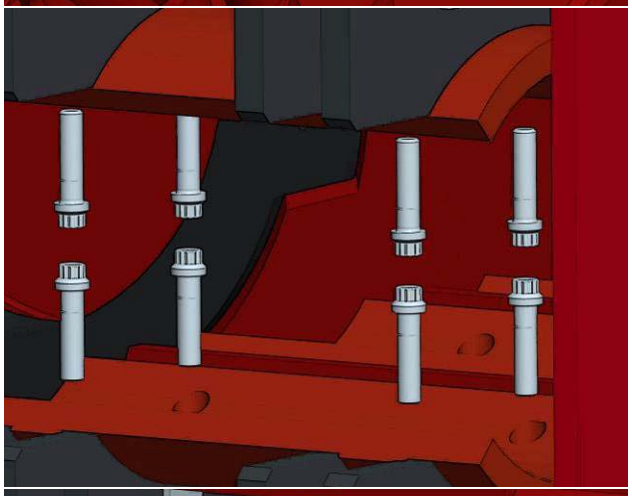


5.3.4 Removing the Crosshead Guides

1 Remove the Crossheads as per 5.3.3.

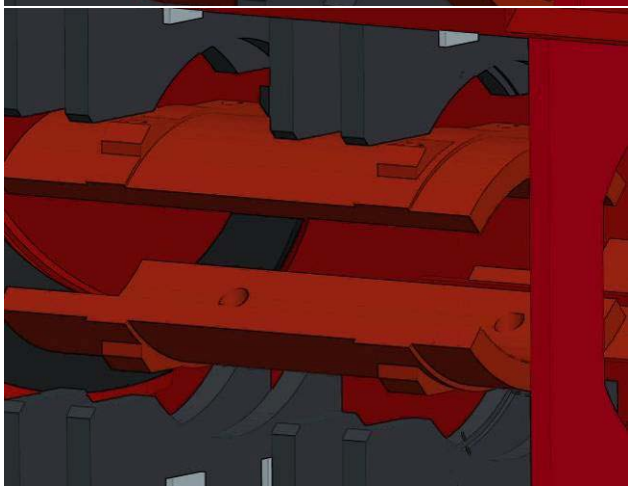


2 Remove the four (4) bolts and clamp bars which affix the crosshead guide to the frame.



3 Remove crosshead guides.
Shims, if present, should be left in place if the guide is to be reinstalled. If not, a new shim package and realignment will be necessary.

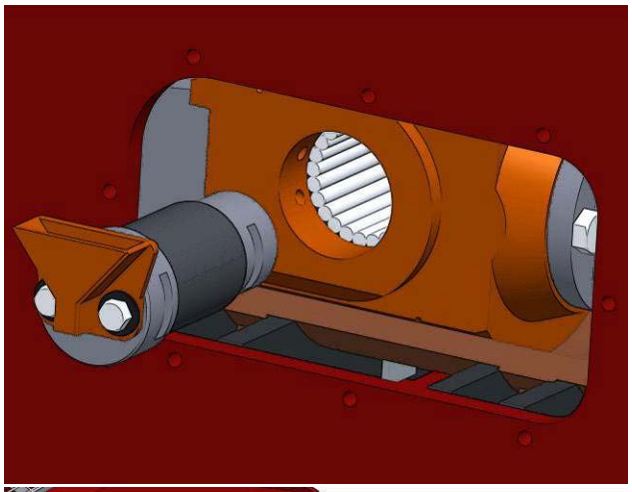
NOTE It is extremely important to make note of the size and placement of shims during removal. Failure to do so can result in excessive piston and liner wear due to misalignment.



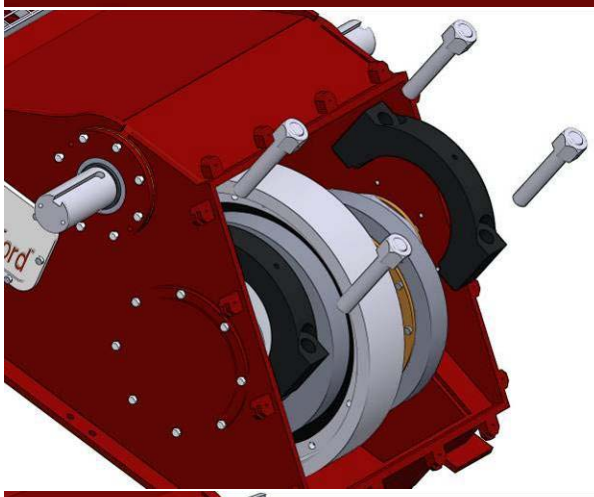
5.3.5 Removing the Crankshaft Assembly

The following procedure will remove the gear, crankshaft, main bearings and connecting rods as a single assembly.

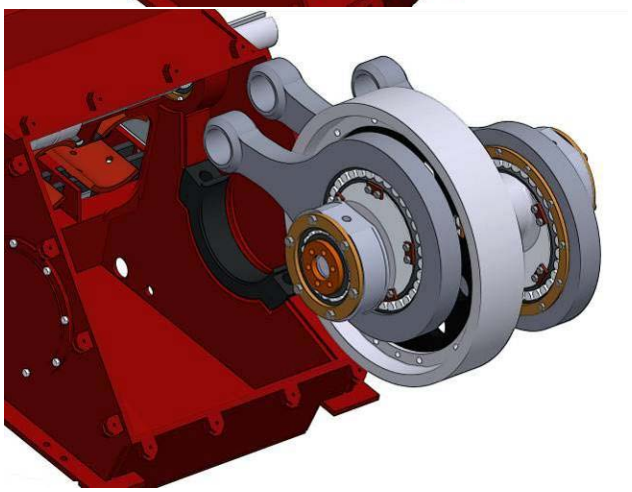
1 Remove the wrist pins from the crossheads as per 5.3.3: Removing the Crossheads (page 66). Make sure to support the connecting rods with come-a-longs and line the inner surfaces of the crosshead guides with wood or heavy cardboard to protect them from damage when removing the crankshaft assembly.



2 Disconnect the lube lines and the crankshaft main bearing housings.



3 Slowly lift the crankshaft assembly free of the pump frame.

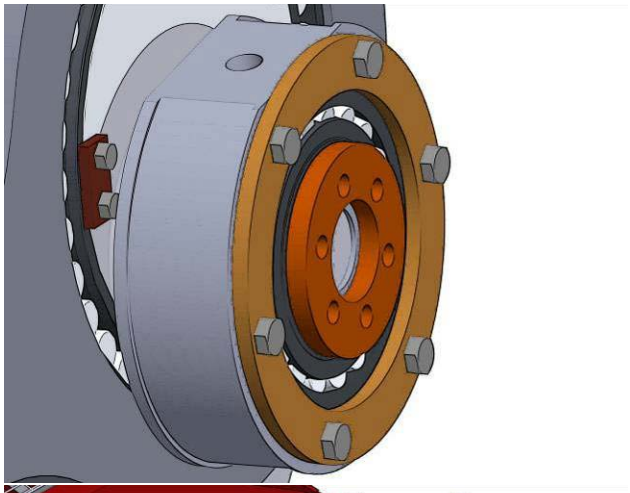


WARNING	The crankshaft assembly is an extremely weighty system, and can cause damage, serious injury and death if dropped or if allowed to impact other objects or personnel. Handle with extreme care and follow all applicable safety procedures when lifting this system.

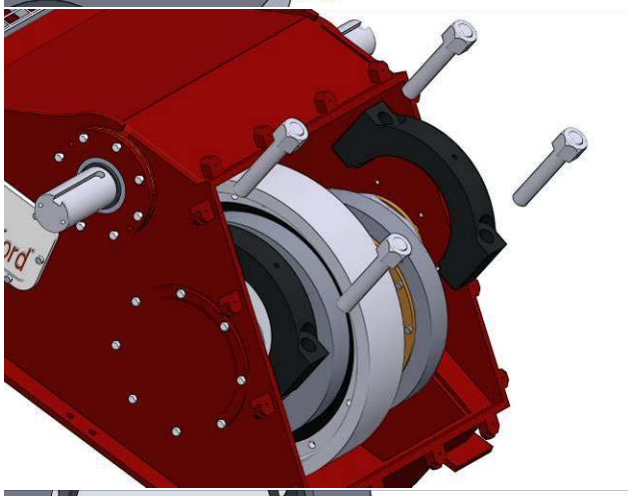
5.3.6 Removing the Main Bearing

Use this guide to remove the main bearing without removing the crankshaft from the floating carrier, or to remove the main bearing from a crankshaft that has already been removed from the power frame.

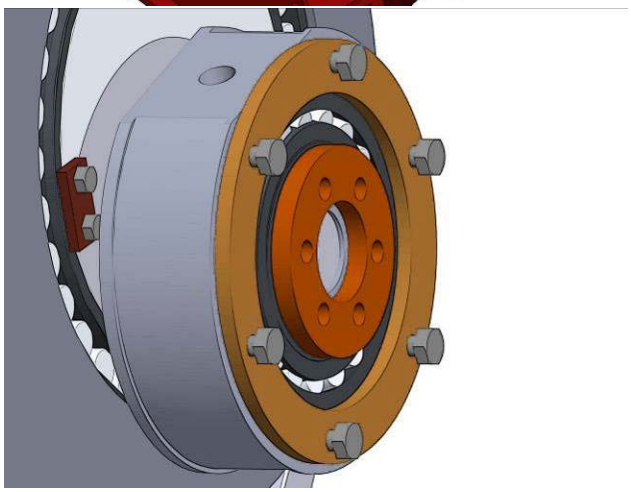
1 Disconnect the lube lines leading to the main bearing.



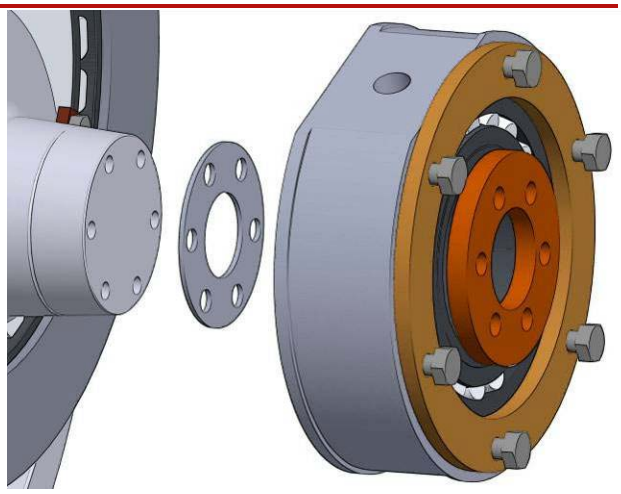
2 Remove the main crankshaft bearing housings, and support the crankshaft assembly so that the load is not resting on the main bearings.



3 Loosen the main bearing. To do so, loosen the retainer bolts 2 to 3 turns, and then inject grease into the grooves in the race until the bearing becomes loose on the shaft.



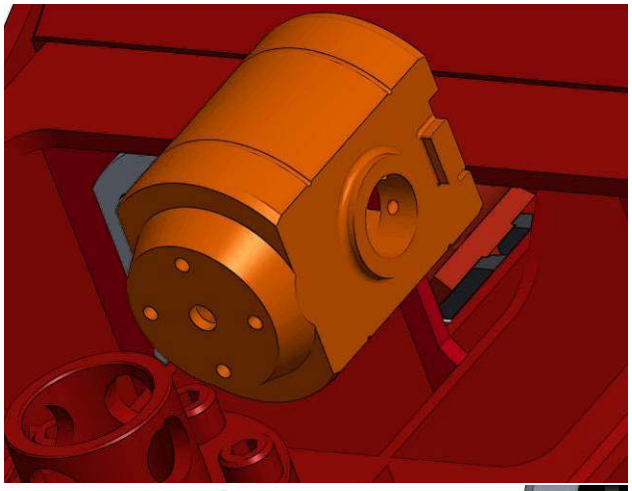
3 Remove the main bearing retainer bolts, and slide the retainer, shims and bearing from the crankshaft.



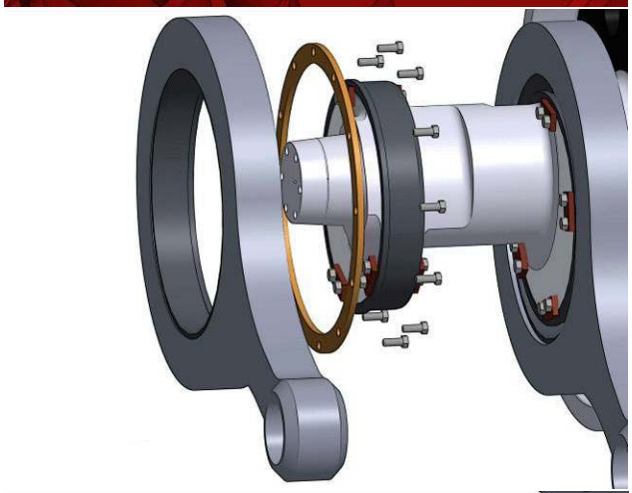
5.3.7 Removing the Connecting Rods

The connecting rods should only be removed if absolutely necessary. If it is necessary to remove multiple connecting rods, each rod should be stored separately to avoid confusion.

1 Remove the crossheads as per 5.3.3 (page 66). Make sure to support the connecting rods with come-a-longs and line the inner surfaces of the crosshead guides with wood or heavy cardboard to protect them from damage when removing the crankshaft assembly.

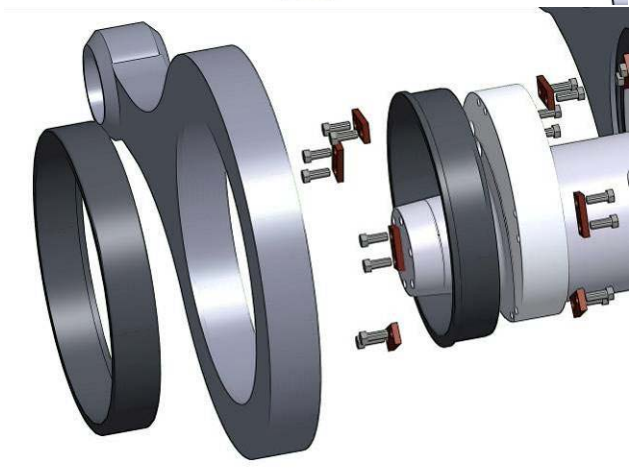


2 Remove the outer bearing retainers and roller retaining ring, and separate the bearing. This should remove part of the bearing in the connecting rod, leaving the other portion of the bearing attached to the crankshaft.



3 Remove the inner retainers for the connecting rod, and use a hammer and brass rod to tap out the bearing parts from the crankshaft and connecting rod.

WARNING	Make sure that all bearing parts are kept with the same bearing. Do not mix parts between the bearings.

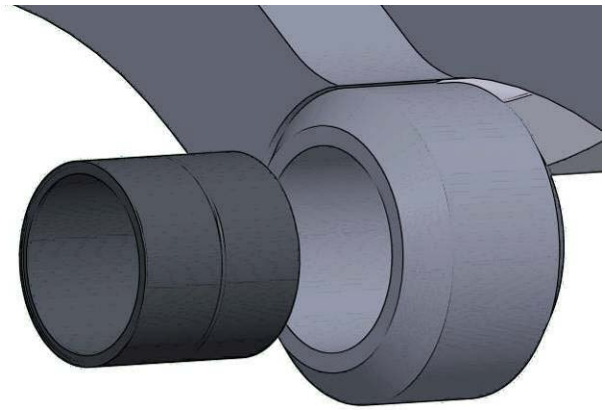


5.3.8 Removing the Wrist Pin Bearings

CAUTION	If any part of a bearing needs to be replaced, then the entire bearing must be replaced. Do Not mix the parts of various bearings.

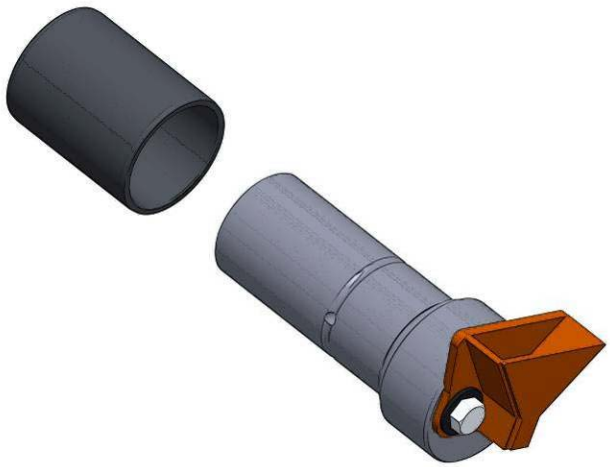
1 Use an adapter plate with a slightly smaller diameter than the bearing to push or pull the outer race of the wrist pin bearing from the connecting rod.

NOTE	Do not drive the bearing from the rod with a hammer, as this may damage the bearing.



2 If the inner race of the wrist pin bearing needs to be replaced, it may be slipped off of the wrist pin by heating it with a torch. The bearing race should not have to be raised to over 200°F to press the wrist pin out of it.

WARNING	During this process, parts can become extremely hot. Allow a few minutes after heating for the races to stabilize, and handle with care.



5.3.9 Turning the Main Gear

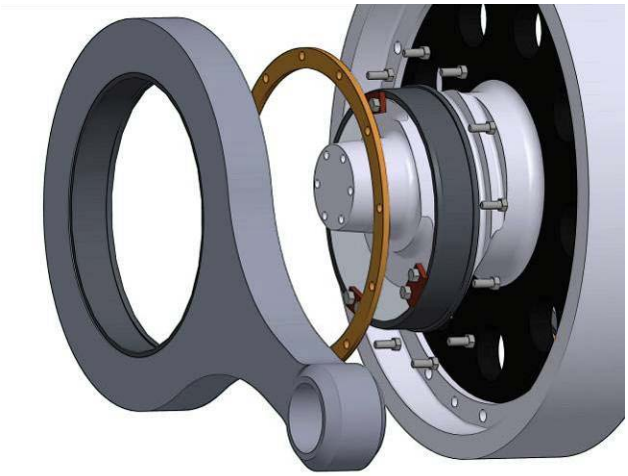
The main gear, like the connecting rods, is a precision piece of equipment, and should not be removed unless it is absolutely necessary. If simply turning it to use the unworn side of the teeth, remove the crankshaft assembly (see 5.3.5: Removing the Crankshaft Assembly on page 69) and rotate with the main gear still attached.

Note that since the main gear is not centered in the pump, turning the gear in this way will require removing and turning the pinion shaft and bearings as well.

5.3.10 Removing the Main Gear

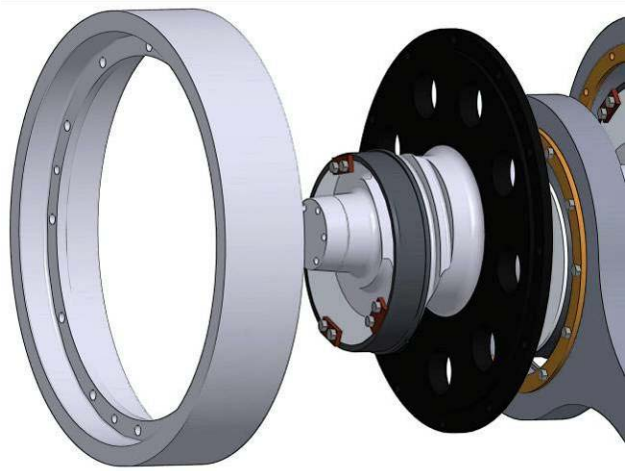
If it does become necessary to remove the Main Gear, use the following procedure.

1 Remove the connecting rod between the main gear and the right end of the crankshaft as per 5.3.7 (page 72)



2 Unbolt the main gear from the crankshaft and remove. The gear may have a slight shrink fit to the crankshaft, so exercise care not to warp or damage the gear during removal.

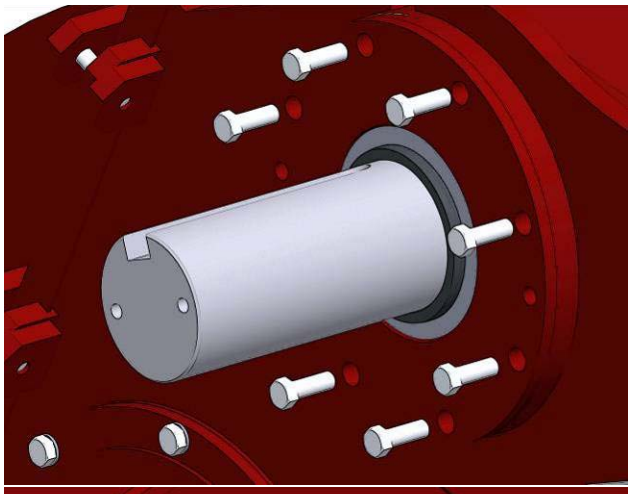
NOTE It is helpful to place match marks on the crankshaft gear flange so that the main gear can be reinstalled in exactly the same position.



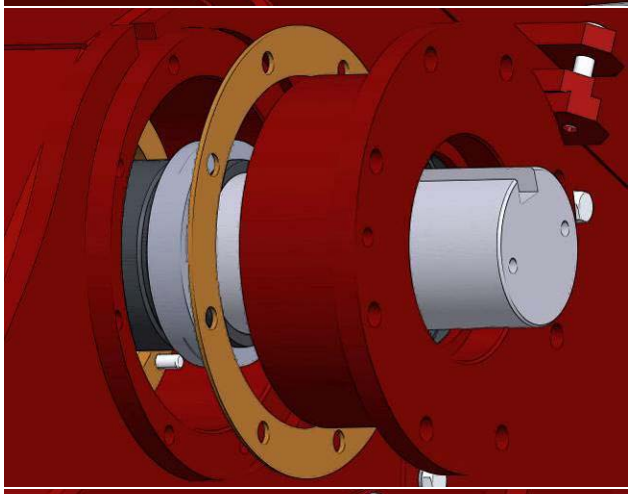
5.3.11 Removing the Pinion Bearing Carriers

The following procedure outlines the removal of the pinion shaft bearings.

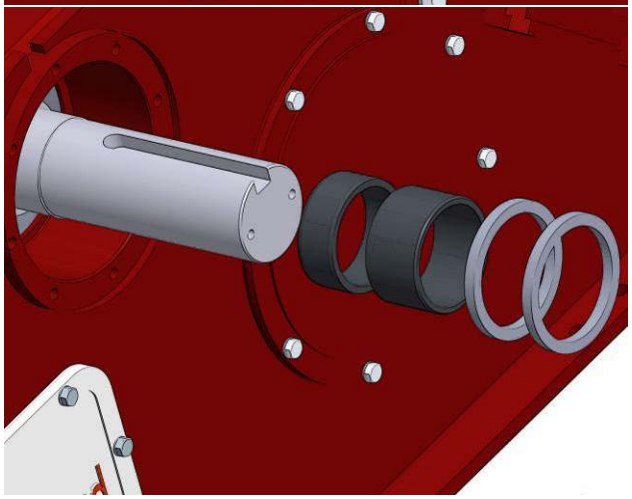
1 Unscrew the pinion bearing carrier and disconnect the oil lube lines. Be sure to support the pinion shaft to prevent it from moving.



2 Use the jackscrew holes in the bearing carriers to remove it from the frame.



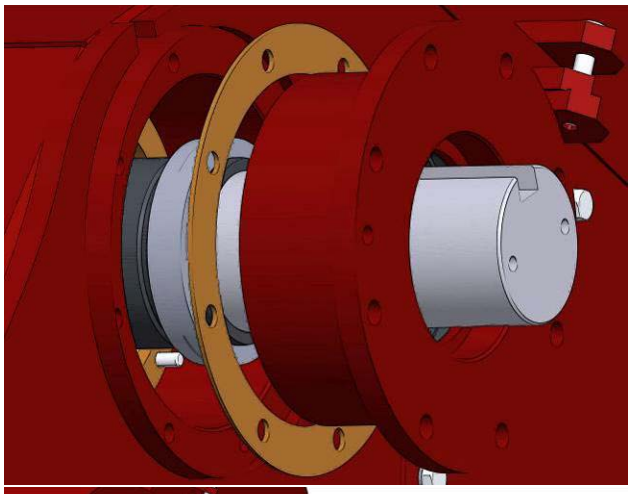
3 Use a puller to remove the inner bearing race and oil seal race from the pinion shaft.



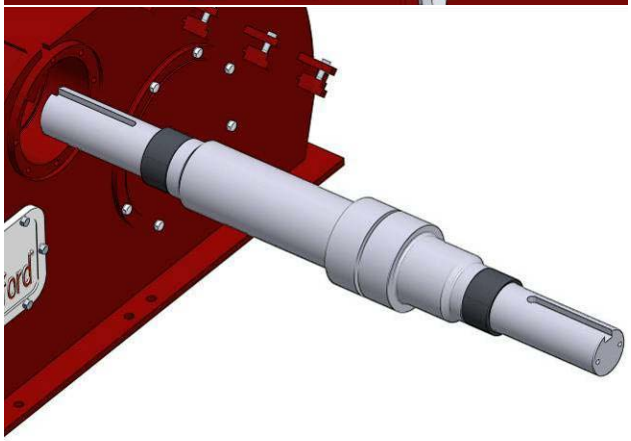
5.3.12 Removing the Pinion Shaft

The following procedure outlines the removal of the pinion shaft.

1 Remove the Pinion Bearing Carriers as per 5.3.11 (page 75).



2 Slide the shaft out of the pump frame. Since the bearings are carrier mounted, the shaft can be removed out of either side of the frame. However, be sure to note its original orientation, as it should be replaced facing the same direction.



5.4 Power End Assembly Procedures

The following are the standard procedures for assembling the various components and systems of the power end of the E-447 pump. All personnel involved in the assembly of the power end must possess a thorough understanding of all of the following procedures, especially any and all safety regulations involved.

All nuts, bolts & studs referenced in this section should be tightened to the appropriate torque in accordance with 4.8.1: Torque Chart (page 54) unless specifically noted otherwise. All nut and bolt connections located inside the pump should use lock nuts, and security washers should be used on all bolts in tapped holes inside the pump.

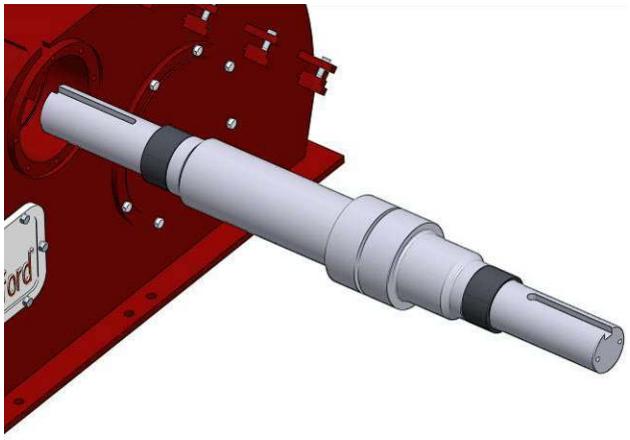
5.4.1 Installing the Pinion Shaft & Bearings

It is possible to install the pinion assembly with or without crankshaft and gear in place. Use the following guidelines to install the pinion shaft.

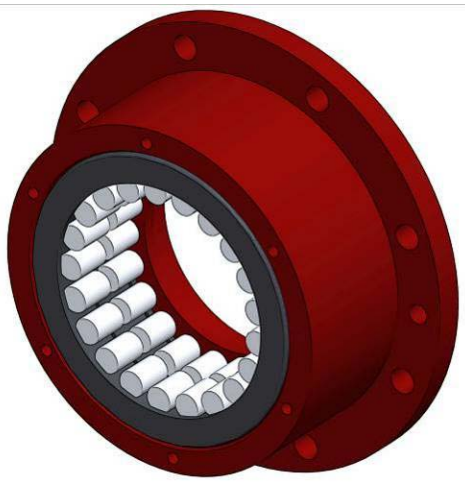
1 Install the pinion bearing inner races and seal races on the pinion shaft by heating to 300°F in an oil bath, electric oven or induction bearing heater. Wait for races to cool before proceeding.

NOTE	Never apply direct flame to the bearings.

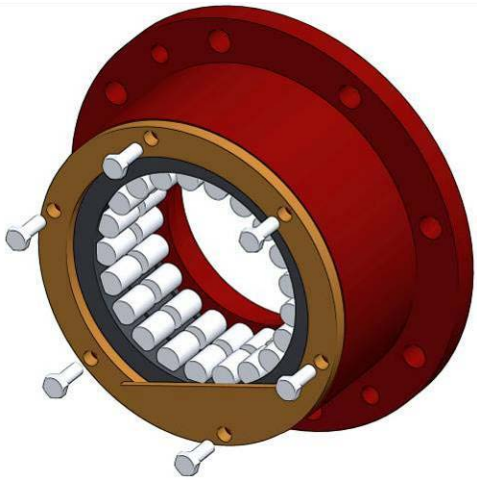
WARNING	During this process, parts can become extremely hot. Allow a few minutes after heating for the races to stabilize, and handle with care.



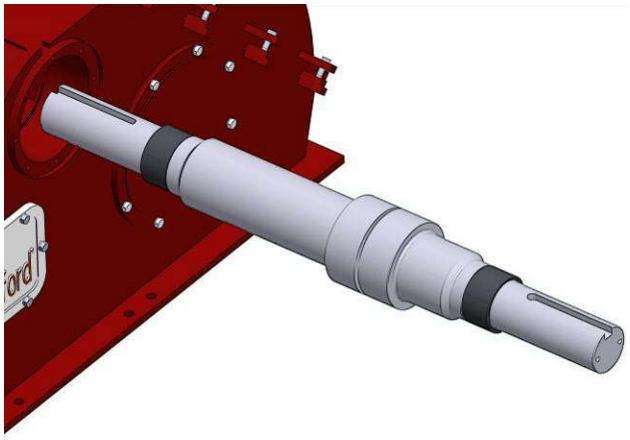
2 Install the pinion bearing rollers and outer race to the bearing carriers using a slip fit.



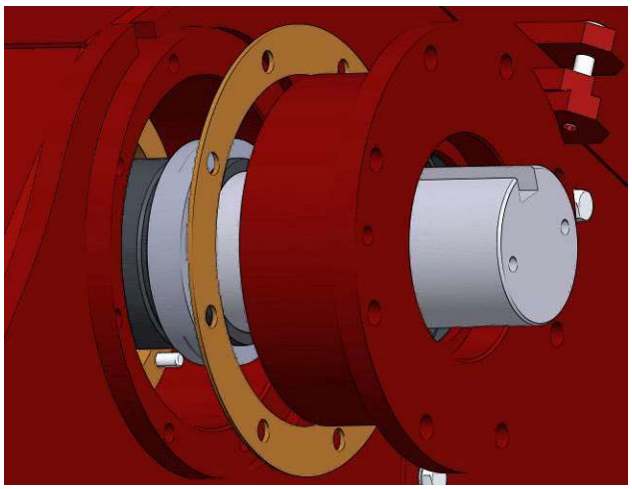
3 Install the bearing retainers and bolts onto the pinion carrier, using a safety washer to secure the bolts.



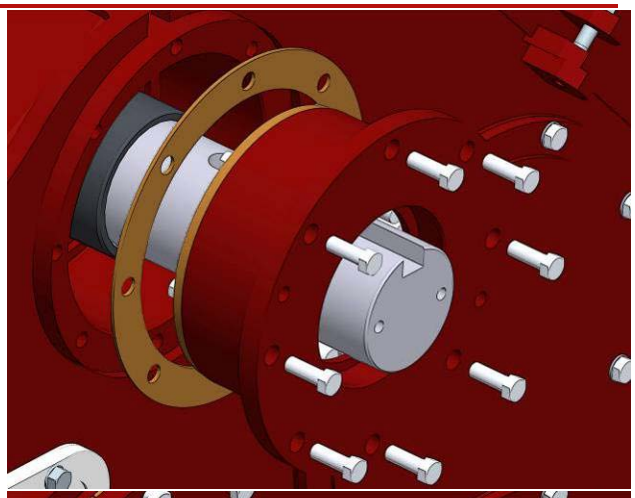
4 Place the pinion shaft into the pump before installing the bearing carrier assemblies. Make sure the pinion shaft is properly supported before proceeding.



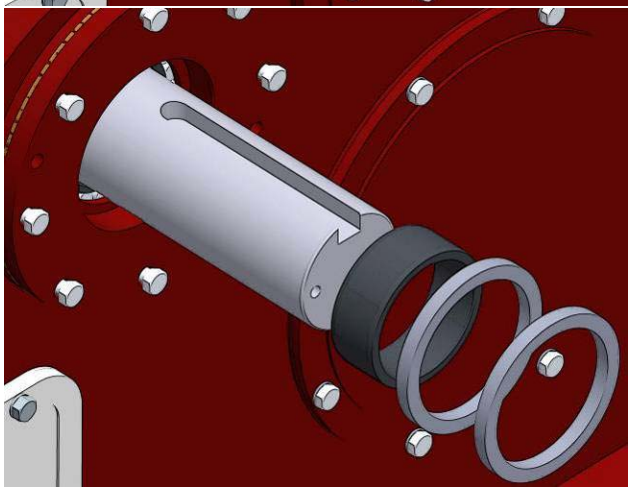
5 Slide the bearing carrier assemblies and gaskets over the pinion shaft and into the pump frame, exercising caution as they meet the inner race.



6 Ensure that the oil line holes in the carrier are oriented to allow the oil lines to be reinstalled, and press the pinion bearing oil seal into the carrier. Use care to prevent damage to the lip of the pinion shaft oil seal.



7 Cover the keyway in the shaft to protect the seal, and install the seal retainer with the gasket and tighten into place. Once set, remove the keyway cover.

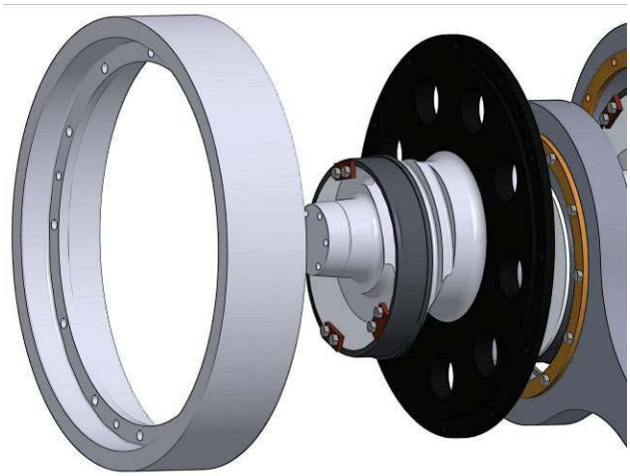


5.4.2 Mounting the Main Gear

The gear is held in place with bolts and locknuts, but the gear pilot diameter may utilize a light shrink fit onto the crankshaft.

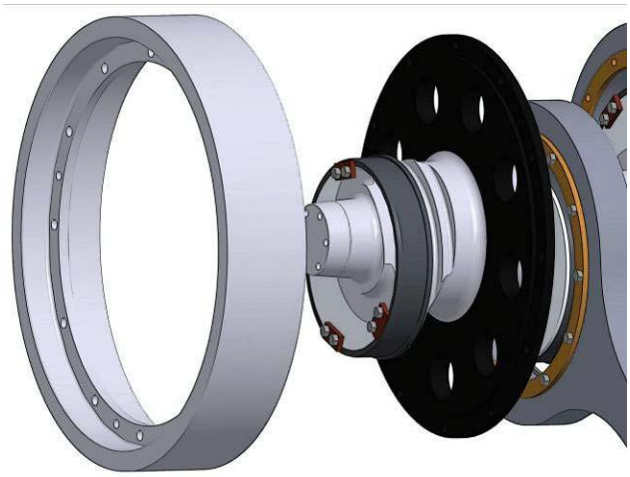
1 Position the crankshaft vertically with the single eccentric side up, supporting it from beneath with the gear-mounting flange.

WARNING	The crankshaft assembly is an extremely weighty system designed to withstand intense pressures, and can cause significant damage, serious injury and death if dropped or if allowed to impact other objects or personnel. Ensure it is properly supported and secure before taking any other steps.

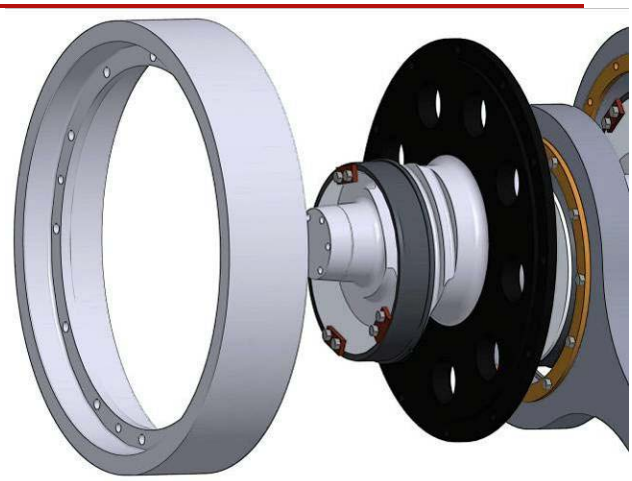


2 Slide the gear over the pilot on the crank. This may require heating the gear. If that is the case, then be sure to uniformly heat all sides to approximately 200°F, and only heat as much as is necessary.

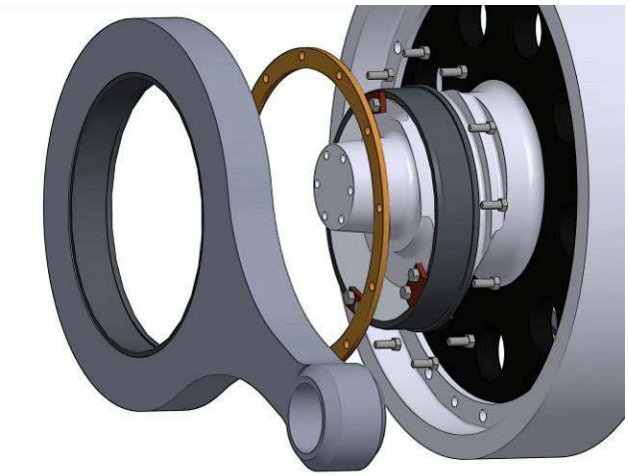
WARNING	During this process, parts can become extremely hot. Allow a few minutes after heating for the gear to stabilize, and handle with care.



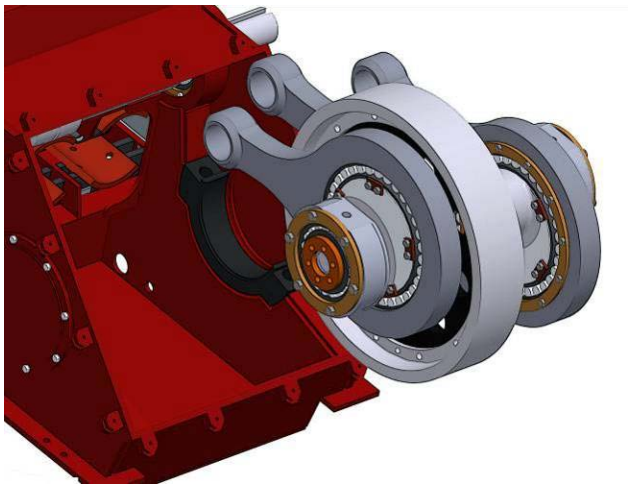
3 Install and tighten the bolts on the gear as per the Torque Chart on page 54. Always use new bolts when mounting the main gear.



4 Reinstall the connecting rod between the right end of the crankshaft and the gear as per 5.4.3: Installing the Connecting Rods & Bearings (page 82).



5 Reinstall the crankshaft, ensuring that the gear teeth will mesh correctly with the pinion. Standard installation positions the gear and pinion to the right of center (if looking from the power end towards the fluid end), but this is not essential.



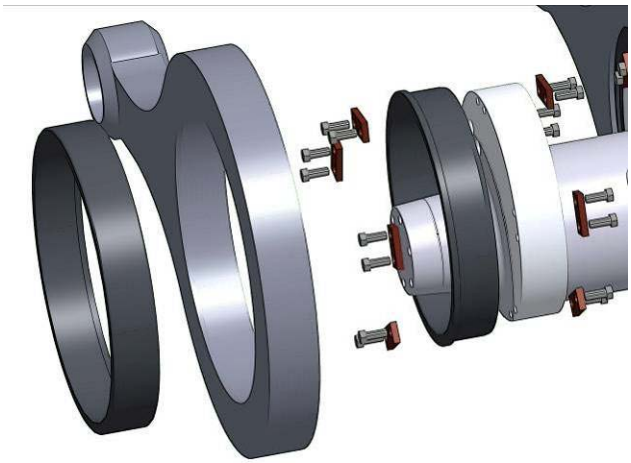
5.4.3 Installing the Connecting Rods & Bearings

The connecting rods are precise systems designed for maximum pump effectiveness and longevity, and so should always be kept together as sets to avoid damage or confusion, and if possible, reinstalled in their original positions on the crankshaft.

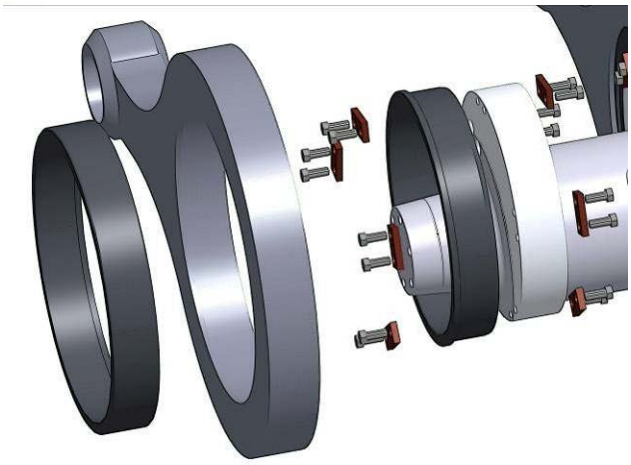
When installing the connecting rods & bearings, be sure to install the inner bearing & connecting rod first, and then the outer bearings. All bearings must be placed against a stop, such as a shoulder or a set of bolt retainers, and should be placed so that the roller assembly may be removed by removing the retainer rings. Use the following procedure.

1 Heat the connecting rods & bearings in an electric oven or oil bath to 200°F. Each bearing consists of 3 parts (outer race, inner race and rollers), which must be kept together as sets.

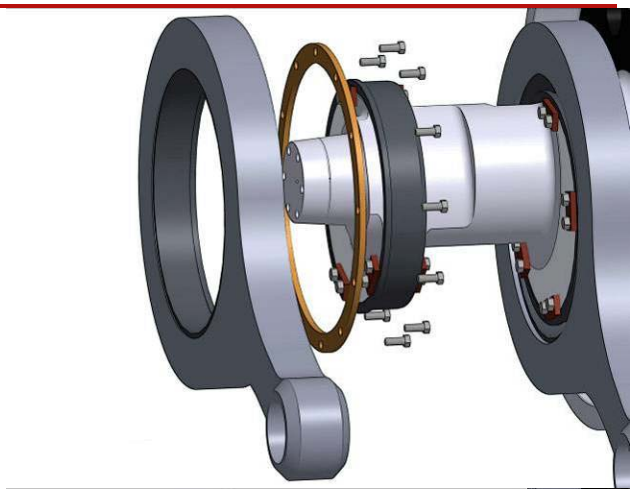
WARNING	During this process, parts can become extremely hot. Allow a few minutes after heating for the gear to stabilize, and handle with care. Do not overheat or apply flame directly to the connecting rods.



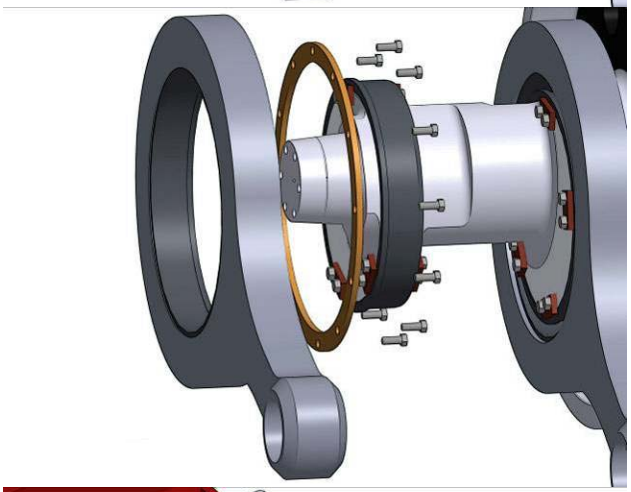
2 Slide the heated bearing onto the crankshaft with the loose ring leading. For bearings that are identical in size, the center bearing should be slipped over the end bearing. Secure the bearing against the stop until it cools.



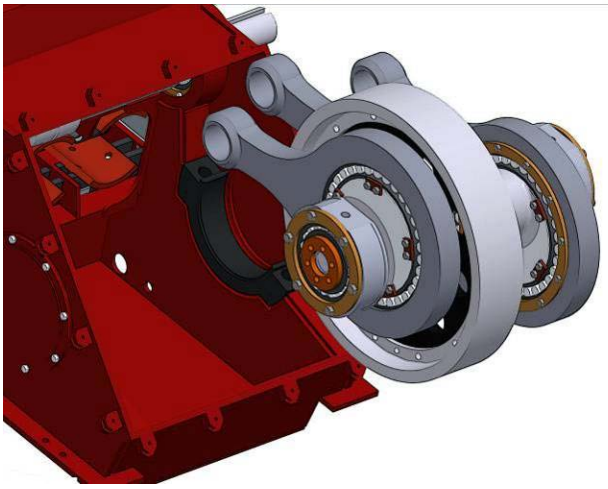
3 Install the segmented retainers to lock the bearing in place.



4 Tighten the retainer bolts in accordance with the Torque Chart (page 54). Where applicable, use tie wire or security washers to secure the retaining bolts.



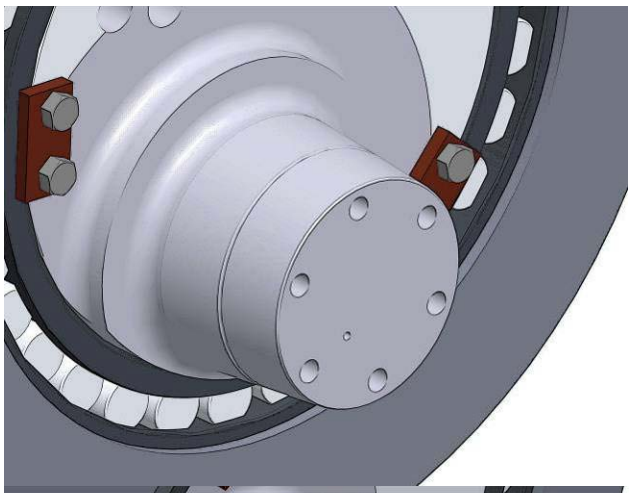
5 Reinstall the crankshaft, ensuring that the gear teeth will mesh correctly with the pinion. Standard installation positions the gear and pinion to the right of center (if looking from the power end towards the fluid end), but this is not essential.



5.4.4 Installing the Main Bearing

These bearings are a double row, spherical roller bearings with a tapered bore. Install as indicated below.

1 Check that the ends of the crankshaft and bearings are grease free. If necessary, assemble the main bearings.



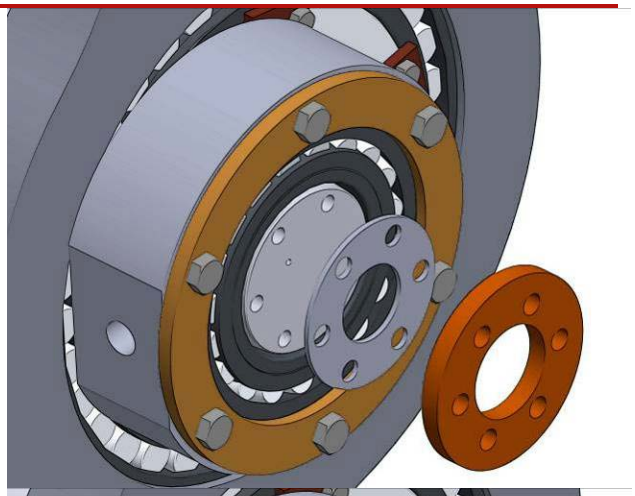
2 Draw the main bearing onto the taper until the internal clearance between the inner bearing race and the rollers is between 0.005” and 0.008”. A feeler gauge should be used to check this clearance.



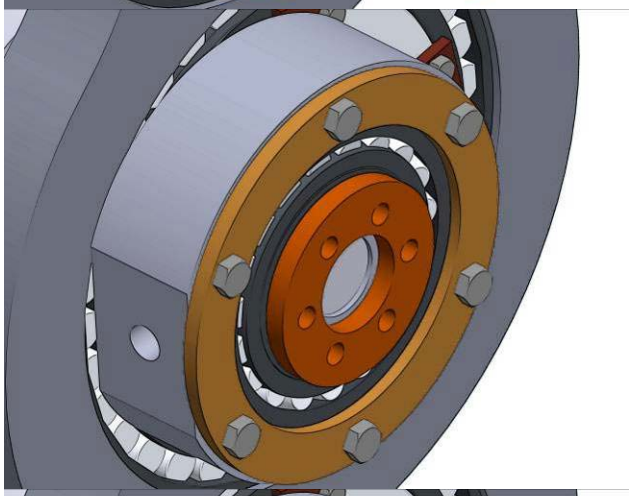
3 Install the main bearing into the bearing carrier using a slip fit. Install the inner and outer bearing retainers.



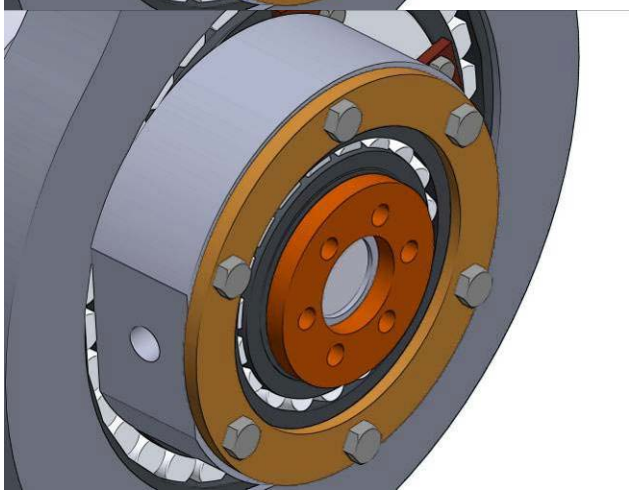
4 Slide the bearing carrier into position on the crankshaft, and measure the shim gap between the inner bearing retainer and the end of the crankshaft. Remove the inner retainer and install shims appropriate to fill the gap.



5 Install the main bearing carrier and retainer onto the crankshaft taper.



6 Tighten the retainer bolts in accordance with the Torque Chart (page 54), then double check the internal bearing clearance. If in error, remove bearings and restart this procedure.



5.4.5 Installing the Wrist Pin Bearing

1 Heat the connecting rod to no more than 200°F, keeping the heat source moving to apply uniform heat.

WARNING	During this process, parts can become extremely hot. Allow a few minutes after heating for the gear to stabilize, and handle with care. Do not overheat or apply flame directly to the connecting rods.



2 Slide the wrist pin bearing onto the rod, ensuring that the ends of the bearing are flush with the sides of the connecting rod.

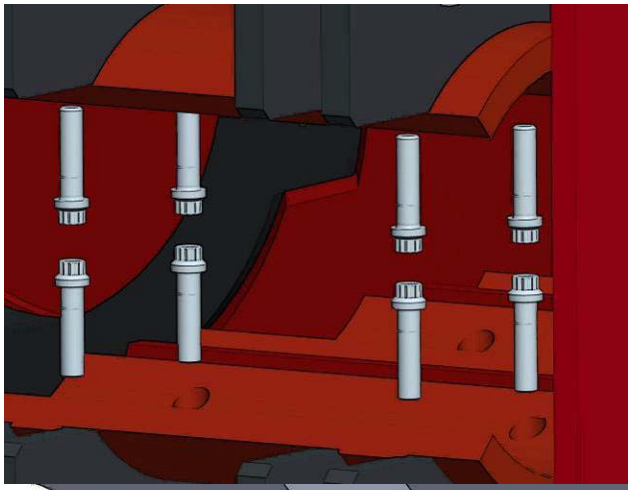


5.4.6 Installing the Crossheads & Crosshead Guides

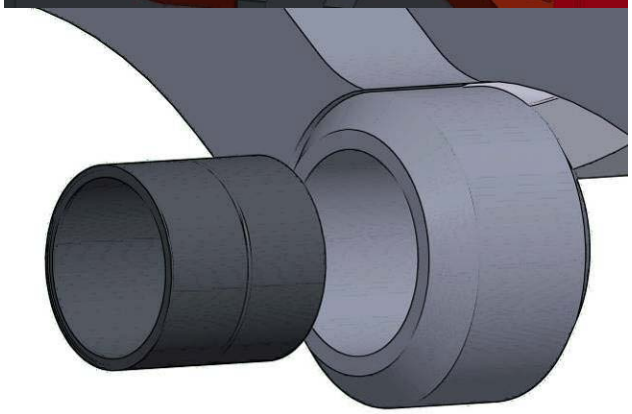
The crosshead guides are bolted into the main frame with clamp bars and bolts. To install, use the following procedure.

NOTE If the original crosshead guides are being reinstalled, it is vitally important to ensure that the guides and shims are reinstalled in the exact location that they were removed from. Failure to do so will result in excessive piston and liner wear.

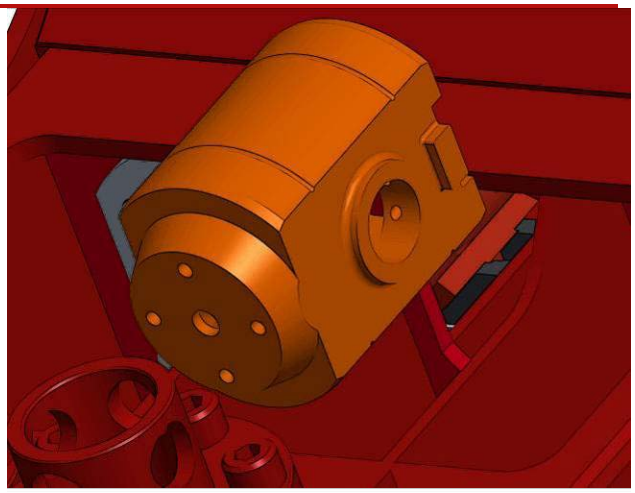
1 Position the crosshead guides within the frame (see above note), and bolt into position at 100 ft. lbs. of torque.



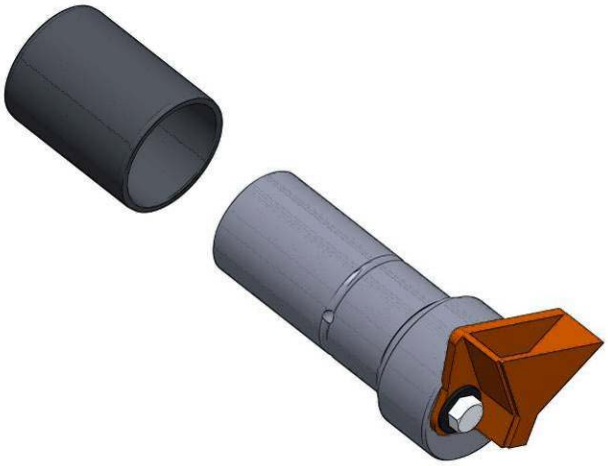
2 Install the outer race of the wrist pin bearing as per 5.4.5: Installing the Wrist Pin Bearing (page 86), then pack the wrist pin bearing rollers with grease to ensure that the rollers stay against the outer race during the wrist pin installation.



3 Place the end of the connecting rod inside the crosshead and align the bearing with the hole running through the crosshead.

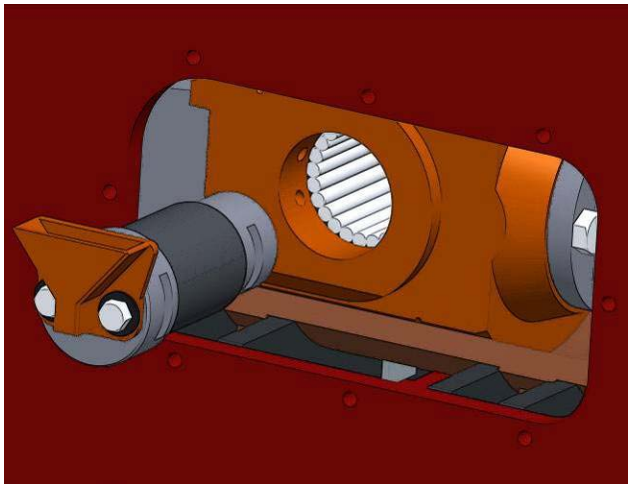


4 Install the inner race of the wrist pin bearing onto the shaft of the wrist pin.

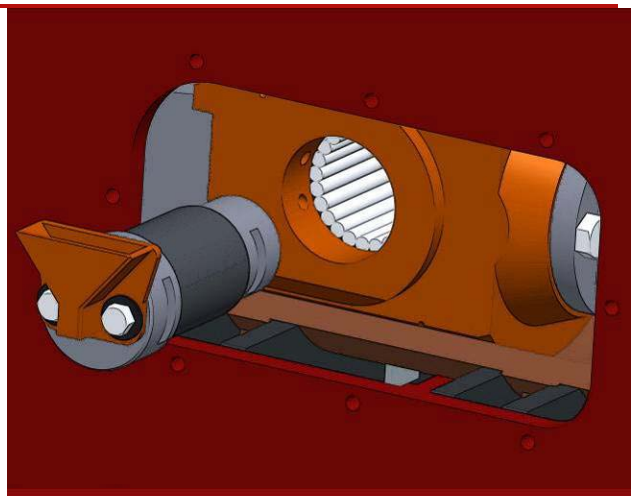


5 Insert the small end of the wrist pin into the wrist pin bearing and gently push into position.

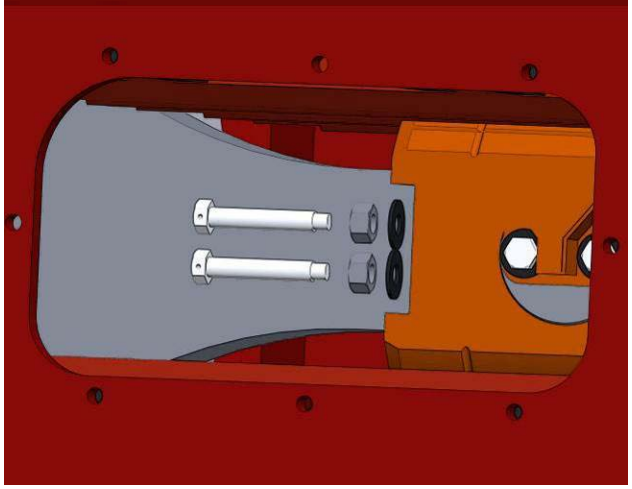
NOTE Do not force or drive the wrist pin. The pin should be a close, tight fit but it must not bind the bearing.



5 Check the clearance between the top of each installed crosshead and the top guide at the front and read or each guide. The measurements should be uniform, with an operating clearance no less than 0.018” and no more than 0.030”. A feeler gauge is recommended for this test.



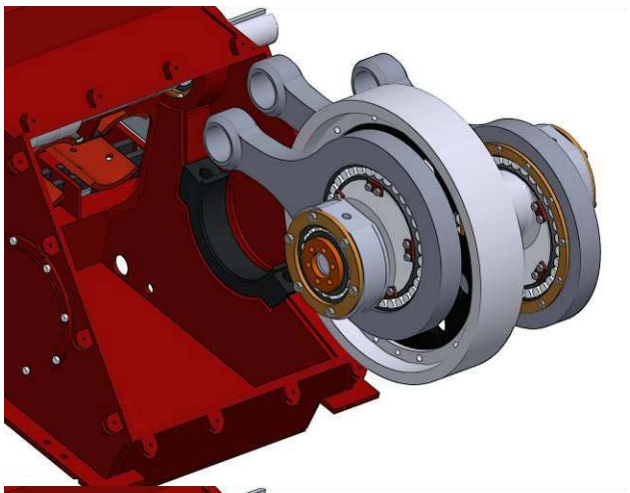
6 Tighten the wrist pin retainer, and recheck clearance.



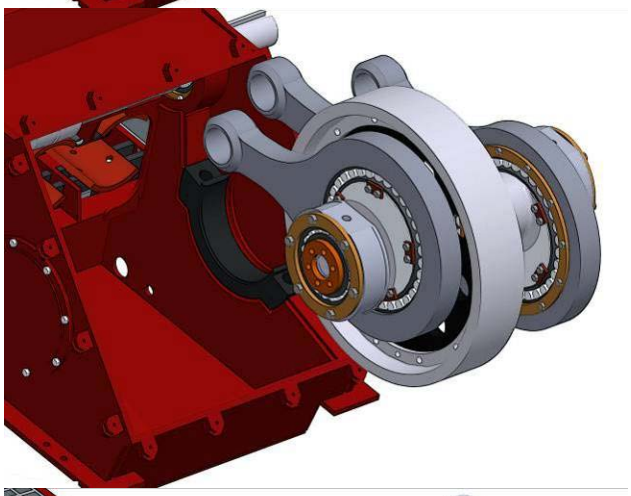
5.4.7 Installing the Crankshaft Assembly

.When installing the crankshaft assembly, be sure to secure pieces of wood to protect the guides from scoring or damage by the connecting rods during the installation process.

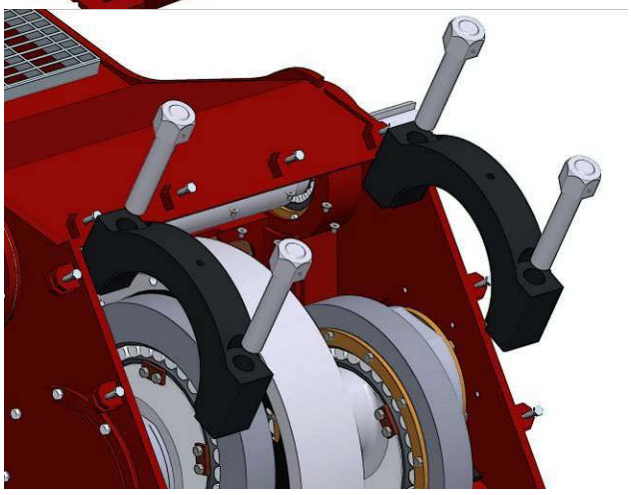
1 Ensure that the come-a-longs are in position to secure the connecting rods and the main bearings have been properly installed as per 5.4.3 (page 82) and 5.4.4 (page 84) respectively.



2 Lower the crankshaft assembly onto the main bearing carriers in the power frame; exercising care to ensure it slides correctly into position. Protect the inner surfaces of the crosshead guides to prevent damage to the surfaces.

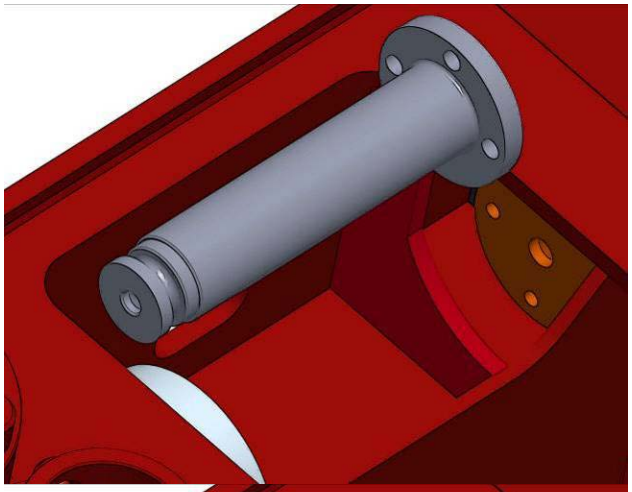


3 Attach the main bearing clamps.

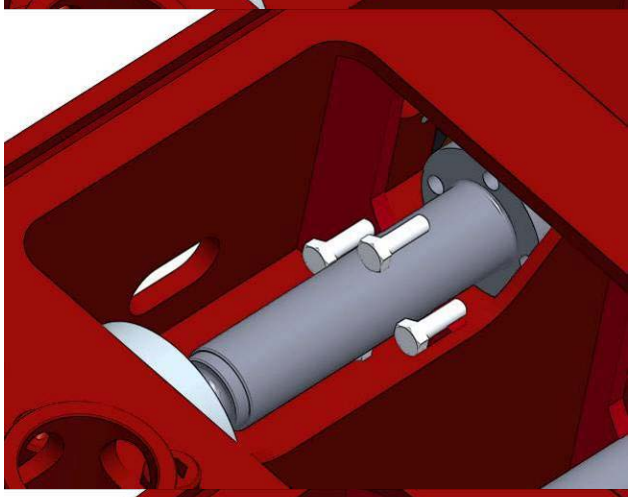


5.4.8 Installing the Crosshead Extension

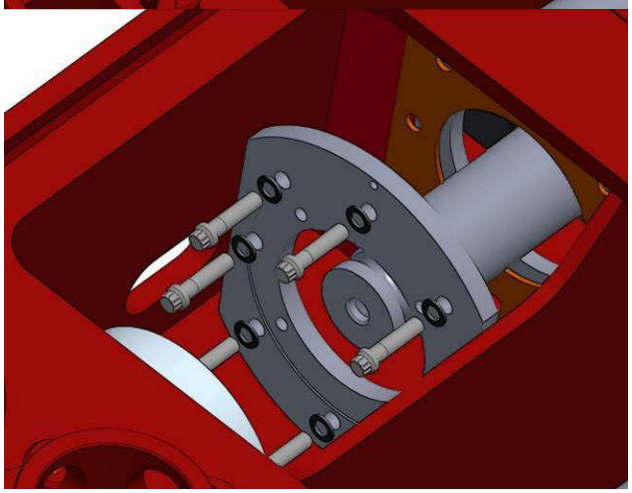
1 Unbolt and remove the diaphragm plate from the crosshead compartment if installed and insert the crosshead extension into the chamber.



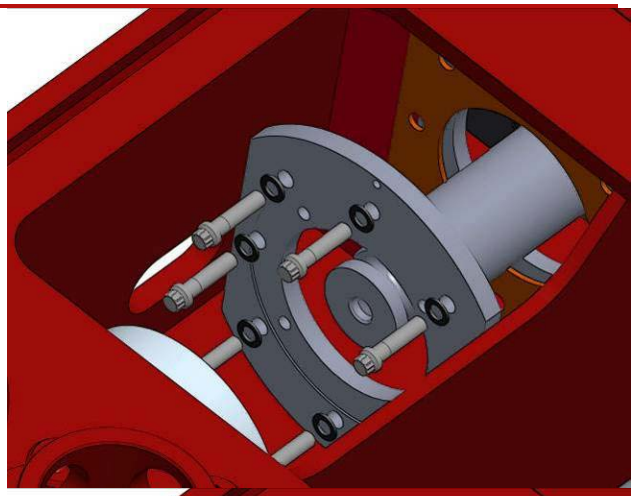
2 Bolt the crosshead extension to the crosshead and torque the bolts to 143 ft. lbs. of torque. Do not over tighten.



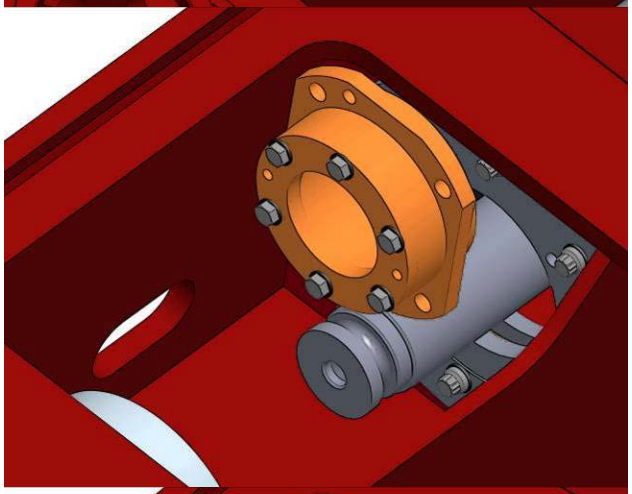
3 Make sure that all the mating surfaces are free of nicks and/or burrs, and slide the diaphragm plate and gasket over the crosshead extension.



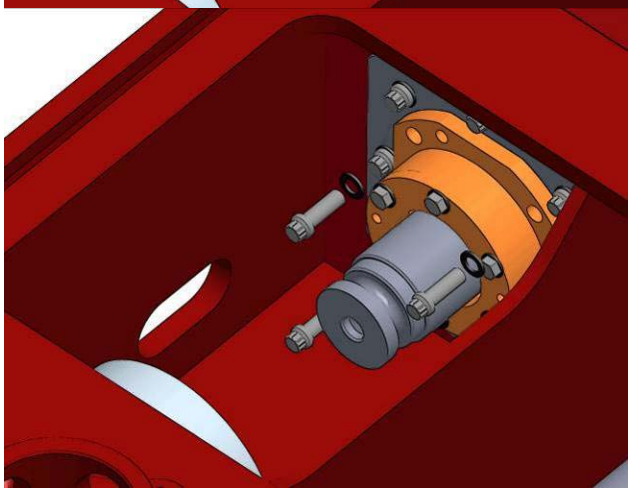
4 Bolt the diaphragm plate to the pump frame in accordance with the Torque Chart (page 54).



5 Slide the wiper box into position on the diaphragm plate.



6 Bolt the wiper box into position.



Chapter 6: Glossary

Adjusting Nut: See Gland

Aeration: Air suspended in the fluid.

AGMA: The American Gear Manufacturers Association.

Bearing: A device that supports, guides, and reduces the friction of motion between fixed and moving machine parts.

Bearing Carrier: A device that fits around a bearing and allows for easy adjustment.

Bearing Housing: The outer shell of a bearing, designed to protect, support and contain the other elements.

Bearing Roller: Bearing elements which move along a fixed track inside of the housing, reducing friction, controlling movement and helping to absorb shocks and stresses.

Bearing, Connecting Rod: See Bearing, Crankpin.

Bearing, Crankpin: A bearing which transmits the oscillating reciprocating load transmitted by the connecting rod to the crankshaft. Also known as the connecting rod bearing.

Bearing, Main: The bearing which supports the crankshaft and absorbs the liquid and inertia loads that are developed by the pistons as they displace the fluid. Also known as the main crankshaft bearing.

Bearing, Main Crankshaft: See Bearing, Main.

Bearing, Wrist Pin: The bearing which attaches the connecting rods to the crossheads and allows the circular motion of the crankshaft to be transformed into an oscillating force on the crossheads. Sometimes known as the Wrist Pin Bushing.

Breather: A vent which allows for pressure equalization between the inside and the outside of the pump.

Bull Gear: See Main Gear.

Bypass Line: A length of piping leading off the main line used to vent excess pressure from the pump.

Bypass Valve: See Valve, Bypass

Cage (Guard): A safety system consisting of a wire-mesh cage which surrounds and prevents access to potentially hazardous systems or components.

Cavitation: The sudden formation and collapse of low pressure bubbles in fluid.

Chain Drive: See Drive, Chain.

Charging Pump: See Pump, Charging.

Come-A-Long: A device for gripping and shortening the effective length of a cable, wire rope or chain by means of two jaws which close when one pulls on a ring.

Connecting Rod: A rod which articulates the motion of the crankshaft to the crosshead. Power is transmitted through the combination of compression and tension.

Connecting Rod Bearing: See Bearing, Crankpin.

Cooling Loop: A device designed to reduce fluid temperatures by pumping a coolant through a loop of hose or piping to absorb heat from the fluid, and then through a second loop to disperse the heat into the environment.

Cradle: The portion of the pump which connects the fluid end to the power frame. Also known as the Frame Extension.

Crankcase: See Power Frame

Crankpin Bearing: See Bearing, Crankpin.

Crankshaft: The stepped shaft which transmits power and motion to the connecting rods through eccentric rotation. Main bearings and connecting rods are fitted to this component.

Crosshead: A system which creates linear reciprocating motion derived from the crankshaft's rotary motion through the connecting rod. The reciprocating motion of the crosshead is applied to the piston via the extension rod.

Crosshead Extension: See Extension Rod.

Crosshead Guide: A track designed to control the movement of the crosshead.

Dampener Charging Kit: A tool used to adjust the pressure in the pulsation dampeners.

Degassing Equipment: Systems designed to remove aeration from the fluid.

Desander: Systems designed to remove sand and solid contaminants from the fluid.

Diaphragm Plate: A metal plate between the cradle and the power frame, designed to prevent environmental contamination of the oil in the crankcase.

Direct Coupled Drive: See Drive, Direct Coupled.

Dirt Excluder: An elastomeric guard designed to keep dirt out of the pump.

Discharge Cross: A flanged cross connected to the discharge manifold allowing for the addition of multiple lines and other systems.

Discharge Dampener: The pulsation dampener mounted in the discharge piping.

Discharge Line: See Discharge Piping.

Discharge Manifold: See Manifold, Discharge

Discharge Module: The portion of the fluid cylinder which discharges fluid from the pump.

Discharge Piping: The piping which carries fluid out from the discharge manifold. Also known as the Discharge Line.

Discharge Pulsation Dampener: See Discharge Dampener.

Discharge Valve: A valve assembly located in the fluid cylinder, designed to channel fluid from the cylinder to the discharge manifold and to prevent return flow.

Drain Valve: See Valve, Drain.

Drilling Fluid: The fluid used when drilling wells. Also known as Mud.

Drilling Mud: See Drilling Fluid.

Drive System: A system which provides power transmission and speed reduction from the prime mover to the pump power end. Usually includes a manual pump rotating device.

Drive, Chain: A drive system consisting of a multiple strand roller chain running on sprockets.

Drive, Direct Coupled: A drive system in which the prime mover is directly connected to the power end of the pump.

Drive, V-Belt: A drive system consisting of a set of V-Belts running on sheaves.

Eccentric Bearing: A bearing set so that its center is offset from a rotating axle, used to convert rotary motion into linear reciprocating motion via the connecting rods and crossheads.

Extension Rod: The rod which is bolted to the crosshead and passes through the stuffing box to connect to the piston. Also known as the piston extension, crosshead extension or pony rod.

External Lube Oil Pump: See Pump, External Lubricating.

External Lubricating Pump: See Pump, External Lubricating.

Flange, Discharge Companion: The main flange extending from the Discharge Manifold, used to attach the Discharge Piping and Cross.

Flange, Suction Companion: The main flange extending from the Suction Manifold, used to attach the Suction Piping.

Fluid: Any non-solid material. In this document, unless otherwise specified the term fluid will refer to the material being moved by the pump.

Fluid Cylinder: A chamber in which the motion of the pistons is imparted to the liquid, which may consist of separate suction and discharge modules. Also known as the Liquid Cylinder.

Fluid End: The portion of the pump which handles the fluid being moved. Includes the fluid cylinder, valves and other systems. Also known as the Liquid End.

Fluid Module: A portion of a multi-part fluid cylinder, usually designed to handle either suction or discharge.

Frame Extension: See Cradle.

Gear End: See Power End.

Gib Crane: A light duty crane mounted atop the pump for handling heavy equipment when servicing the pump. Also known as the Service Crane.

Gland: A threaded adjusting nut located at the atmospheric side of the stuffing box, used to compress the packing. Also known as the Adjusting Nut.

Guard: A portion of the pump designed to protect users by preventing access to potentially hazardous areas or blocking debris.

Heat Exchanger: A device designed to transfer heat from one medium to another.

Hydrogen Sulfide: A colorless gas with a rotten egg smell that often forms in crude oil, natural gas and hot springs. The gas is explosive and corrosive to machine parts, and exposure is extremely hazardous to humans and animals in small doses, and lethal at as low as 8 parts per million. Also known as Sour gas.

Internal Lubricating Pump: See Pump, Internal Lubricating.

Jackscrew: A mechanical lifting device driven by turning a lead screw.

Knocking: An arrhythmic pounding in the fluid end, usually the result of aeration of the fluid.

Liner: The hardened chamber through which the piston moves and applies its force to pumping the fluid.

Liner Bushing: The removable metal frame into which the liner is inserted. Also known as the Liner Retainer.

Liner Lock Ring: A ring which screws into place over the liner bushing to hold the liner in place. Also known as the Liner Retainer Nut.

Liner Retainer: See Liner Bushing.

Liner Retainer Nut: See Liner Lock Ring.

Liner Spray System: See Liner Wash System.

Liner Wash Pump: See Pump, Liner Wash.

Liner Wash System: A lubrication system consisting of a number of valves which spray lubricants onto the pistons and extension rods. Also known as the Liner Sprayer System.

Liner Wash Tank: Storage tank for the liner wash fluid, including a settling section and a reservoir section.

Liquid Cylinder: See Fluid Cylinder.

Liquid End: See Fluid End.

Lubricant: A liquid designed to reduce friction.

Main Bearing: See Bearing, Main.

Main Crankshaft Bearing: See Bearing, Main.

Main Gear: The heavy-duty gear affixed to the crankshaft which translates motion from the pinion rod.

Manifold: A chamber which accepts and directs the flow of fluid.

Manifold, Discharge: A manifold which accepts fluid from the individual discharge valves and directs it to the discharge valve assemblies.

Manifold, Suction: A manifold which accepts fluid from the suction ports and distributes it to the suction valve assemblies.

Mud: See Fluid, Drilling.

Mud Pit: A tank near the rig into which mud is circulated.

Noseplate: The vertical steel plate on the power end onto which the fluid ends are connected.

Packing: The material used to provide a seal around the plunger.

pH: The measure of the acidity or basicity of a solution.

Pinion: A gear with a small number of teeth designed to mesh with the main gear.

Pinion Rod: A rod containing the pinion designed to transfer motive power from the prime mover to the crankshaft via the pinion and main gear. Also known as the Pinion Shaft.

Pinion Shaft: See Pinion Rod.

Piston: A rod which is attached to the crosshead and is capable of exerting pressure upon the fluid within the fluid cylinder. The piston contains its own seals, and moves through a hardened cavity (see Liner).

Piston Assembly: The complete piston, including the cup, hub, rod and seal.

Piston Cup: The rubber cup on the end of the piston which transfers its motive power to the fluid.

Piston Extension: See Extension Rod.

Piston Hub: The metal retainer that screws onto the piston rod and holds the seal and cup in place.

Piston Hub Seal: An extended seal directly behind the piston hub, used to prevent leakage from the liner.

Piston Rod: The body of the piston which connects the hub to the extension rod.

Pitch Line: The line around the circumference of a gear along which its teeth are intended to operate.

Pony Rod: See Extension Rod.

Power Crosshead: See Crosshead.

Power End: The portion of the pump in which the rotating motion of the crankshaft is converted into reciprocating motion through the connecting rods and crossheads. Also known as Gear End.

Power Frame: The portion of the power end that contains the crankshaft, connecting rods, crossheads and bearings used to transmit power and motion to the fluid end.

Pressure Relief Valve: See Valve, Pressure Relief.

Prime Mover: The device which provides power to the drive system.

Pulsation Dampener: A liquid or gas charged, chambered device that minimizes periodic increases and decreases in the pressure of a fluid.

Pump, Charging: A pump that provides pressurized fluid flow to the suction of the main pump.

Pump, External Lubricating: An electrically powered pump located outside of the power frame which provides lubrication pressure to the pump crankcase.

Pump, Internal Lubricating: A crankshaft-powered pump located inside of the crankcase which provides it with lubrication pressure.

Pump, Liner Wash: An electric centrifugal pump circulating liner wash and cooling fluid from the liner wash tank to the liner spray nozzles.

Pump, Triplex: A reciprocating pump utilizing three plungers or pistons working in three separate cylinders, designed so that its power strokes are evenly distributed over the course of a crankshaft revolution.

Race: A groove in a machine through which a moving part slides or rolls.

Retainer: A device which affixes one component to another, usually mounting a component onto a frame.

Rod Clamp: The clamp which affixes the piston or plunger rod to the extension rod.

Seal: A device designed to prevent fluids from leaving a specific location.

Seat Driver: A driving tool used to move the seat into position in the cylinder, consisting primarily of a long, heavy rod with a seat adapter at the end.

Seat Puller: A system used to remove the valve seat from the cylinder. The system comes in many configurations, but most commonly consists of a valve seat adapter attached to a pulling rod, which itself is mounted on a heavy duty frame and driven by a manual hydraulic pump. The when the pump is used, the pulling rod exerts vertical pressure on the seat, eventually wrenching it free from the fluid cylinder.

Service Crane: See Gib Crane.

Settling Tank: A tank designed to filter solid contaminants from fluid by allowing them to settle in the base of the tank while the fluid flows over.

Shield: A type of guard designed to protect against flying debris or components.

Shim: A thin and often tapered or wedged piece of metal, used to ensure components remain properly aligned.

Snap Ring: An oblong metal ring which can be deformed and put into place, at which point it will snap back to its unstressed position in a groove or retainer.

Sour gas: See Hydrogen Sulfide.

Spring Retainer: The part of the Valve Assembly which guides and controls the movement of the spring.

Stop: A device that obstructs movement.

Strainer Cross: A discharge cross containing a strainer screen to remove debris from the pump discharge.

Suction Depulser: See Suction, Stabilizer.

Suction Line: The piping which carries fluid into the suction manifold. Also known as Suction Piping.

Suction Manifold: See Manifold, Suction.

Suction Module: The portion of a multi-part fluid cylinder which accepts fluid into the pump.

Suction Piping: See Suction Line

Suction Stabilizer: A low-pressure pulsation dampener mounted in the suction piping.

Suction Valve: A valve assembly located in the fluid cylinder, designed to channel fluid from the suction manifold to the fluid cylinder and prevent return flow.

Sump: A reservoir of oil, usually located in the crankcase.

Teflon Tape: A film cut to specified widths for use in sealing pipe threads.

Thread Compound: A paste for pipe joint threads that holds the pipes in place and prevents corrosion.

Tie Wire: A fine wire that is twisted around a bracket to keep the fastener from loosening.

Torque: A measure of twisting force, usually indicated in terms of foot-pounds.

Triplex Pump: See Pump, Triplex.

Valve: A structure which regulates the flow of fluid through a system by opening and closing under set conditions.

Valve Assembly: A configuration of parts including, but not limited to, the valve itself, a seat, spring, and spring retainer, all in normal operating positions relative to each other.

Valve Cover: The cover which holds the valve in place in the fluid cylinder.

Valve Cover Seal: The seal around the valve cover.

Valve Puller Assembly: See Seat Puller

Valve Seat: A surface against which a valve may rest in order to seal the aperture.

Valve Seat Puller: See Seat Puller.

Valve Stem Guide: A channel which supports the stem of a valve for maintenance of alignment.

Valve, Bypass: A specialized pressure relief valve hooked to the bypass line.

Valve, Discharge: The valve assembly through which fluid exits the pump into the discharge manifold.

Valve, Line: A valve designed to control flow through the piping.

Valve, Pressure Relief: A valve designed vent excess pressure from the system by opening at a set pressure value.

Valve, Shut-Off: A valve designed to completely stop the flow of fluid.

Valve, Suction: The valve assembly through which fluid enters the pump from the suction manifold.

V-Belt: A belt designed with a “V” shape to mate with a tracking groove in the sheave in order to enhance traction and prevent the belt from unintentionally slipping off.

V-Belt Drive: See Drive, V-Belt.

Vent: A system in the piping designed to remove aeration from the fluid.

Wear Plate: A component used to reduce wear and add support.

Wiper Box: A cylindrical cavity through which the extension rod reciprocates and in which liquid leakage is controlled by means of wipers.

Wrist Pin: The component which connects the connecting rod to the crosshead.

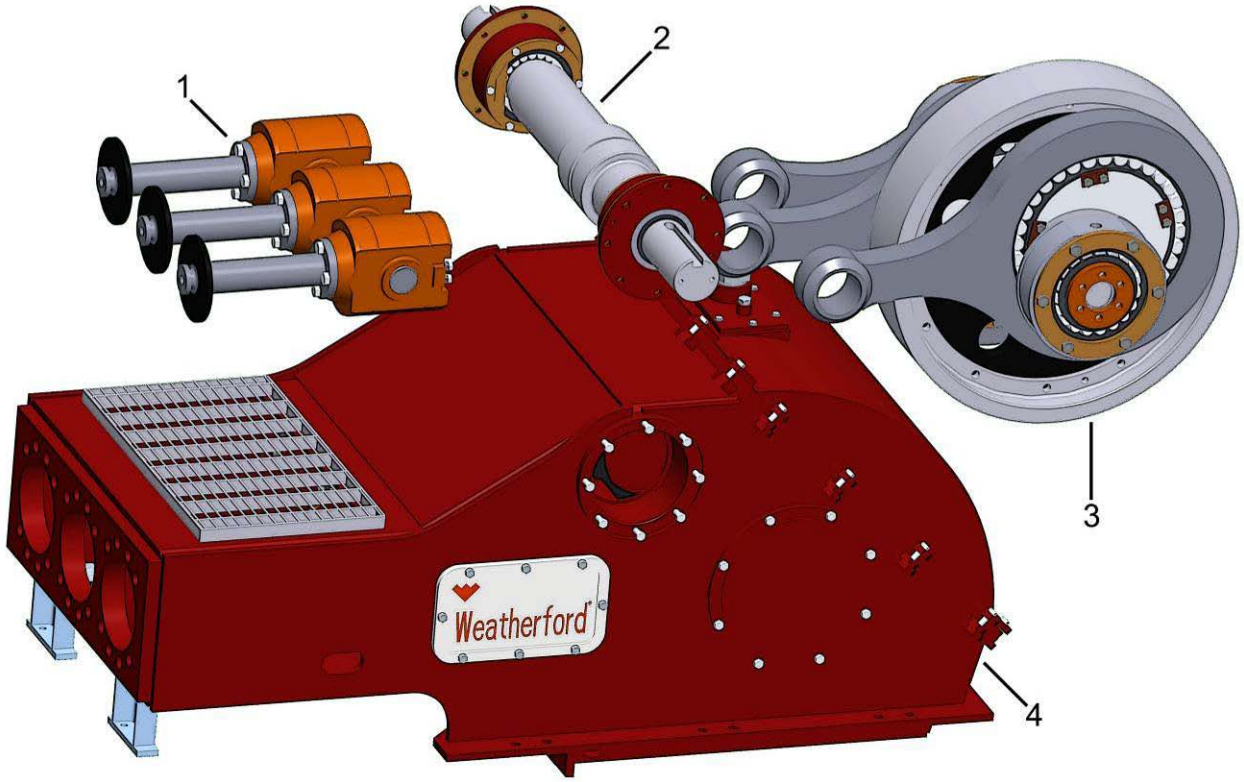
Wrist Pin Bearing: See Bearing, Wrist Pin.

Zerk Fitting: A lubrication fitting in mechanical systems used to allow grease to be added with a grease gun.

Chapter 7: Parts Lists

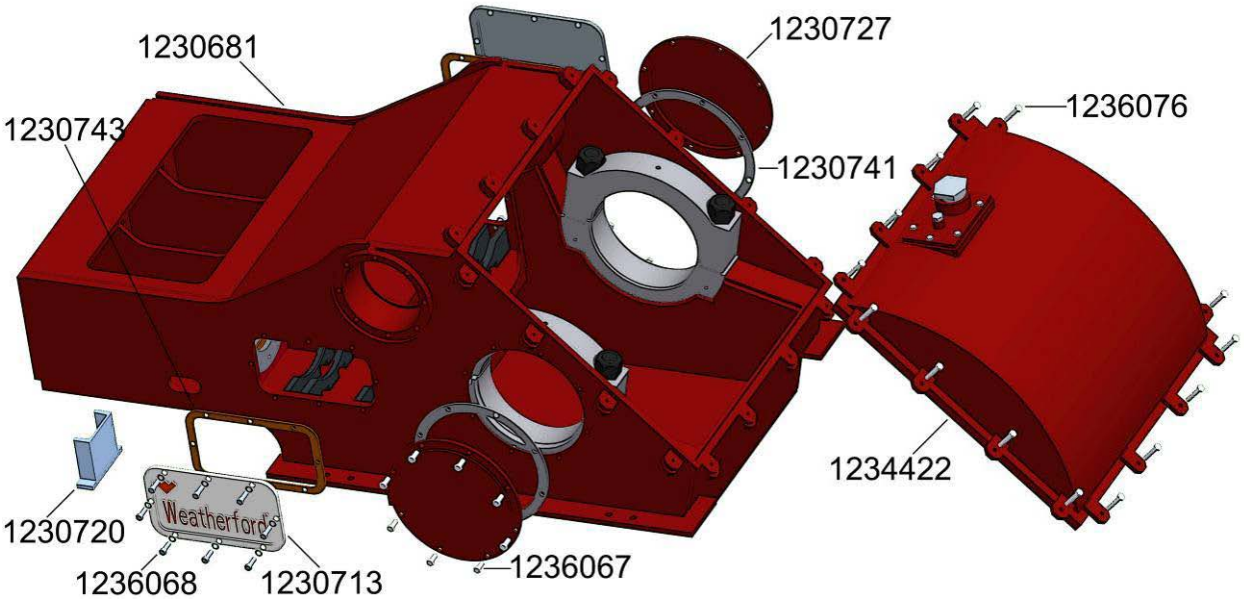
The following sheets contain the master parts lists for the E-447 triplex pump. These lists are designed to be comprehensive to every pump made, and so may include parts and systems that are not included on the particular unit this manual came with. For a specific list of exactly which parts and components are on a particular unit, consult the specifications sheet that came with the pump.

7.1 Power End Assembly



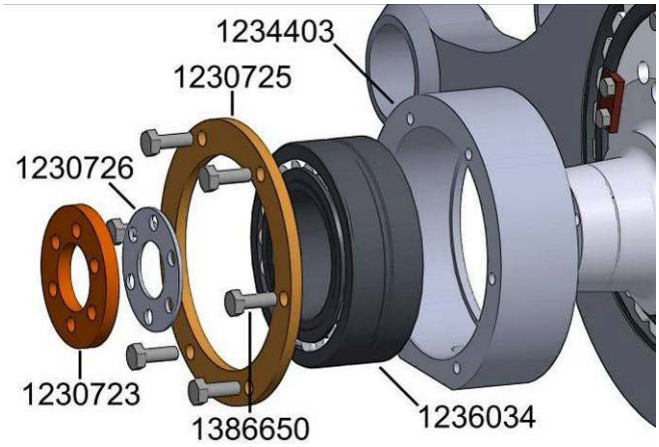
Item	Description	Part Number	Qty.
	Assembly, Power End	1255965	1
1	Assembly, Crosshead	1230750	3
2	Assembly, Pinion	1230748	1
3	Assembly, Crankshaft	1230749	1
4	Assembly, Power Frame	1248494	1

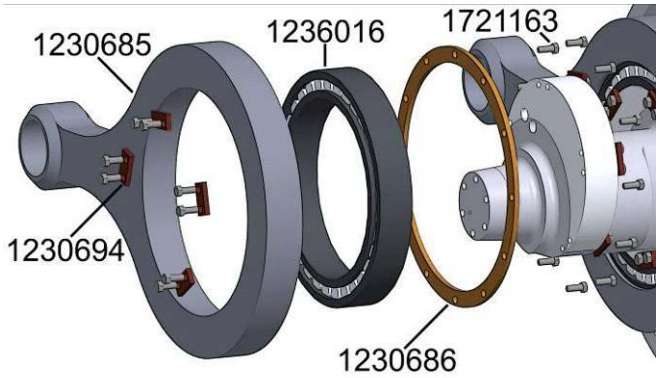
7.1.1 Power Frame Assembly

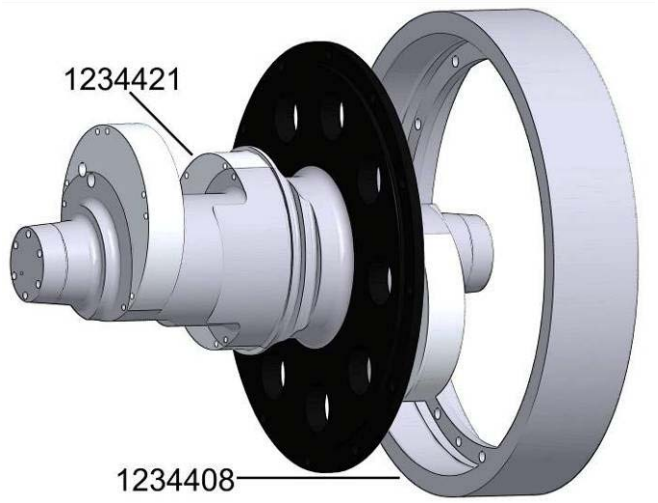


Part Number	Description	Qty.
1248494	Assembly, Power Frame	1
1230681	Machining, Frame	1
1234422	Assembly, Crankcase Cover	1
1236076	Screw, Hex Cap ⅝" – 11 x 2½" CS	16
1230741	Gasket, Main Bearing	2
1230727	Cover, Main Bearing	2
1236067	Screw, Hex Cap ½" – 13 x 1¼" CS	16
1230743	Gasket, Crosshead Cover	2
1230713	Cover, Crosshead	2
1236068	Screw, Hex Cap ½" – 13 x 1½" CS	16
1230720	Support, Front	2

7.1.2 Crankshaft Assembly

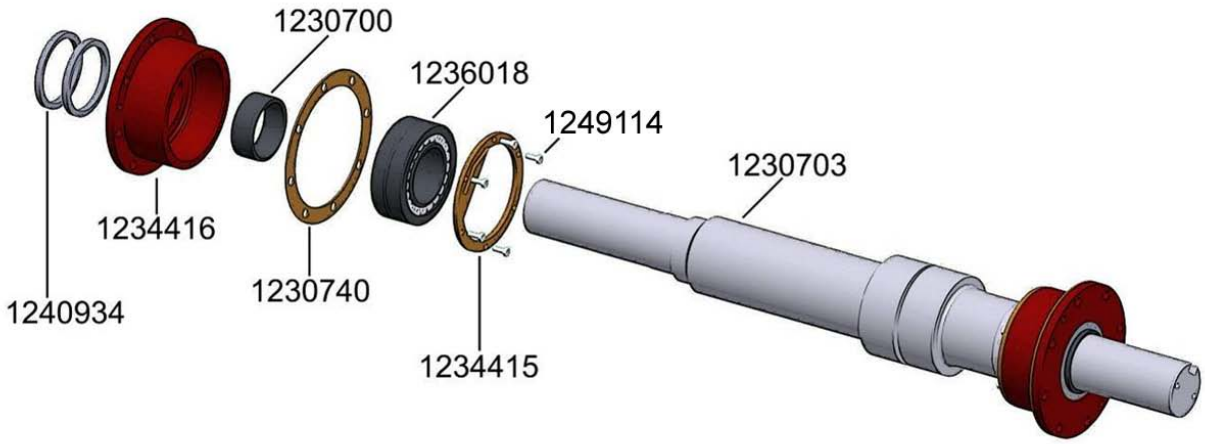






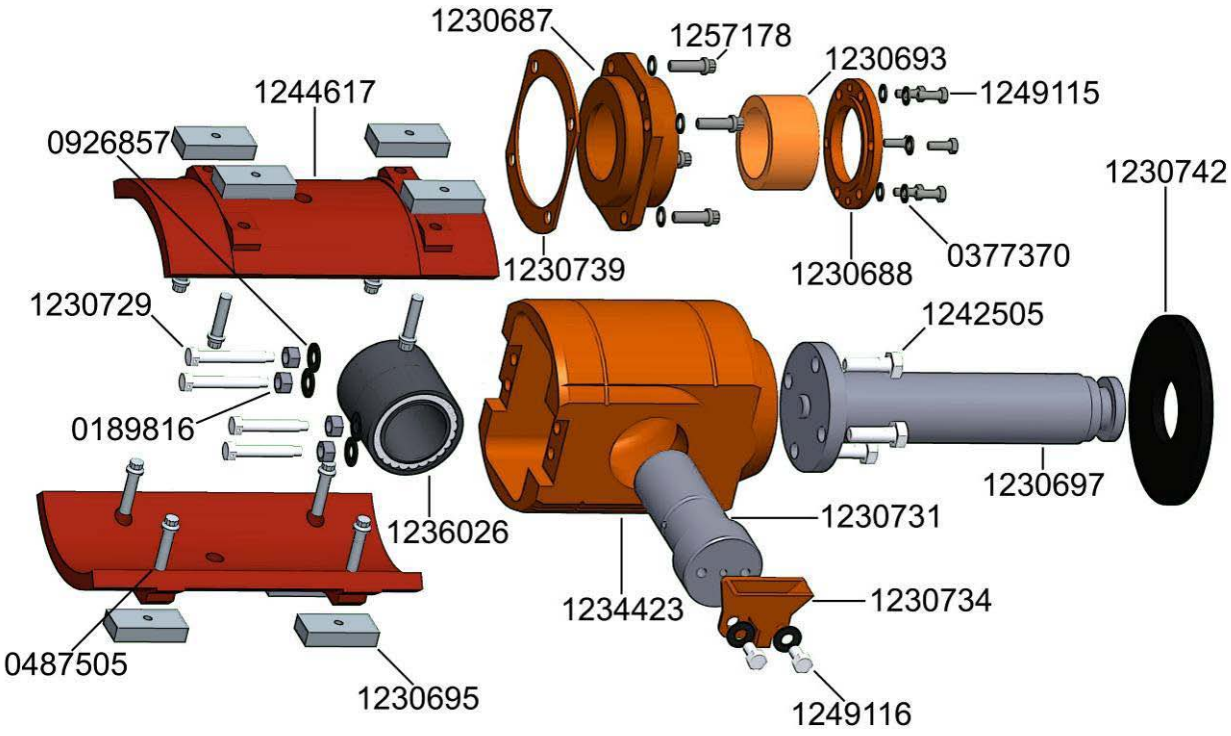
Part Number	Description	Qty
1230749	Assembly, Crankshaft	1
1234403	Carrier, Main Bearing LH	1
1230683	Carrier, Main Bearing RH (NS)	1
1236034	Bearing, Roller 9.843" OD x 5.512" ID x 3.464" WD Spherical Bronze	2
1230725	Retainer, Outer Race, Main Bearing	2
1230723	Retainer, Inner Race, Main Bearing	2
1230726	Shim Set, Main Bearing	2
1386650	Screw, Drilled Hex Cap ⅝" – 11 x 1½" Alloy B18.2.1 GR8 (NS)	24
0104658	Washer, Lock ⅝" (NS)	
1230685	Rod, Connecting	3
1236016	Bearing, Cyldrical Roller 457mm x 343mm x 70mm	3
1230686	Retainer, Eccentric, Outer Race	3
1230694	Retainer, Eccentric, Inner Race	16
1721163	Screw, Drilled Hex ½" - 13 x 1" CS B18.2.1 Zn GR8	68
1234421	Machining, Crankshaft	1
1234408	Gear, Main	1
1236087	Screw, Hex Cap ¾" – 10 x 3" CS B18.2.1 Zn GR5 (NS)	12
0221052	Nut, Hex ¾" – 10 UNC Plated STL Nylon Insr (NS)	12
1249544	Tie Wire, 0.048" OD SS	-

7.1.3 Pinion Assembly



Part Number	Description	Qty.
1230748	Assembly, Pinion Shaft	1
1230703	Shaft, Pinion	1
1234416	Carrier, Pinion Bearing	2
1230740	Gasket, Pinion Bearing Carrier	2
1236018	Bearing, 7.874” OD x 4.331” ID x 2.75” WD	2
1230700	Race, Pinion Oil Seal	2
1240934	Seal, Oil 6.001” Housing x ½” WD	4
1234415	Retainer, Pinion Bearing	2
1249114	Screw, Cap Drilled Hex ⅜” – 16 x 1” CS B18.2.1 Zn GR8	12
1094083	Screw, Cap Hex ⅝” – 11 x 2¼” Alloy B18.2.1 Zn GR8 (NS)	16
1249544	Tie Wire, 0.048 OD SS	-

7.1.4 Crosshead Assembly

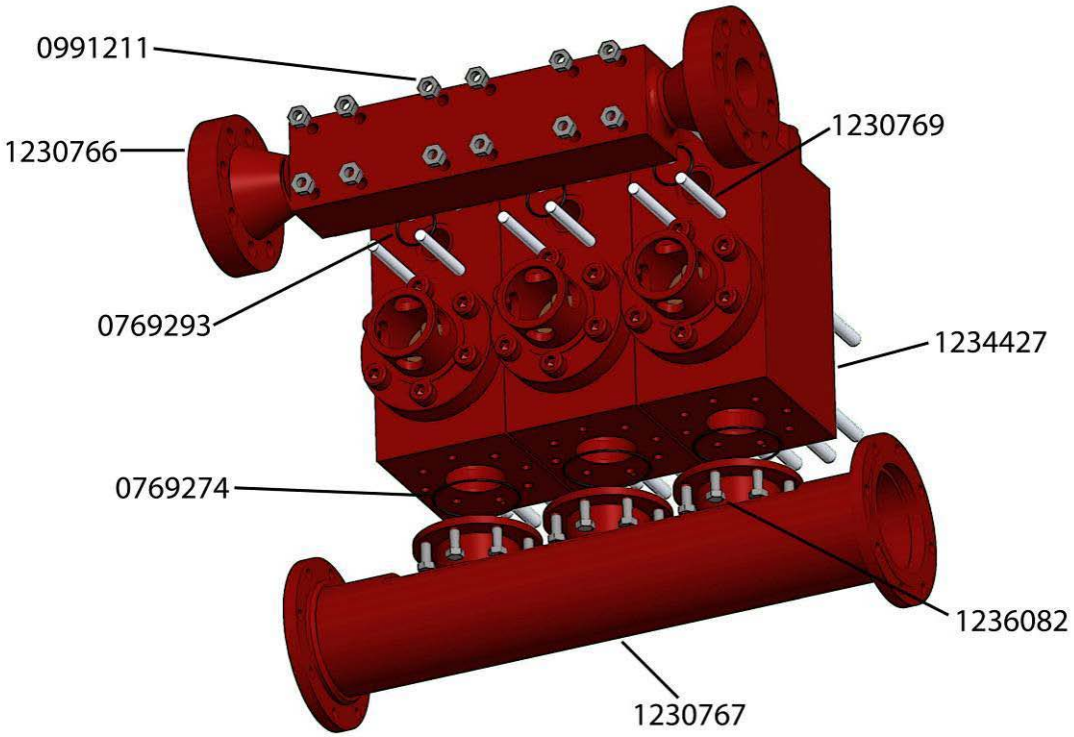


Part Number	Description	Qty.
1230750	Assembly, Crosshead	1
1234423	Crosshead, Machining	3
1236026	Bearing, Needle	3
1230731	Pin, Wrist	3
1230734	Cup, Lube, Wrist Pin	3
1249116	Screw, Cap Drilled Hex ½”	6
0926857	Washer, Flat ½”	12
0189816	Nut, Hex ½” – 13 UNC	12
1230729	Screw, Wrist Pin Long	6
1230730	Screw, Wrist Pin Short	6
1230697	Rod, Extension	3
1242505	Screw, Drilled Hex ⅝”	12
1230742	Disc, Baffle	3

Part Number	Description	Qty.
1230739	Gasket, Stuffing Box	3
1230687	Box, Stuffing	3
1230693	Packing, Extension Rod	3
1230688	Plate, Cover, Stuffing Box	3
0377370	Washer, Lock ⅜”	18
1249115	Screw, Cap Hex ⅜”	18
1257178	Screw, Cap Hex ½”	12
1244617	Guide, Crosshead	6
1230695	Plate, Nut, Crosshead Guide	24
0487505	Screw, Cap Flg 12 pt. ½”	24
1249544	Wire, Tie (Not Shown)	-

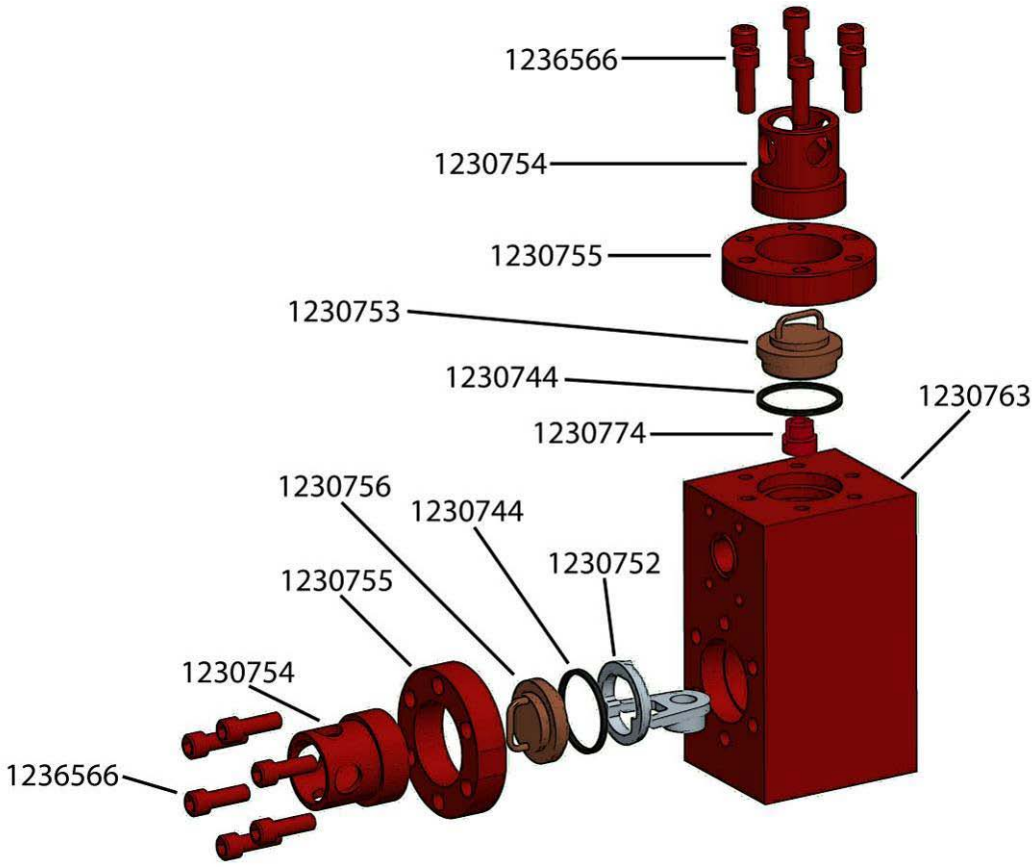
7.2 Fluid End Assembly

7.2.1 Fluid End – Front Mount Discharge



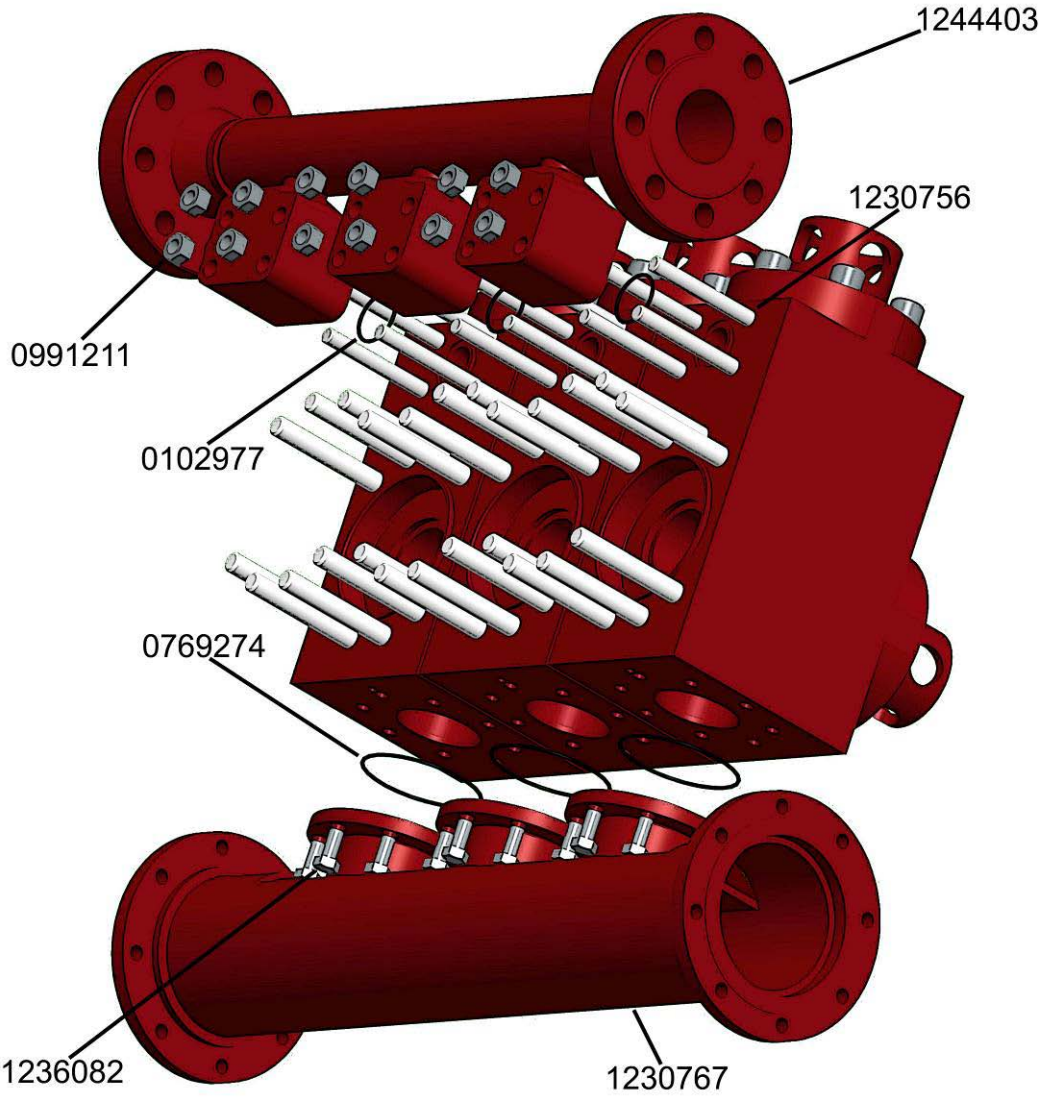
Part Number	Description	Qty.
1234427	Assembly, Front Mount Fluid End	1
1230766	Manifold, Discharge	1
1230769	Stud, Discharge Manifold	12
0991211	⅞” Heavy Hex Nut	12
0769293	O-Ring, 340 FKM 90D	3
1230767	Manifold, Suction	1
1236082	¾” Heavy Hex Head Caps	24
0769274	O-Ring, 363 FKM 90D	3

7.2.2 Fluid Module – Front Mount Discharge



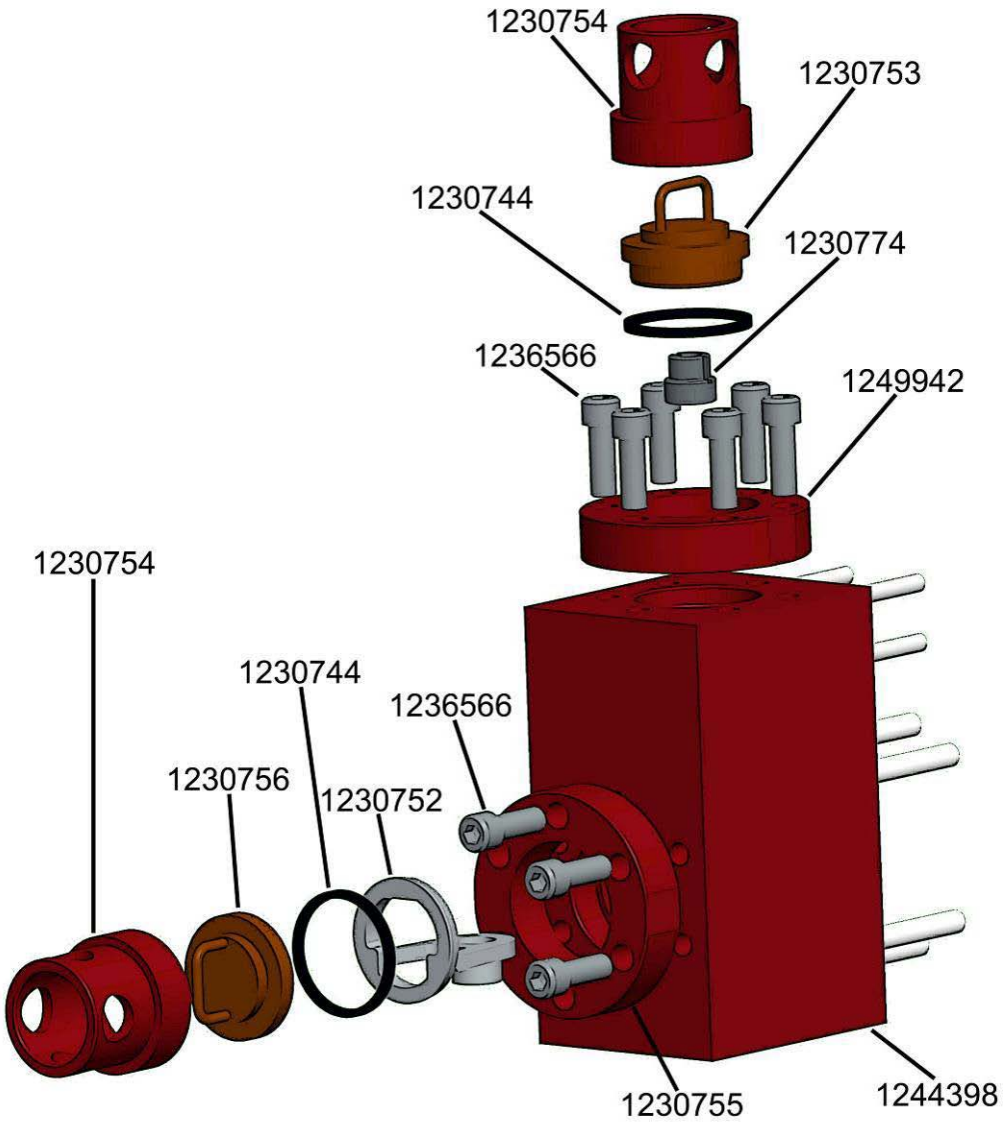
Part Number	Description	Qty.
1230763	Module, Fluid End	1
1230755	Flange, Valve Cover	2
1230754	Lock, Valve Cover	2
1236566	Cap Screw, 1¼"	12
1230756	Cover, Cylinder Head	1
1230753	Cover, Valve	1
1230744	Gasket, Cover	2
1230752	Guide, Lower Valve	1
1230774	Bushing, Discharge Valve Guide	1

7.2.3 Fluid End – Rear Mount Discharge



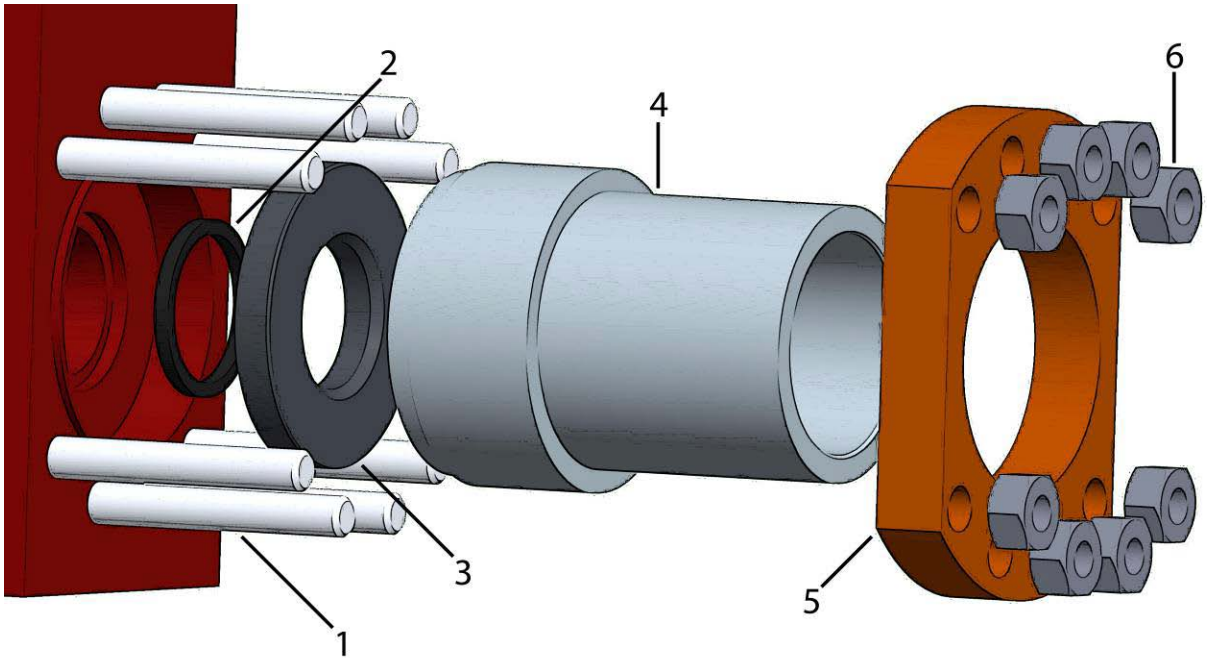
Part Number	Description	Qty.
1263766	Assembly, Rear Mount Fluid End	1
1244403	Manifold, Discharge	1
1230756	Stud, Discharge Manifold	12
1230756	⅞" Heavy Hex Nut	12
0102977	O-Ring, 340 FKM 90D	3
1230767	Manifold, Suction	1
1236082	¾" Heavy Hex Head Capscrew	24
0769274	O-Ring, 363 FKM 90D	3

7.2.4 Fluid Module – Rear Mount Discharge



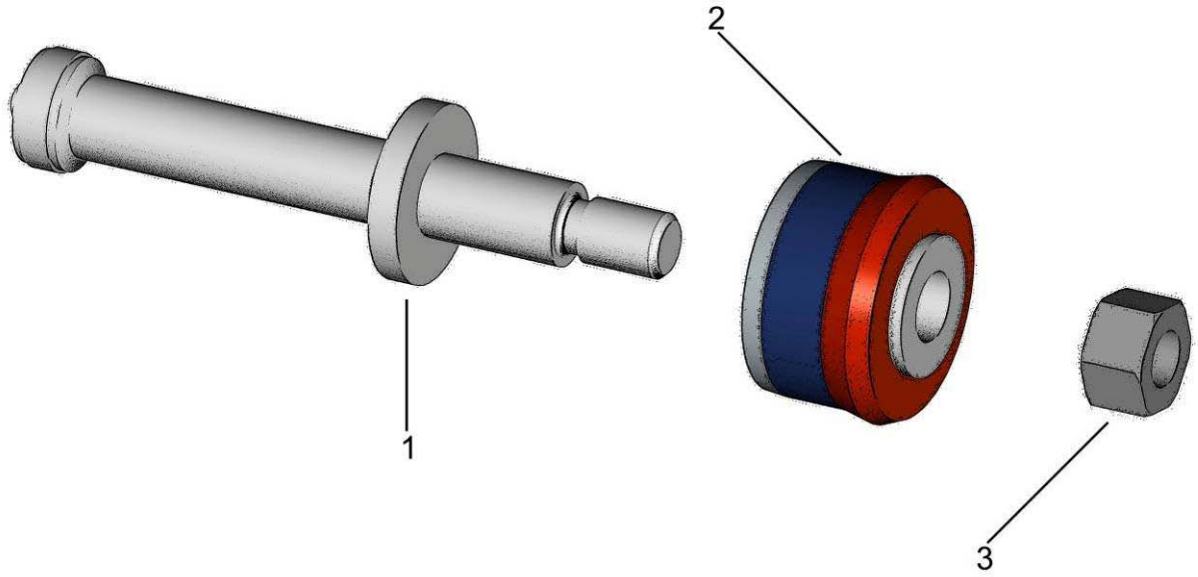
Part Number	Description	Qty.
1244398	Module, Fluid End	1
1230756	Flange, Suction Valve Cover	1
1249942	Flange, Discharge Valve Cover	1
1230754	Lock, Valve Cover	2
1236566	Cap Screw, 1¼"	12
1230753	Cover, Valve	2
1230744	Seal, Valve Cover	2
1230774	Retainer, Discharge Valve	1
1230752	Retainer, Suction Valve	1

7.2.5 Liner Assembly



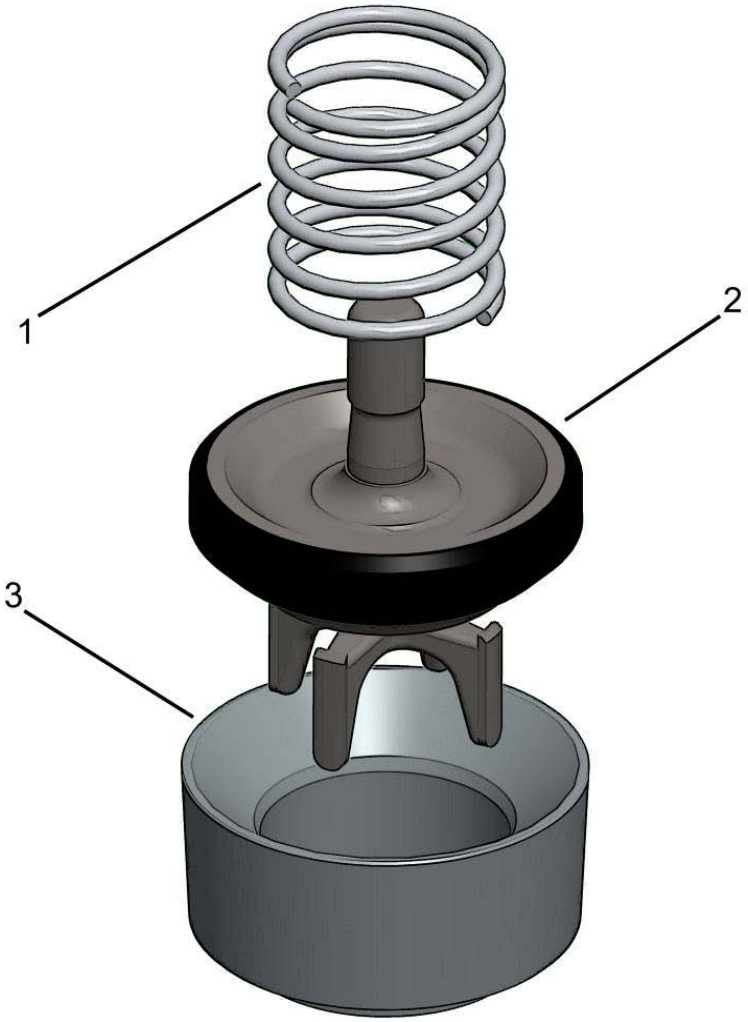
Item	Description	Chrome Iron	Zirconia	Qty.
1	Stud, Liner Lock Ring	1230764		24
2	Seal, Wear Plate CS	1372263		3
	Seal, Wear Plate SS	1231181		
3	Wear Plate, CS	1230762		3
	Wear Plate, SS	1372275		
4	Liner, 4.000”	1244387	1378172	
	Liner, 4.500”	1244388	1378175	
	Liner, 5.000”	1244389	1378176	
	Liner, 5.500”	1244390	1378180	
	Liner, 6.000”	1244391	1378184	
5	Lock Ring, Liner	1230761		3
6	1⅛” Heavy Hex Nut	991094		24

7.2.6 Piston Assembly



Item	Description	Bonded DD Urethane	Bonded DD HT Urethane	Bonded Nitrile	Replacable Nitrile	Replacement Kit	Qty.
1	Rod, Piston	1230759					3
3	Piston, 4.00 inch	1317542	1317541	1317543	1317544	1317520	3
	Piston, 4.25 inch	1317546	1317545	1317547	1317548	1317521	
	Piston, 4.50 inch	1317550	1317549	1317551	1317552	1317522	
	Piston, 4.75 inch	1317554	1317553	1317555	1317556	1317523	
	Piston, 5.00 inch	1317558	1317557	1317559	1317560	1317524	
	Piston, 5.25 inch	1317562	1317561	1317563	1317564	1317525	
	Piston, 5.50 inch	1317566	1317565	1317567	1317568	1317526	
	Piston, 5.75 inch	1317570	1317569	1317571	1317572	1317527	
	Piston, 6.00 inch	1317574	1317573	1317575	1317576	1317528	
3	Nut, Lock	1191249					3
	Clamp, Piston Rod (NS)	1230698					3
	Bolt, Clamp (NS)	0357441					6

7.3 Valve Assemblies



Item	Description	Full Open	Full Open HT	3 Web CG	3 Web CG HT	4 Web CG	4 Web CG HT	Qty.
	Valve Assembly, API #5	1803912	1318060	1411440	1318056	1318058	1318057	3
1	CS Spring	1318030		-		1318026		3
1	SS Spring	1318039		1318032		N/A		3
2	Valve	1318043	1318044	1318040	-	1318042	1318041	3
3	Valve Seat	1318003		-		1318026		3
NS	Valve Insert	-	-	1317985	-	1317986	1317982	3
NS	Seat Puller Head	1317871		1317869		1317870		1
NS	Valve Seat Puller Kit	1241141						1